DEVELOPMENTS IN DIACHRONIC THINKING, TEMPORAL COGNITION, AND EPISODIC MEMORY IN 5- TO 10 YEAR OLD CHILDREN

By

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Abstract

DEVELOPMENTS IN DIACHRONIC THINKING, TEMPORAL COGNITION, AND EPISODIC MEMORY IN 5- TO 10 YEAR OLD CHILDREN

By

Brandy Moore

Adviser: Patricia Brooks, Ph.D.

The current study investigated the relationship between developments in diachronic thinking, temporal cognition, and episodic memory. Children (n=90, 5;0-10;10) divided into younger (i.e., ages 5, 6, and 7) (n=44, M age = 6;7) and older (i.e., ages 8, 9, and 10) (n=46, M = 9;5) groups completed a battery of tasks evaluating different components of diachronic thinking (tendency, transformation, and synthesis), temporal cognition (forward, backward, and relative ordering of events; using space to conceptualize distances in time, labeling time concepts), and episodic memory. We evaluated the extent to which these measures were inter-correlated and related to measures of nonverbal and verbal intelligence evaluated factors underlying diachronic thinking, temporal cognition, and episodic memory, with a principal-components analysis yielding two factors. The first factor was positively associated with all measures, including verbal and nonverbal intelligence. The second factor was positively related to measures of diachronic thinking, but negatively related to episodic memory and most measures of temporal cognition. This second factor most strongly distinguished performance on the synthesis and labeling time concepts tasks, and was independent of age and verbal and nonverbal intelligence. Regression analysis

showed children's ability to label time concepts to be predictive of performance on all other temporal cognition tasks, over and above the effects of verbal and nonverbal intelligence. Synthesis, a measure of diachronic thinking, was predictive only of measures of temporal ordering. Episodic memory was strongly predicted by verbal intelligence, and marginally by labeling of temporal concepts. Episodic memory failed to predict performance on any of the diachronic thinking and temporal cognition tasks over and above the effects of verbal and nonverbal intelligence. Thus, it appears that the multiple measures of time travel ability in children tap into somewhat different ways of keeping track of time. The results provide support for the view that diachronic thinking and temporal cognition are overlapping, but distinct abilities, with the latter more closely related to developments in episodic memory.

Dedication

This dissertation is dedicated to my son, Zane. May you utilize your time travel and future planning abilities to achieve all of your goals, too.

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My son, Zane, has been patient during my journey through college. It is now my turn to support him, as he enters his teenage years and begins his own preparation for college.

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CHAPTER 1: INTRODUCTION

Overview

Mental time travel refers to the ability to conceptualize the passage of time and includes the capacity to project oneself into the past and future. Suddendorf and Corballis (2007) contend that the capacity to escape the present moment (i.e., by thinking about the past and using that information to predict the future) is a tool that has played an important role in human evolution. This ability appears to be uniquely human, and allows people to think in more cognitively advanced ways than other species (Suddendorf & Corballis, 2007). The capacity for mental time travel appears to emerge during the preschool years (Atance & O'Neill, 2005) and undergoes subsequent refinement in middle childhood (Boucher, Pons, Lind, & Williams, 2007). Suddendorf and Corballis (2007) view mental time travel as intimately linked to the episodic memory system, which allows one to recall personally experienced events.

Much of the current literature on the construction of time concepts in school age children has focused on children's ability to remember past experiences or experimentally presented information within two broad areas of mental time travel: (1) *diachronic concepts* of transformation (imagining how objects change over time), tendency (imagining prior events leading up to a depicted moment in time or to subsequent events), and synthesis (imagining how a series of discrete actions make up an event) (Montangero, 1996); and (2) *temporal cognition* (monitoring how children keep track of time) (Friedman, 2000).

Researchers have developed numerous tasks to assess these aspects of diachronic thinking and temporal cognition (Montangero & Pons, 1985; Friedman, 2000). One goal

of the current study was to explore the various tasks used to measure these constructs and determine whether there are meaningful differences in the abilities underlying children's performance on the different tasks. In other words, we will ask what are the principal components of variation underlying performance on extant measures of mental time travel in childhood? In addition, we will investigate the relationship between age and intelligence and children's performance on these tasks.

Researchers who have studied diachronic thinking (i.e., Montangero, Pons and colleagues, 1985; 1992; 1995; 1996; 1999; 2000; 2002) have used a Piagetian framework, which views the child as developing abilities by observing others, i.e., acting as a genetic epistemologist analyzing the world. In contrast, researchers who study temporal cognition (i.e., Friedman, 2000) view the child as developing abilities through participating in and experiencing life. Friedman contends that there are multiple representations and processes involved in humans' memory of the past and ability to think about the future, and he questions the "extent common processes underlie episodic memory and future-directed thinking in general" (Friedman, 2007, p. 323). In contrast, Suddendorf and Corballis (2007) and Tulving (1985a; 1985b; 2002) view diachronic thinking and/or temporal cognition as heavily reliant on the episodic memory system. To better understand these conceptual differences and their utility, the current study explores the relationship among measures of diachronic thinking, temporal cognition, and episodic memory in children of ages 5 to 10 years. Most of the tasks used in this study were drawn from published research (i.e., Boucher et al., 2007; Friedman, 2000; Cycowicz, Friedman, Snodgrass, & Duff, 2001), and have been validated previously. In general, tasks drawn from Boucher and colleagues (2007) explore developments in diachronic thinking while

Friedman (2000) tasks explore developments in temporal cognition. In addition, we draw upon Cycowicz and colleagues' work (2001), which utilizes a memory task sensitive to developmental changes in episodic memory in middle childhood. In this study we evaluate the extent to which all of these measures are inter-correlated and also related to measures of both nonverbal and verbal intelligence in a sample of children.

Mental Time Travel

There are numerous studies of children's future thinking focused on preschool-age children's abilities to plan ahead. This research suggests that children's ability to think about the future emerges between the ages of 3 and 5 (Atance & O'Neill, 2005b; Suddendorf & Busby, 2005), and increases gradually with age (e.g., Atance & Meltzoff, 2005; 2006; Atance & O'Neill, 2001; 2005a; 2005b; Carlson, Moses, & Claxton, 2004; Fabricius, 1988; Hudson and Fivush, 1991; Hudson, Shapiro, and Sosa, 1995; Moore, Barresi, & Thompson, 1998; Suddendorf & Busby, 2005; Thompson, Baressi, & Moore, 1996). Research also suggests that diachronic thinking undergoes subsequent refinement in middle childhood (Boucher et al., 2007).

Montangero and Pons's Studies on Diachronic Thinking

Montangero, Pons, and colleagues (1985; 1992; 1995; 1996; 1999; 2000; 2002) use a Piagetian framework (i.e., the child as an observer or genetic epistemologist analyzing the world) to understand the development of time concepts. In Piaget's (1966; 1974) constructivist approach, the processes of developmental change are assumed to be universal, with each stage of development leading to the next as children modify previously constructed schemas when presented with new information. Therefore, as a child acts on the world and searches to understand new experiences, the child begins to

create a more inclusive, complex form of knowledge, which brings the child to new stages of development. Additionally, the development of diachronic thinking appears to be a naturally occurring phenomenon that is expected to advance with age. In theory, older children should perform better than younger children on tasks of diachronic thinking.

Montangero (1985) contends that understanding time concepts involves making several judgments and coordinating different modes of judgments (i.e., children observe and analyze). Children use patterns of judgments and transfer them from one situation to another, but they always use modifications of previous patterns to make new judgments when presented with new information. Montangero suggested that at each level of development, several types of duration judgments coexist, but if the number of cues provided is too high, children become confused. As children grow older, the meanings involved in time judgments evolve. According to Montangero "As far as process of progress is concerned, the alterations we sometimes observed (in the centration of dimensions or couples of dimensions) as well as the shift in the predominance of subsystems are compatible with Piaget's concept of equilibration." (p. 94) Disequilibration, according to Piaget (1977), is a state in which children encounter an experience that is unknown, and equilibration occurs when children begin to create a balance between the unknown and what they do know. In other words, they create a new understanding of the environment through assimilation (i.e., taking in new information into previously existing schemas) and accommodation (i.e., altering existing schemas when presented new information).

There are three distinct components of diachronic thinking: *Tendency*, *Transformation*, and *Synthesis* (Montangero et al., 1996). Research suggests that performance on tasks within each of these components is inter-correlated but not strongly related to level of nonverbal intelligence (Pons & Montangero, 1999). The first component of diachronic thinking, Tendency, refers to the ability to think 'backwards' and 'forwards' across time. Research reveals that Tendency develops slowly but steadily between the ages of 7 and 12; thus, younger children describe objects or situations only as they exist in the present moment while older children make reference to past or future states of objects and situations (Montangero & Parrat-Dayan, 1992; Montangero & Pons, 1995; Montangero, Pons, & Cattin, 2000; Pons, Montangero, Quadir, & Bazan, 2002).

The second component of diachronic thinking is Transformation, which refers to the understanding that certain entities change qualitatively over the course of time, yet maintain their identity. Research suggests that until children are about 9 years old they only conceive changes quantitatively, but by ages 11 or 12, they understand that many entities change qualitatively over time (Maurice-Naville & Montangero 1992; Tryphon & Montangero, 1992; Montangero, Pons, & Scheidegger, 1996; Pons & Montangero, 1999).

The third component of diachronic thinking is Synthesis, which refers to the ability "to conceive of temporal succession of states or events as compressed into a unitary whole temporally spanning the subordinate events" (Boucher et al., 2007, p. 1414). Like Tendency, Synthesis is rarely seen in 7 year olds but is observed in most 12 year olds (Montangero & Parrat-Dayan, 1992; Pons & Montangero, 1999; Montangero et al., 2000).

Temporal Cognition

Friedman's Research on Temporal Cognition

Friedman (1993) contends that the ability to think temporally relies on repeatedly experienced events. He writes that multiple representations of previously experienced events are used when thinking about the past and predicting the future (Friedman, 2007), and he suggests that there are three main types of information that adults use to remember past events: distances, locations, and order (Friedman, 1993). Adults use distances to estimate how much time has passed from the date of an event to the present. Locations in natural, personal, or conventional time patterns, such as time of day or season of the year in which an event occurred help pinpoint events in time. Finally, adults use order to remember whether a certain event came before or after another event. According to Friedman (2005, p. 153) "Adults' sense of the future is not integral, but the product of multiple representations. We use different representations to think about future times on different scales, employing one kind of representation to consider the events that will take place later today, others to think about times later in the week, and so forth."

Friedman outlined three categories of codes that are used to keep track of time. First, one may represent events either semantically or in image-based ways. For example, a person may remember that something happened on a specific day of the week or during a specific month (i.e. semantically) or that something happened during the summer because it was hot outside (i.e. image-based). Second, one may use order codes to remember events (e.g. Thanksgiving comes after Halloween). Third, one may use representational systems to organize time. According to Friedman (2005, p. 152), "representations allow us to think about 'where' in the future various anticipated events

will occur. Because representations of long-scale time patterns emerge during middle childhood, we might expect that younger children lack a differentiated sense of the future beyond the present day." By age 10, however, children can judge distances of events up to one year in the future by using representations of the annual cycle (Friedman, 2000).

Friedman (1977; 1986; 1989; 1990; 1993; 2000; 2002; 2003; 2004; 2005) and colleagues (Friedman, Gardner, Zubin, 1995; Friedman & Kemp, 1998; Friedman & Lyon, 2005) have conducted many studies to determine how children construct time concepts during the period of middle childhood. Friedman's (1977; 1989) research indicates that between ages 6 and 8, the ability to order the days of the week, seasons, and months of the year is consolidated in American children. Additionally, by age 10, children can mentally move forward through these elements from different points of the cycles. Other research (Friedman, Gardner, & Zubin, 1995; Friedman & Kemp, 1998), however, suggests that children as young as 4 years possess some type of representation of the future and show a sense of knowing that some events are coming soon, especially if the events are to occur within the next two months.

In one study, Friedman (2000) asked children ages 4, 7, and 10 to view pictures of common holidays (e.g., Valentine's Day, Thanksgiving, Christmas), and to make judgments about their temporal order. Results indicated that the 4-year-olds were very limited in their ability to distinguish future distances; they did not make longer estimates for items that would happen a long time from now as compared to events that were happening very soon (Friedman, 2000). By contrast, for the 7 and 10 year olds, representational judgments for events differed according to their actual distances. In a second study, the researchers replicated the findings in children ages 4, 5, 6, and 7.

Results indicated that even 5-year-old children could represent events spatially in a consistent and correct manner (Friedman, 2000).

Friedman (2000) also asked third- and fifth-graders to perform four other temporal order tasks for months and holidays. Results of the studies did not find a statistically significant difference between groups. The authors suggested that errors made by the children may be due to the fact that children's knowledge of events is socially constructed and representations of conventional time patterns are taught to children, primarily in school, and take years to acquire (Friedman, 2000).

Fivush and Mandler's Temporal Cognition Task

In a series of experiments investigating temporal cognition in young children, Fivush and Mandler (1985) asked 4, 5, and 6-year-olds to sequence pictures of events in forward or backward order, and they found several developmental trends. First, older children performed better than younger children. Second, all children performed better when the event pictures were presented in backward order and then arranged by them in forward order; notably, the children performed better on this task if the event was a familiar one. Third, the children had difficulty sequencing unfamiliar events in both forward and backward order. Fourth, children were not able to put familiar or unfamiliar events in backward order if the pictures had been presented in forward order. They suggested that, "children must be able to understand the organization of the presented sequence in order to be able to use that organization to guide the subsequent sequencing tasks" (Fivush & Mandler, 1985, p. 1444). This ability to order events in forward or backward order is another aspect of temporal cognition that develops in middle childhood.

Episodic Memory

Tulving's Framework

Mental time travel has been viewed as a manifestation of the episodic memory system (i.e., memory of personally experienced events) (Tulving, 1985b; Suddendorf & Corballis, 2007). Tulving (1985a) has argued that there is a close relationship between episodic memory and episodic future thinking (i.e., the ability to think about personally experiencing events in the future.) Tulving (1985a; 2002) presented the case of K.C., who sustained head trauma, exhibited memory loss, but retained language function (i.e., semantic memory), intelligence, and attention. K.C. was unable to recollect episodic events from his personal past, but he could recite recently presented information, suggesting that his short-term memory was generally intact. Tulving (1985a) also found that K.C. was unable to think about his personal episodic future, which suggested that there is a close relation between episodic memory and episodic future thinking. Other studies have similarly reported that patients with traumatic brain injury who exhibit episodic memory loss are also unable to imagine personal future events (Hassabis, Kumaran, Vaan, & Maguire, 2007; Klein, Loftus, & Kihlstrom, 2002).

Nonetheless, there appear to be differences in the mental processes involved in episodic memory and future thinking. Studies with adult participants suggest that remembering personal events from the past is less cognitively demanding than imagining personal events in the future. A brain imaging study using fMRI revealed increased neural activity in the left hippocampus, posterior visuospatial regions, right frontopolar cortex, right hippocampus and left ventrolateral prefrontal cortex while participants imagined future personal events than while they remembered past personal events, which

showed brain activity in the left hippocampus and posterior visuospatial regions only (Addis, Wong, & Schacter, 2007). Another study found that imagined future events contained fewer sensory details and referred less frequently to specific episodes than did most memories of past events (Addis, Wong, & Schacter, 2008).

Cycowicz and Colleagues' Episodic Memory Task

Cycowicz and colleagues (2001) created a task that is sensitive to developmental changes in episodic memory in middle childhood. Participants, ages 7 and 8, viewed a set of pictures (Snodgrass & Vanderwart, 1980) presented individually, with each picture outlined in either red or green. To ensure that participants paid attention to each picture, the researchers asked them to categorize each one as being either an animate or an inanimate object before viewing the next picture. After viewing the initial set of pictures, participants then viewed another set of pictures outlined in black, and they were asked to judge whether or not each picture was previously presented. If the participant said the picture was previously presented, the researcher asked whether or not the picture was previously outlined in red or green. They found that episodic memory ability improved dramatically with age. Children had more difficulty than adults remembering whether or not the pictures were presented initially in red or green than remembering whether or not they previously had seen pictures.

The Role of Language Acquisition in Temporal Understanding

Nelson's Vision.

Nelson (2007a) agrees with Suddendorf and Corballis' (2007) view that the evolution and development of memory are important for survival. However, she argues that an important limitation to their view is the neglect of culture in mind. She urges

researchers to explore the ways in which developments in language, conversational exchanges about the past and future, and cultural practices influence children's time travel abilities. According to Nelson and Fivush (2004), social experiences mediate the mind. Nelson (1996; 2007b) has detailed the interaction between the acquisition of language and the emergence and development of autobiographical memory. In order to share personal memories with others, children must be able to use language to convey their thoughts (Nelson, 1996). As children learn language and participate in daily events, adults ask them questions about their experiences, and children learn how to answer these questions. Through acquiring the ability to verbally share their experiences with others and through repeatedly sharing information about experienced events with others, children begin to realize that events have a beginning, middle, and end. They learn to represent events in temporal order and to understand temporal relationships of familiar events (McCormack & Horel, 1999; Nelson, 1996; 2007b). Through repeatedly experienced activities with their caregivers and verbally sharing experiences with others, children remember more and more about the activities, developing both an autobiographical memory and an understanding of temporal relationships.

Summary

The ability to mentally travel through time, plan ahead, and anticipate the future has facilitated human survival (Suddendorf & Corballis, 2007). Humans can, to a certain extent, use these abilities to manipulate and control their environment in ways that non-humans cannot. Researchers have recently begun to explore the components of these abilities, and how they develop in childhood. Previous research has outlined two types of mental time travel. In the first, diachronic thinking, developments are thought to be

dependent upon children's observing and analyzing the world around them. In the second, temporal cognition, developments are thought to be dependent upon children's participating in and experiencing daily events. No previous study has investigated both the domains of temporal cognition and diachronic thinking in the same group of children. Consequently, important questions remained unanswered. This dissertation explores the extent to which developmental increases in diachronic thinking and temporal cognition are interrelated, and how they are linked to developments in episodic memory in middle childhood. We further evaluate the extent to which performance on these various measures of diachronic thinking, temporal cognition, and episodic memory are related to developmental increases in nonverbal and verbal intelligence. To evaluate factors underlying diachronic thinking, temporal cognition, and episodic memory, we conducted a principal-components analysis. The results will be discussed in the context of different theories of how mental time travel, episodic memory, and language development are inter-related.

CHAPTER 2: EXPERIMENTAL METHODS

Participants

Participants were 90 children between the ages of 5 and 10. They were divided into two age groups. The younger, 5, 6, and 7 year old group, consisted of 44 children, 21 girls and 23 boys (*M* age = 6;7, *SD* = 0.93), and the older, 8, 9, and 10 year old group, consisted of 46 children, 25 girls and 21 boys (*M* = 9;5, *SD* = 0.85). Almost half the children in each group were recruited from a small, rural town in southwest Arkansas, and the remainder was recruited from the New York City area. Each child displayed normal verbal and nonverbal intelligence (see Table 1). In addition, each child received a $20 gift card for his or her participation.

Procedure

Participation took place in the children's homes or in classrooms at Brooklyn College and required two visits. Each visit lasted approximately one hour. At each child's first visit, the parent received an informed consent form, and any questions he or she had were answered. The parent read and signed the form and received a copy to keep. The child was then asked for verbal assent.

Tests and Measures

Testing occurred over two days, and the children underwent 24 tests and measures. These are outlined in the following paragraphs. The first 10 were presented on day one, and the remaining 14 were presented on day two. The Boucher et al. (2007) tasks and Friedman (2000) tasks were replications of the tasks presented in these publications (i.e. the experimental and control tasks were the same and were designated as experimental/control tasks by the authors of the original research).

Day 1

Standardized Clinical Tests

The Peabody Picture Vocabulary Test – Fourth Edition (PPVT-4)

The Peabody Picture Vocabulary Test – Fourth Edition (PPVT-4), Form B (Dunn & Dunn, 2007) was administered on the first day of testing. The PPVT-4 measures vocabulary skills and is used to estimate verbal intellectual ability (Dunn & Dunn, 2007). During the 15 minutes it takes to administer this test, the researcher showed the child sets of four pictures at a time and said a stimulus word. The child then pointed to the picture that best fit the word. For example, if the child saw a page with pictures of a fish, candy, baby, and a car, the researcher asked, "Can you show me the fish?" After the child pointed to a picture on the page, the researcher then proceeded to the next set of items.

TONI-3 Test of Nonverbal Intelligence

The second test administered on the first testing day was the Test of Nonverbal Intelligence (TONI-3), Version 3 (Brown, Sherbenou, Johnsen, 1997). This is a language-free assessment of nonverbal intelligence and reasoning abilities. It focuses on two major components of intelligence: abstract reasoning and problem solving, and takes about 15 minutes to complete. There are 45 items arranged in order of difficulty in a picture book. Participants viewed a series/pattern of shapes, with one empty space located in the series. They then viewed a series of four possible shapes or patterns and were asked to point to the one that best completed the series/pattern.

Experimental Tests

Measures of Diachronic Thinking and Control Tasks

These tasks and order of tasks are a replication of Phase 2 of Boucher et. al's (2007) research on diachronic thinking.

Diachronic Tendency, Task 1. This task was used to test children's ability to draw non-temporal references. Participants viewed a scene (see Figure 1) and were asked to explain what was going on in the picture. The researcher wrote down everything the child said until the child had mentioned 10 things.

Responses were scored as 0, 1, or 2. Those that included no mention of past or future events received a 0. Responses that included a single past or future event received a score of 1, and those that included two or more past or future events received a score of 2. The total possible points awarded was 20; scores were converted to percent correct for statistical analyses.

Figure 1 Man at the beach (Boucher et al., 2007, p. 1417) Used with Permission.

Diachronic Tendency, Task 2. Participants were asked the following questions from the Boucher et al. (2007, p. 1420-1421) study:

1) "Is it summer or winter in this picture?" If the child responded correctly, the child was asked, "Why do you think it's summer? – What can you see in the picture that shows it's summer, not winter?" If the response was inappropriate, the researcher would ask "Is that the best reason for saying it's summer? Can you think of anything else?"

   This order of the wording of the questions was counter-balanced across participants. Half the participants were asked if it was summer or winter in the picture, and the other half were asked if it was winter or summer.

2) "Do you think this person" (pointing to the surfer) "is a little boy/girl, much younger than you? Or do you think it's a grown-up person/adult, perhaps a mom or a dad?" If the participant responded correctly, he or she was asked "Why do you think it's an adult?" If the response was inappropriate, the researcher would ask, "Is there any other reason why this is probably a grown up person, not a little boy/girl?"

3) "Why do you think the man's lying on a rug/towel?" (pointing at the sunbather). If the response was inappropriate, the researcher would ask, "Is that the best reason you can think of? Can you tell me something else about why he's lying on a rug/towel?"

4) "Why did the man bring an umbrella, I wonder? Can you tell me why he brought an umbrella and set it up?" If the child answered inappropriately, the researcher

would ask, “Is that the best reason you can think of? Can you tell me another reason why he put the umbrella up?”

Responses were scored from 0 to 10. For the first two items, the response received a score of 0 (for incorrect responses) or 1 (for correct/accurate responses). For all four items, the responses received an additional score of 0-2. In order to receive a 0, the child provided no justification for the answer. To receive a 1, the child provided intermediate justification for the answer, and to receive a 2, the child provided good justification for his or her answer. For example, when asked why the man is lying on the towel, if the child responded, “Because he’s lying on it,” the response would earn 0 points. If the child responded, “It’s soft,” the child would earn 1 point, and if the child responded, “So sand doesn’t get on his back,” the child would earn 2 points (Boucher et al., 2007, p. 1421). The scores for each question were totaled for the complete 0-10 score, and the total score was converted to percent correct for statistical analyses.

Diachronic Tendency, Task 3. The picture in Figure 1 was used along with a blank sheet of 8.5 x 11 paper. The researcher placed the blank paper to the right or left of the picture and asked, “Suppose we had another piece of paper over here, what could we draw? – Something different to what’s there” (indicating the main picture), “Things further along the beach?” or “What might there be over here? – What might you see?” (Boucher, 2007, p. 1421). After the child answered the questions, the researcher placed the blank paper to the other side of the picture and repeated the above questions.

Responses were scored from 0 to 4 for the number of novel responses generated. Children who provided more than four novel responses received a maximum score of 4. Scores were then converted to percent correct.

Diachronic Tendency, Task 4. The picture in Figure 1 was used again, and six line drawings printed individually on 4x5 cardstock paper were shown to the children (see Figure 2). These line drawings portrayed the person from Figure 1 engaged in activities earlier in the day and then later in the day. The back of each picture was marked, in order from first to last, T, E, N, D, C, or Y.

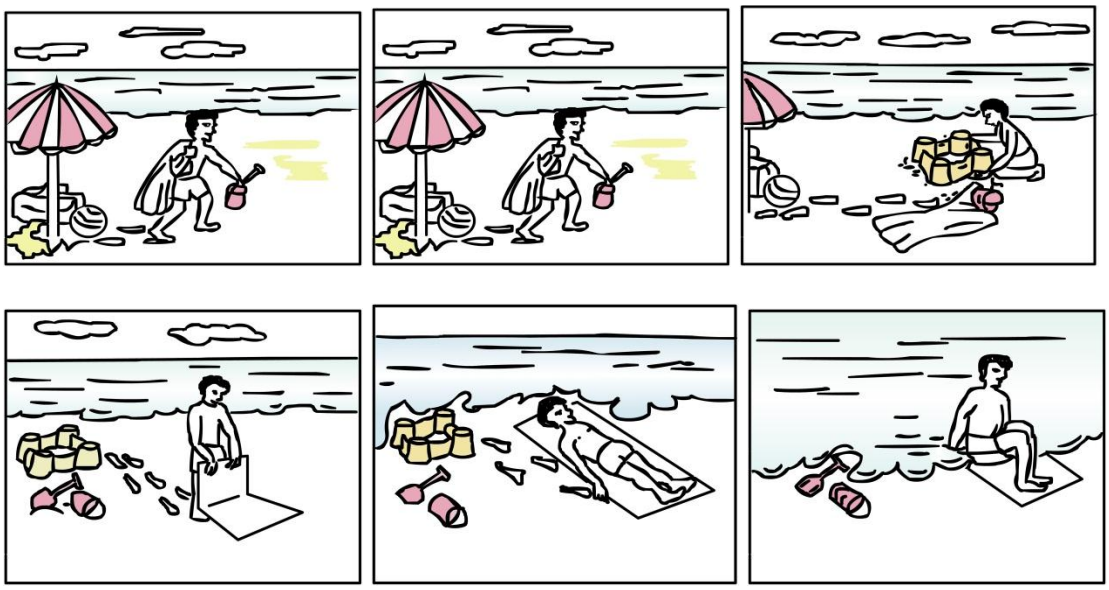

Figure 2. Man at the beach's past and future activities (Boucher et al., 2007, p. 1422)

Participants were asked the following questions:

> "Do you remember the picture we looked at before, showing a man on the beach?" (children will view the picture again). "These little pictures make a story about the man's day on the beach. The story starts here." (researcher points to an area to the left of the table) "and ends here" (researcher points to an area to the right of the child). "Let's make the story. I'll start off. What happened next? Which picture goes here?" (Boucher, 2007, p. 1421)

The children took the remaining pictures and placed them in temporal order. When they finished the task, the researcher asked the children if they wished to make any changes or if they wanted to keep the pictures in the arranged order.

When placed in the correct order, the letters on the back of the cards were T E N D C Y. For each sequence the child got correct, the child received a score of 1, and the maximum score was 5. For example, if a child chose the order T E D N C Y, the child received 1 point for putting T and E in the right order, 0 points for putting the E and D in the wrong order, 0 points for putting the D and N in the wrong order, 0 points for putting the N and C in the wrong order, and 1 point for putting the C and Y in the correct order. The total score for that example would be 2 out of 5. Scores were converted to percent correct.

Diachronic Transformation Task 1. Participants were asked to draw a picture of a tree. After competing the drawing, the researcher praised the children for the drawing and asked whether or not they knew about the "whole life of a tree." The researcher then placed two additional sheets of paper to the left and the right of the first sheet and said:

> "I want you to draw some more pictures to show me the *whole life of the tree*, how it looked *before* this and how it will look *after* this. I'll write 'Before' over here, and 'After' over here. You can draw as many pictures as you like. Remember to draw the *whole life* of the tree." (Boucher et al., 2007, p. 1416-1417).

The researcher provided non-specific prompts if a child appeared to be struggling with his or her drawing. For example, "Now show me how it looked after this?" or "Remember, I want you to draw the *whole life* of the tree." Testing was terminated when

a child drew at least one before and after picture that differed qualitatively from the child's original picture. In the Boucher et al. (2007) study, the researchers also terminated the task if a child did not draw two qualitatively different pictures. For the current study, if a child failed to draw a picture, the researcher asked, "Do you not know how to draw what you are thinking about?" If this was the case, the researcher asked the child to explain what he or she would like to draw. The child's words were written verbatim on the paper. Also, if a child made any comments while drawing, the researcher noted the comments. For example, one child drew a picture and stated: "This is supposed to be a dead tree, but it doesn't really look like one." The researcher noted the child's comment.

The sets of trees were scored from 0 to 2. Drawings that differed only in size with no indication of a qualitative change received a 0. Drawings that differed in size but also depicted some qualitative change received a 1. Drawings that included two or more trees showing qualitative changes received a score of 2. In instances where a child described what was supposed to be there but the drawing did not look like that type of tree (i.e. a child was physically unable to draw a tree and, consequently scribbled on the paper), the child received a score that reflected what he or she said the drawing was. For example, one child scribbled on the paper, and when asked to share details about the picture, he said that it was a "little baby apple tree." In his next picture, he also scribbled and said that it was "a big apple tree with apples on it." The size of the trees did not differ on paper, but the child demonstrated verbally that he knew that they were qualitatively different; therefore, he received a score of 2. Total scores were converted to percent correct.

Diachronic Transformation, Task 2. After the child drew the whole life of the tree, the researcher showed the child the first drawn tree and asked: "This is what lots of trees look like, isn't it? But some trees look quite different. Can you draw a *different sort* of tree? – A tree that looks quite different from this one?" (Boucher et al., 2007). If the child produced a qualitatively different looking tree, the researcher praised the child and asked him or her to produce another tree that was different from both trees. If the child did not produce an acceptable response or only one response, he or she was then asked: "What about a tree that grows where it's very very hot – in a desert?" (Boucher et al., 2007). If the child was unable to draw a tree after this prompt, the researcher provided a full instruction "Can you draw a palm tree?" (Boucher et al., 2007). If the child continued to not be able to produce two qualitatively different trees, the researcher asked: "What about a tree that grows where it's very cold and snowy?" If that prompt still did not help the child, the researcher instructed the child to "Draw a Christmas tree/a fir tree" (Boucher et al., 2007). Children who failed to produce any acceptable responses received help from the researcher to draw a Christmas tree (unscored) to end the task on a positive note.

Scores were categorized as spontaneous, prompted, or instructed and further scored between 0 and 2. For each category, a score of 0 indicated that the child drew a picture of a tree that was either the same as in the main task or contained only quantitative differences. A score of 1 indicated that the child drew a tree that was different from the one in the main task with primarily quantitative differences, and a score of 2 indicated that the child drew a clearly, qualitatively, different tree as compared to the tree in the main drawing of a tree. Total scores were converted to percent correct.

Diachronic Transformation, Task 3. A picture of a mature tree was placed in front of the child (see the third drawing in Figure 3; this picture has an X on the back), and the researcher then showed the child a set of four pictures of different stages of a tree's life (Boucher et al., 2007). The child was asked to place the four additional pictures to the right or left of the first picture, creating the correct sequence of stages in a tree's life. The drawings of trees used in the current study were drawn by the principal investigator, as Boucher et al. (2007) did not provide their stimuli. The back of each card was marked, T, R, X, E, S according to its proper order.

When placed in the correct order, the letters on the back of the cards were T R X E S. For each sequence the child got correct, the child received a score of 1, and the maximum score was 4. For example, if a child chose the order T X E S R, the child received 0 points for putting T and X in the wrong order, 1 point for putting the X and E in the correct order, 1 point for putting the E and S in the correct order, 0 points for putting the S and R in the wrong order. The total score for that example would be 2 out of 4. Scores were converted to percent correct.

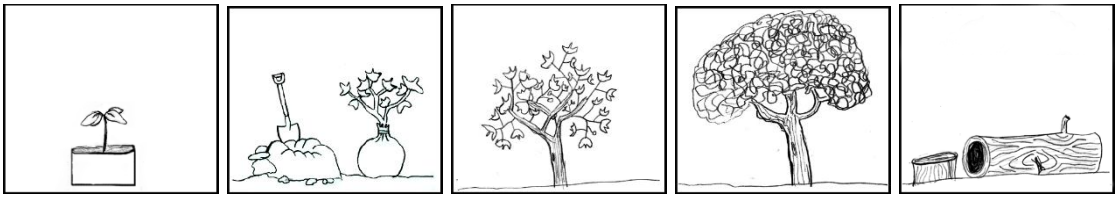

Figure 3
The whole life of a tree

Diachronic Synthesis. The children viewed six 4x5 inch pictures (see Figure 4), which depicted the activities of a man spending a whole day on the beach, and the researcher said "These cards tell a story." Next, the researcher placed the cards in front of the child in temporal order in a single line from left to right. Subsequently, the researcher

pointed to the sun in the sky in the first picture to draw the child's attention to the pictures and said:

1. "Look, it's morning, the sun is just rising. He's off to the beach."
2. "It's later in the morning, and the sun is higher. He's building sandcastles."
3. "It's the middle of the day and the sun is high in the sky. He's having a rest."
4. "It's the afternoon, and the sun has gone down a bit. He's playing with his football."
5. "It's the end of the day and the sun is going down. Time to go home."
6. "Now it's night, and he's asleep in bed" (Boucher et al., 2007, p. 1417-1418).

Finally, the researcher gathered the cards and asked, "What do all the pictures together show? Can you think of something we could write on the envelope to describe what all the pictures together show?" (Boucher et al., 2007, p. 1418).

The child's response was written on the score sheet. If the child's response clearly reflected a capacity for synthesis, the test was terminated. If the child either failed to respond or produced a response that did not clearly indicate a capacity for synthesis, the researcher prompted the child as follows: "Suppose this story" (gathering the pictures and holding them like a hand of cards to remind the child of the general content) "was in a book, what could we call the book? - What name could we give it?"

Task results were scored from 0 to 2. Responses that included a picture-by-picture description of some or all of the events received a 0. Responses that included a partial attempt at synthesis received a score of 1. Two examples of responses that included a partial attempt at synthesis are: "He went to the beach and he built sandcastles and played with his football – he had a nice day" and "The sunny beach." Responses that

included a complete and accurate synthetic description of the pictures received a score of 2. An example of a complete and accurate synthetic description is: “A day at the beach.” All scores were converted to percent correct.

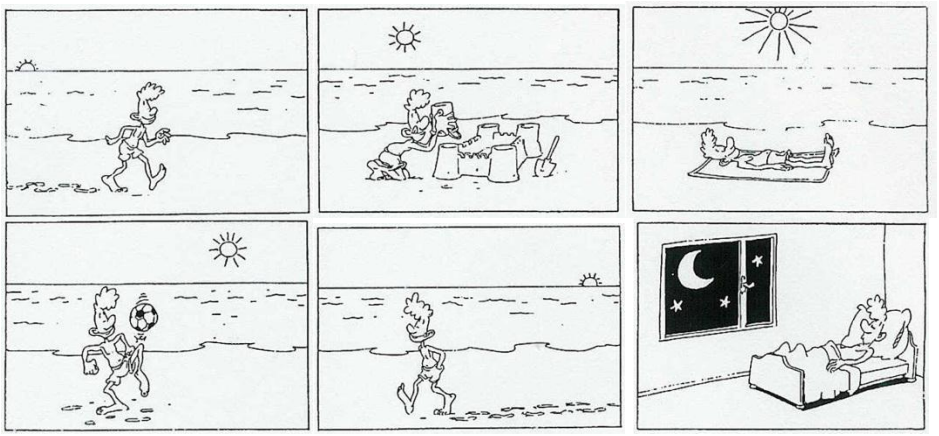

Figure 4
Synthesis (Boucher et al., 2007, p. 1418) Used With Permission.

Day 2

Measures of Temporal Cognition

Naming Future Events (control task). Children were presented with the following questions:

> “Tell me some things that will happen soon. What else will happen soon? Now tell me some things that won’t happen for a long time. What else? Is your birthday coming soon? How long is it until your birthday?” If a child responded with “I don’t know,” he or she was asked “Is it a long time, a short time, or an in-between amount of time?” (Friedman, 2000, p. 916).

The purpose of this task was to get children to think about time, and responses were not scored or analyzed.

Picture-pointing task (control task). After answering the questions, the researcher showed the children the picture in Figure 5 (see below). The children were told the

following as first described by Friedman (2000). Please note that the portion of text in italics was altered by the principal investigator.

> "We are going to play a game with this picture. We'll use it to show how far things are in the future. So pretend we're standing here (pointing to the closest part of the road). Things that are near us (pointing to a spot half an inch ahead) will happen very soon. Things that are here (pointing to the farthest visible part of the road) will happen a very, very long time from now. Let's try it out. Here are two pictures (see Figure 6 for male participants and Figure 7 for female participants). *Let's pretend this little boy/girl walks in the room right now, where would we put this picture of the little boy/girl who just walked in the door? We would put it here (pointing with an unsharpened pencil to the nearest part of the road), because that will happen very soon. This other picture is when the boy/girl is all grown up. Where should we put it? We would put it here (pointing to the farthest part o the road), because that's a very, very long time from now."* (Friedman, 2000, p. 916).

Friedman used drawings of a child leaving a room and then an adult; however, he did not make these available. For the current research, the principal investigator created stimuli depicting a little boy, little girl, old man, and old woman.

Figure 5
Representation of future distances used in the picture pointing task

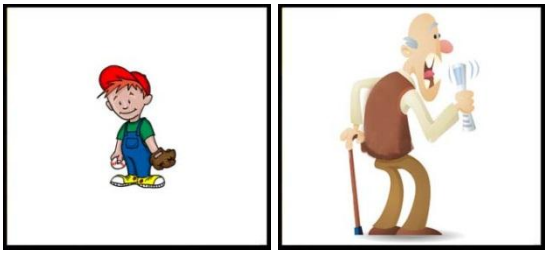

Figure 6
A boy: Now and A Very Long Time from Now

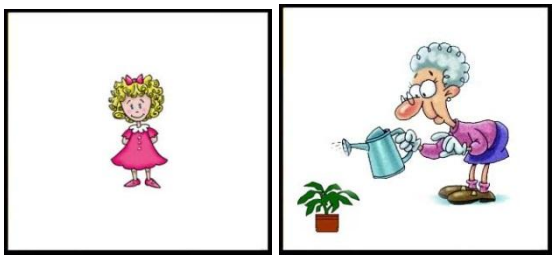

Figure 7
A girl: Now and A Very Long Time from Now

The purpose of this control task was to help participants understand the test phase of the picture-pointing task. As soon as a child understood how to use the road to represent time, he or she was administered the test phase.

Picture- pointing task (test). Participants viewed seven stimulus cards (dinner time, summer, Christmas, sitting in a Classroom, Thanksgiving, Halloween, and Valentine's Day) in random order (see Figure 8), and the researcher told the participants which holiday was depicted in each picture. These stimulus cards were created by the principal investigator as Friedman (2005) did not provide his stimuli.

The researcher shuffled the cards and asked the child to identify them. All children successfully identified the events depicted in the pictures without prompts from the researcher. When the child demonstrated knowledge of what holiday each card depicted, the researcher said:

> "Now I want you to show me where you think they go. If something is going to happen very soon, then point (with an unsharpened pencil) to here (indicating the fence posts closest to the person in the picture). If something will happen in a very, very long time from now, point here (indicating the last posts). Point here (the middle posts) if it will happen an in-between amount of time from now." The children were given one card at a time (Friedman, 2000, p. 916).

The researcher wrote down the number of the fence post beside where the child pointed to place each holiday. Also, testing dates were noted. For each holiday, the child received a score of 0-1. The score reflected whether or not the child accurately chose whether the holiday was going to happen very soon, a very long time from now, or an in-between amount of time. Additionally, the child received a score of 0-1 that reflected whether he or she accurately placed the picture on the drawing of the road. Two composite scores, with a maximum of 7 points each, were created, and each was converted to percentage correct.

Figure 8
Picture-pointing stimulus cards

Holiday-order task. The children viewed the cards representing Halloween, Valentine's Day, Thanksgiving, summer, and Christmas in a circular arrangement (Friedman, 2000, p. 927-928). They were asked if they could put them in temporal order.

The correct order of the holidays varied depending on the test date, because the children put the cards in order beginning with the next occurring holiday from the test date. For scoring purposes, the researcher noted the correct order of the holidays. For each sequence the child got correct, he or she received a score of 1, and the maximum score was 4. For example, if the child was tested in January, the correct order of holidays was Valentine's Day, Summer, Halloween, Thanksgiving, and Christmas. If the child chose the order Valentine's Day, Summer, Thanksgiving, Halloween, and Christmas, he or she received 1 point for putting Valentine's Day and Summer in the correct order, 0 points for putting Summer and Thanksgiving in the incorrect order, 0 points for putting Thanksgiving and Halloween in the incorrect order, and 0 points for putting Halloween and Christmas in the incorrect order. The total score for that example would be 1 out of a possible 4 points. Scores were converted to percent correct.

Holiday-relative-order task. Five problems were presented in 24 random orderings. For each problem there was a reference event and two choices: Valentine's Day: summer or Christmas; summer: Halloween or Valentine's Day; Halloween: Christmas or summer; Thanksgiving: Christmas or summer; and Christmas: Valentine's Day or summer. Participants were told: "If you go through the year, tell me the holiday that will come next after these." For each of the five problems, the card representing the starting event (see Figure 8) was placed slightly to the left of the child and the two choice events just to its right, one above the other (randomly varied). The child was told, "Let's pretend it's ___ (starting event; the tester will point to this event). Which of these two do we come to first? Which is closer to _____ (starting event) if we go forward in time (pointing to the two choices)?" (Friedman, 2000, p. 928).

Responses were scored as either correct or incorrect. Correct responses received a score of 1 and incorrect responses received a score of 0. Correct responses were tallied, and a composite percent correct score was calculated.

Months of the holidays task (i.e., labeling time concepts task). The purpose of this task was to determine whether or not children have the language ability to label time concepts; specifically, whether they know when important events occur throughout the year. Participants again viewed the stimulus cards presented in Figure 9 (without the dinner and classroom cards). The children were asked "What month is ____?" for each of the four holidays and "What months are in summer?" (Friedman, 2000, p. 928). These questions were presented in one of 24 random orderings.

Responses to the five questions were scored as either correct or incorrect. Correct responses received a score of 1 and incorrect responses received a score of 0. Correct responses were tallied, and a composite percent correct score was calculated.

Month-relative-order task. This task replicated Friedman's (2000) study. Eight months, two randomly selected from each quarter of the calendar year, were used as reference points. The children were then asked whether a month that occurs 4 months later or a month that occurs 8 months later comes next in the year. The eight problems were presented in 1 of 24 random orders, and the order of mention of the two choices was randomly varied. Before the first problem, children were told, "If you go through the year, tell me the month that will come next." Individual questions were of the form, "Does February or June come next after October?" (Friedman, 2000, p. 928).

Participant responses were scored as correct or incorrect. Correct responses received a score of 1 and incorrect responses received a score of 0. Correct responses were tallied, and a composite percent correct score was calculated.

Daily script forward order task, part 1. This task is similar to the task used by Fivush and Mandler (1985). Four 4x6 inch color photographs of a child making his breakfast were used (see Figure 9). The events depicted in the pictures were: 1) getting out supplies, 2) pouring cereal, 3) pouring milk, and 4) eating cereal. Because people vary in the order in which they pour milk and cereal when making breakfast, the researcher told a story about the way a particular child pours his cereal: "This story is about a boy named Zane who makes his own breakfast in the mornings. He doesn't like when his mom makes cereal for him, because she can never give him enough milk. Now his mom says that he has to make his own cereal. First he gets out all of his supplies.

Then he pours his cereal. Next, he pours milk until it completely covers his cereal. Finally, he eats breakfast." The researcher then shuffled the photographs and placed them in random order in front of the participant. As each photo was placed, the researcher said, "This is a photo of ____ (eating cereal), (pouring milk), (pouring cereal), or (getting out his supplies)." The researcher then said, "I want you to look at these pictures and put them in forward order the way that it really happens. Place what happens first right here." The researcher pointed to the left of the child. "And place what happens second beside it here, and so on."

Figure 9
Zane making breakfast

The back of each picture was marked 1 through 4 according to the correct order, and the child's response was recorded on the score sheet. When placed in the correct order, the numbers on the back of the cards were in the order 1, 2, 3, 4. For each sequence the child got correct, the child received a score of 1, and the maximum score was 3. For example, if a child chose the order 1, 2, 3, 4, the child received 1 point for correctly

putting 1 and 2 in the correct order, 1 point for putting 2 and 3 in the right order, and 1 point for putting 3 and 4 in the right order. The total score for that example would be 3 out of 3. Scores were converted to percent correct.

Daily script forward order task, part 2. The idea for this task comes from Fivush and Mandler (1985) who asked children to put four drawings depicting events in a child's typical day in forward order. The materials used for this task, however, were 12 4x6 inch colored photographs of the script of a child's typical day (see Figure 10). The 12 events were 1) waking up, 2) getting dressed, 3) eating breakfast, 4) going out the door of his apartment, 5) sitting in a classroom, 6) going inside the door of his apartment, 7) eating dinner, 8) getting ready to take a bath, 9) putting on his pajamas, 10) brushing his teeth, 11) having a bedtime story read to him, and 12) sleeping. The children heard the following story, "I have some more pictures of Zane. We are going to pretend that this is what he does every day. He wakes up in the morning and then puts on his clothes. Next he eats breakfast and then goes out the door. He sits in class at school and then walks home and goes inside his house. After that, he eats dinner. Then he has a bath, puts on his pajamas, and brushes his teeth. Finally, his mom reads a bedtime story to him, and he falls asleep."

After telling the story of a typical day in Zane's life, the researcher showed each photo to the children, in a random order, saying, "This is a picture of _____." Next, she placed them one at a time in two rows, in front of the participant. As the researcher placed each photo on the table, she repeated, "This is a picture of _____." Once all of the photographs were placed in the rows, the researcher said, "I want you to look at these pictures and put them in forward order the way that it really happens. Place what happens

first right here." The researcher pointed to the left of the child. "And place what happens second beside it here, and so on." If the child ran out of room to put the photos in a linear line, the researcher instructed the child to continue placing the cards in a second line under the first one. This task was scored like the *Daily script forward order task, part 1*, but with a maximum score of 11. Scores were converted to percent correct.

Figure 10
Daily script for Zane

Daily script backward order task, part 1. This task is similar to the task used by Fivush and Mandler (1985), and implemented the use of the same photographs for the daily script forward order task, part 1.

The researcher asked, "Do you remember how Zane eats his breakfast? I want you to look at these pictures again and put them in backward order the way that it really happens. Place what happens last right here." The researcher pointed to the left of the child. "And place what happens right before that here, and so on." This task was scored exactly like the *Daily script forward order task, part 1*. Scores were converted to percent correct.

Daily script backward order task, part 2. The idea for this task comes from Fivush and Mandler (1985) who asked children to put four drawings depicting the events in a child's typical day in backward order. The materials used for this task, however, were the same 12 photographs used in the daily script forward order task, part 2.

The researcher brought out the 12 photographs and shuffled them to ensure that they were in random order. She then showed each photo to the child, saying: "Remember how Zane's day goes? Let's look at the pictures again. This is a picture of _____." Next, she placed them one at a time in front of the participant, making two linear lines. As she placed each photo down, she repeated, "This is a picture of _____." Once all of the photographs were placed in two parallel, linear rows, the researcher said: "I want you to look at these pictures and put them in backward order the way that it really happens backward. Place what happens last in Zane's day right here." The researcher pointed to the left of the child. "And place what happens right before that here, and so on." If the child ran out of room to put the photos in a linear line, the researcher told the child that

the script could be continued in a second line under the first one. This task was scored exactly like the *Daily script forward order task, part 1*. The only difference was that the maximum score was 11. Scores were converted to percent correct.

Daily Events Relative Order, Part 1. The 4 pictures in Figure 9 were used for this task. For each problem there was a reference event and two choices. Two examples are: 1) Pouring Cereal: Eating Cereal or Getting out supplies 2) Getting out Supplies: Pouring Cereal or Pouring Milk. Participants were told: "Think about Zane eating breakfast. Tell me the event that will come next after (or before) this." For each problem, the picture representing the starting event was placed slightly to the left of the child and the two choice events just to its right, one above the other (randomly varied). The child was told, "Let's pretend it's ___ (starting event; the tester will point to this event). Which of these two happens next/before? Which is closer to _____ (starting event) if we go forward/backward in time (pointing to the two choices)?" The children were asked 6 questions; three were forward order and three were backward order. Participant responses were scored as correct or incorrect. Correct responses received a score of 1 and incorrect responses received a score of 0. Correct responses (0-6) were tallied, and the percent correct score was calculated.

Daily Events Relative Order, Part 2. The 12 pictures in Figure 10 were used for this task. For each problem there was a reference event and two choices. Two examples are: 1) Sitting in the Classroom: Eating Breakfast or Taking a Bath 2) Eating Dinner: Going to School or Bedtime Story. Participants were told: "If we follow Zane through his day, tell me the event that will come next after (or before) this." For each problem, the picture representing the starting event was placed slightly to the left of the child and the

two choice events just to its right, one above the other (randomly varied). The child was told, "Let's pretend it's ___ (starting event; the tester will point to this event). Which of these two happens next (or before)? Which is closer to _____ (starting event) if we go forward/backward in time (pointing to the two choices)?" The children were asked 14 questions. Seven were forward order, and 7 were backward order. Participant responses were scored as correct or incorrect. Correct responses received a score of 1 and incorrect responses received a score of 0. Correct responses (0-14) were tallied, and a percent correct score was calculated.

Measure of Episodic Memory

Based on Cycowicz and colleagues' (2001) research, four different power point presentations were created. Each presentation consisted of 50 slides. The first slide contained instructions asking the participants to view the pictures on the following 16 slides, say whether the object in each picture was animate or inanimate, and remember whether or not the pictures were outlined in red or green. The 18th slide informed the participants that they were going to view 32 more slides containing pictures outlined in black and instructed the participants to judge whether or not each picture was previously presented. If the participant said the picture was previously presented, the participant then had to judge whether or not the picture was previously outlined in red or green. No slide contained pictures from another presentation, and the pictures chosen were from Snodgrass and Vanderwart's (1980) standardized set of pictures.

Practice Tests. Each participant underwent two practice tests, each containing different sets of pictures. The practice tests contained 5 slides containing pictures outlined in red or green, and 10 slides containing pictures outlined in black. The

researcher read the instructions from slide one, clicked the mouse to present the next slide, and waited for the child to say the word “animate” or “inanimate.” As soon as the judgment was made, the researcher clicked the mouse to continue to the next slide. This continued until the child viewed all 5 red or green outlined pictures. The researcher then read the next slide with the instructions for the next section before clicking through each of the final 10 slides and asking for memory judgments.

Experimental Tests. This task was presented in the same manner as the practice test. However, the test contained 16 pictures outlined in red or green and 32 pictures outlined in black and white.

A total of 64 points was possible for each experimental test. As the researcher presented the 32 pictures in black and white, she gave the child a score of either 0 or 1 for correctly identifying whether or not the picture was previously presented. An additional score of 0 or 1 was given for correctly identifying the previous color. If a child judged that a picture was not previously presented, yet it was, the child received a score of 0 out of 2. If a child judged that a picture was previously presented and said that it was either red or green, yet it was not previously presented, the child scored a 0 out of 2.

CHAPTER 3: STATISTICAL ANALYSES

Reliability

The data from all 90 participants were scored by one rater, and an additional rater scored data from a randomly selected 10 participants. Interrater reliability was calculated using the intraclass correlation coefficient (Shrout & Fleiss, 1979). The observed interrater reliability scores ranged from .94 to 1.00, with all reliability scores significant at $p < .001$. Thus, raters did not significantly differ in their scoring of the tasks.

Creating Composite Scores for Experimental Tests

For the purpose of statistical analyses, eight composite scores were created. The first three were related to diachronic thinking: tendency, transformation, and synthesis. The other five were related to temporal order: spatial, labeling time concepts, forward ordering, backward ordering, and relative order.

Diachronic Thinking Composite Scores

Tendency

To calculate the composite score for tendency, the scores from tasks 1-4 were summed and divided by the total number of points possible. The result became the composite tendency score.

Transformation

To calculate the composite score for transformation, the scores from tasks 1-3 were summed and divided by the total number of points possible. The result became the composite transformation score.

Synthesis

The percent correct score for the diachronic synthesis task was used as the composite score for synthesis.

Temporal Cognition Composite Scores

Spatial

To calculate the composite score for spatial, the second percent correct score for the picture-pointing task became the composite spatial score.

Labeling Time Concepts

The score for the months of holidays task (i.e., labeling time concepts) was used as the composite score for labeling time concepts.

Forward Order

To calculate the composite score for forward order, the scores from the daily script forward order tasks 1 and 2 were summed and divided by the total number points possible. The result became the composite forward ordering score.

Backward Order

To calculate the composite score for backward order, the scores of the daily script backward order tasks 1 and 2 were summed and divided by the total number points possible. The result became the composite backward ordering score.

Relative Order

To calculate the composite score for relative order, the scores for the holiday relative order task, month relative order task, and two daily events relative order tasks were summed and divided by the total number points possible. The result became the composite relative order score.

Episodic Memory Composite Score

To calculate the composite score for episodic memory, the score of the Cycowicz and colleagues' (2001) task was calculated and divided by the total number of points possible. The result became the composite episodic memory score.

Standardized Clinical Tests

We computed the mean standardized and raw scores for the clinical tests (i.e., PPVT-4 and TONI-3). As the TONI-3 is not standardized for 5-year-olds, we used the norms for 6-year-olds to compute the standardized scores. After establishing that older and younger children were comparable with respect to their standardized IQ scores, we subsequently used raw scores in all further analyses.

CHAPTER 4: RESULTS

As preliminary analyses, we first compared older and younger children on the PPVT-4 and TONI-3 to ascertain whether the two age groups were comparable with respect to their standardized scores. Second, we compared the accuracy (percent correct) for measures of diachronic thinking, temporal cognition, and episodic memory for the younger and older children. Third, we computed Pearson correlation coefficients between the PPVT-4 and TONI-3 raw scores (controlling for age in months) and each of the measures of diachronic thinking, temporal cognition, and episodic memory. These preliminary analyses provided confirmation that the measures of diachronic thinking, temporal cognition, and episodic memory showed the age-related improvements documented in the literature, and explored the extent to which these measures were correlated with verbal and nonverbal intelligence.

To test whether measures of diachronic thinking, temporal cognition, and episodic memory are indices of the same underlying constructs, we conducted a principal components factor analysis to find underlying variance components among the measures. This analysis enabled us to determine the extent to which the measures of diachronic thinking, temporal cognition, and episodic memory were inter-correlated. We report the full correlation matrix from the principal components analysis. For each of the derived factors, we used general linear regression to determine its relationship to age (months) and verbal and nonverbal intelligence (PPVT-4 and TONI-3 raw scores). In the regression analyses, all predictors were entered simultaneously.

Based on the results of the principal components analysis, we conducted general linear regression analyses using measures of verbal and nonverbal intelligence, synthesis

(an index of children's ability to view parts of an event as comprising a whole), and labeling time concepts (an index of children's ability to label the specific month in which recurrent events occur) as predictors of the other measures of diachronic thinking, temporal cognition (i.e., (Tendency, Transformation, Synthesis, Spatial, Forward Order, Backward Order, and Relative Order, Episodic Memory), and episodic memory.

Finally, we explored whether episodic memory in children was predictive of their performance on each of the diachronic thinking and temporal cognition tasks, over and above the effects of verbal and nonverbal intelligence. We conducted a general linear regression analysis using measures of verbal and nonverbal intelligence and episodic memory as predictors of the measures of diachronic thinking and temporal cognition.

Preliminary Analyses

Table 1 presents the mean standardized and raw scores for standardized clinical tests of verbal (PPVT-4) and nonverbal intelligence (TONI-3), for younger and older children.

Table 1

Mean standardized and raw scores for standardized clinical tests for younger (n=44) and older children (n=46) (standard deviations in parentheses)

Age Group	Age in Months	PPVT-4 Standard	PPVT-4 Raw	TONI-3 Standard	TONI-3 Raw
5-7	79 (11)	104 (13)	115 (21)	104 (14)	12 (6)
8-10	113 (10)	109 (16)	158 (20)	106 (16)	21 (7)

Children of ages 5-7 years did not differ from children of ages 8-10 years with respect to standardized scores for verbal (PPVT-4), t (88) = 1.4, *ns*, or nonverbal (TONI-3) intelligence, t (88) = .6, *ns.* Thus, our younger and older children were comparable with respect to standardized scores for verbal and nonverbal intelligence.

Table 2 presents the accuracy (percent correct) on measures of diachronic thinking and temporal cognition for children of ages 5-7 years and 8-10 years.

Table 2

Accuracy (% correct) on measures of diachronic thinking, temporal cognition, and episodic memory for younger (n=44) and older children (n=46) (standard deviations in parentheses)

Task	5-7 year olds	8-10 year olds	*t*
Tendency	52.6 (19.3)	67.0 (14.4)	4.0***
Transformation	59.5 (26.4)	86.1 (15.6)	5.8***
Synthesis	72.7 (33.2)	88.0 (24.0)	2.5*
Spatial	75.3 (15.9)	84.5 (16.2)	2.7**
Forward Ordering	80.4 (17.6)	95.7 (7.7)	5.3***
Backward Ordering	59.2 (30.2)	85.4 (16.9)	5.1***
Relative Order	75.9 (13.0)	92.5 (9.5)	7.0***
Labeling Time Concepts	62.2 (23.2)	83.5 (16.7)	5.0***
Episodic Memory	74.2 (15.1)	81.9 (11.4)	2.7**

*$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

On all of the measures, the younger children had significantly lower scores than the older children, all values of $t > 2.5$, all *p values* < 0.05. Thus, we replicated the age-

related improvements in diachronic thinking, temporal cognition, and episodic memory (Boucher et al. 2007; Cycowicz, et al., 2001; Fivush & Mandler, 1985; Friedman, 2000).

Next, we computed Pearson correlation coefficients, controlling for age in months, to examine the relationship between verbal and nonverbal intelligence and each of the measures of diachronic thinking, temporal cognition, and episodic memory (see Table 3).

Table 3

Partial correlations, controlling for age in months, between verbal and nonverbal intelligence (PPVT-4 and TONI-3 raw scores) and measures of diachronic thinking, temporal cognition, and episodic memory.

Task	PPVT-4	TONI-3
Tendency	.25*	.26
Transformation	.39***	.33**
Synthesis	.13	.12
Spatial	.32*	.30**
Forward Ordering	.27**	.26*
Backward Ordering	.20	.32**
Relative Order	.45***	.35***
Labeling Time Concepts	.41***	.36***
Episodic Memory	.26*	.03

*$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

With the exception of the synthesis measure, which was not significantly correlated with verbal or nonverbal intelligence, and episodic memory, which was not correlated with

nonverbal intelligence, the other tasks tended to be moderately correlated with both verbal and nonverbal intelligence (values ranging from r = .20 to .45).

Principal Component Analysis

Given the proliferation of measures of diachronic thinking, temporal cognition, and episodic memory, the main goal of this study was to determine whether these different measures are indices of the same underlying abilities. The principal components analysis examined the dimensionality of the nine measures of diachronic thinking, temporal cognition, and episodic memory, and provides a correlation matrix for these nine measures. These correlations and their significance values are presented in Table 4. All measures were inter-correlated with the exception of 1) synthesis and spatial, and 2) synthesis and labeling time concepts.

Table 4

Correlations between measures of diachronic thinking, temporal cognition, and episodic memory

	Transformation	Synthesis	Spatial	Labeling Time Concepts	Relative Order	Forward Order	Backward Order	Episodic Memory
Tendency	.49***	.31*	.28*	.29*	.44***	.22*	.47***	.20*
Transformation		.36***	.45***	.36***	.44***	.31*	.50***	.19*
Synthesis			.10	.12	.45***	.36***	.39***	.19*
Spatial				.66***	.42***	.30***	.36***	.31*
Labeling					.62***	.55***	.47***	.41***
Relative Order						.69***	.61***	.38***
Forward Order							.47***	.39***
Backward Order								.30***

p * < 0.05, ** < 0.01, *** < 0.001

The principal components analysis yielded two interpretable factors. The first factor accounted for 46.3% of the item variance, and the second factor accounted for an additional 13.1% of the item variance. Table 5 presents the standardized coefficients for the two principal components for each of the nine measures. Factor 1 was moderately positively correlated with all measures, whereas Factor 2 seemed to distinguish the measures of diachronic thinking (tendency, transformation, and synthesis) from most of the remaining measures. Factor 2 most strongly distinguished performance on the measure of synthesis with labeling of time concepts. Thus, the presence of Factor 2 provides support for the idea that diachronic thinking and temporal cognition are distinct abilities.

Table 5

Standardized coefficients for the two principal factors

Task	Factor 1	Factor 2
Tendency	.14	.35
Transformation	.16	.25
Synthesis	.12	.50
Spatial	.15	-.35
Labeling Time Concepts	.18	-.41
Relative Order	.21	.02
Forward Ordering	.17	-.12
Backward Ordering	.18	.17
Episodic Memory	.13	-.29

To evaluate the relationship between the two factors and verbal and nonverbal intelligence, we conducted regression analyses with each component as an outcome measure and age (in months), and verbal and nonverbal intelligence (i.e., PPVT-4 and TONI-3 raw scores) as predictors. All three predictors were entered simultaneously. The results are presented in Table 6. Overall, the first model was statistically significant, $F(3, 86) = 63.2$, $p < .001$, whereas the second model was not significant, $F(3, 86)$, $p > .05$. As shown in Table 6, the first principal factor was strongly linked to verbal and nonverbal intelligence, but not age, whereas the second principal component was independent of verbal and nonverbal intelligence, as well as age. That is, Factor 2, which distinguished among the measures of diachronic thinking, temporal cognition, and episodic memory, was independent of increases in verbal and nonverbal intelligence.

Table 6

Standardized regression coefficients obtained from multiple regression analysis with principal components as criterion variables and age (months), verbal and nonverbal intelligence (PPVT-4 and TONI-3 raw scores) as predictor variables

	Factor 1	Factor 2
Age in Months	.15	.07
PPVT-4	.48***	-.15
TONI-3	.29***	.06
R^2 total	.69	.01
model F	63.2***	.2

***$p < .001$

Predictors of Diachronic Thinking, Temporal Cognition, and Episodic Memory

Given our findings that both verbal and nonverbal intelligence were linked to Factor 1, and that Factor 2 most strongly distinguished performance on the synthesis and labeling of time concepts measures, we used these four variables as predictors of performance on the remaining outcome measures (i.e., Tendency, Transformation, Synthesis, Spatial, Forward Order, Backward Order, and Relative Order, Episodic Memory). In the regression models, verbal intelligence, nonverbal intelligence (i.e., PPVT-4 and TONI-3 raw scores), synthesis, and labeling time concepts were entered simultaneously. The results are presented in Table 7. Overall, the effect size of each model was statistically significant: tendency, $F(4, 85) = 7.9$, $p < .001$, transformation, $F(4, 85) = 14.7$, $p < .001$, spatial, $F(4, 85) = 16.7$, $p < .001$, forward order, $F(4, 85) = 17.3$, $p < .001$, backward order, $F(4, 85) = 13.4$, $p < .001$, relative order, $F(4, 85) = 36.3$, $p < .001$, and episodic memory, $F(4, 85) = 7.5$, $p < .001$.

These analyses indicate that increases in verbal intelligence (i.e., receptive vocabulary as measured by the PPVT-4) correlated with improvements on all measures of diachronic thinking and temporal cognition with the exception of spatial and backward order tasks. Nonverbal intelligence (i.e., TONI-3) was linked to performance only on the transformation and backward ordering tasks. Synthesis was consistently linked to performance across the three ordering tasks (forward, backward, and relative), but was not linked to performance on either of the remaining measures of diachronic thinking. Labeling time concepts was linked to performance on all of the measures of temporal cognition and episodic memory. Labeling time concepts was most closely linked with performance on the spatial task. In contrast, labeling time concepts was unrelated to any

of the measures of diachronic thinking. These regression analyses fail to support a clear separation between measures of diachronic thinking and temporal cognition. Episodic memory was strongly related to improvements in verbal intelligence, and marginally linked to labeling of time concepts.

Table 7

Standardized regression coefficients obtained from multiple regressions with measures of diachronic thinking and temporal cognition as criterion variables and verbal and nonverbal intelligence (PPVT-4 and TONI-3 raw scores), synthesis, and labeling time concepts as predictor variables

	Tendency	Transformation	Spatial	Forward Order	Backward Order	Relative Order	Episodic Memory
PPVT-4	.29*	.42***	.07	.25*	.08	.36***	.40**
TONI-3	.23	.23*	.08	.13	.26*	.14	-.14
Synthesis	.15	.15	-.02	.20*	.26**	.26***	.07
Labeling Time Concepts	-.04	-.06	.57***	.30**	.24*	.28**	.24+
R^2 total	.27	.41	.44	.45	.39	.63	.26
model F	7.9***	14.7***	16.7***	17.3***	13.4***	36.3***	7.5***

+ $p < .06$, *$p < .05$, **$p < .01$, ***$p < .001$

Episodic Memory as a Predictor of Diachronic Thinking and Temporal Cognition

Suddendorf and Corballis (2007) and Tulving (1985a; 1985b) view episodic memory as providing the foundation for mental time travel, which, in our view, would include both diachronic thinking and temporal cognition. In a final set of regression analyses, we explored whether episodic memory in children was predictive of their performance on each of the diachronic thinking and temporal cognition tasks, over and above the effects of verbal and nonverbal intelligence. In the regression models, the predictor variables were entered simultaneously. The results of these analyses are presented in Table 8. Overall, the effect size of each model was statistically significant: tendency, $F(3, 86) = 9.5$, $p < .001$, transformation, $F(3, 86) = 18.6$, $p < .001$, synthesis, $F(3, 86) = 3.9$, $p < .05$, spatial, $F(3, 86) = 10.5$, $p < .001$, labeling time concepts, $F(3, 86) = 24.0$, $p < .001$, forward order, $F(3, 86) = 18.8$, $p < .001$, backward order, $F(3, 86) = 13.4$, $p < .001$, and relative order, $F(3, 86) = 34.6$, $p < .001$.

These analyses once again suggest that verbal intelligence (PPVT-4) correlated with all measures of diachronic thinking and temporal cognition with the exception of synthesis, spatial, and backward order. Nonverbal intelligence was correlated with only transformation in the measures of diachronic thinking; however, it now correlates with all measures of temporal cognition with the exception of the spatial task. No correlation was found between episodic memory and any task of diachronic thinking or temporal cognition, suggesting that verbal and nonverbal intelligence have stronger influences on children's diachronic thinking and temporal cognition abilities than episodic memory.

Table 8

Standardized regression coefficients obtained from multiple regressions with measures of diachronic thinking and temporal cognition as criterion variables and verbal and nonverbal intelligence (PPVT-4 and TONI-3 raw scores), and episodic memory as predictor variables

	Tendency	Transformation	Synthesis	Spatial	Labeling Time Concepts	Forward Order	Backward Order	Relative Order
PPVT-4	.32*	.50***	.22	.26	.36**	.35**	.20	.52***
TONI-3	.24	.23*	.13	.24	.28*	.25*	.36**	.25*
Episodic Memory	-.02	-.11	.05	.12	.16+	.16	.10	.06
R^2 total	.25	.40	.12	.27	.46	.40	.32	.54
model F	9.5***	18.6***	3.9*	10.5***	24.0***	18.8***	13.4***	34.6***

+$p < .08$, *$p < .05$, **$p < .01$, ***$p < .001$

CHAPTER 5: DISCUSSION

According to Suddendorf and Corballis (2007), the ability to mentally travel through time is a manifestation of the episodic memory system. While agreeing on the importance of mental time travel in human cognition, researchers have questioned aspects of Suddendorf and Corballis's theory with regards to its origins (e.g., Friedman, 2007; Nelson, 2007b). Specifically, Friedman (2007) has argued that there are multiple ways in which children keep track of time and that genuine episodic memories are reached by mentally traveling through temporally organized representations. Nelson (2007a) suggests that Suddendorf and Corballis's (2007) view fails to acknowledge the influences of language development, the sharing information about past and future experiences with others, and cultural practices on time travel developments. This dissertation attempts to shed light on this issue by exploring how mental time travel abilities develop in middle childhood. Using tasks validated in previous research (Boucher et al., 2007; Cycowitz et al., 2001; Friedman, 2000), we investigated developments in diachronic thinking, temporal cognition, and episodic memory in 5- to 10-year old children. No previous study has examined relationships among these tasks in the same group of children, with the exception of the daily life forward, backward, and relative order tasks. Therefore, we explored the extent to which developmental increases in diachronic thinking and temporal cognition were interrelated, and how they might be linked to developments in episodic memory.

We further evaluated the extent to which performance on these various measures of diachronic thinking, temporal cognition, and episodic memory were related to developmental increases in nonverbal and verbal intelligence. To evaluate factors

underlying diachronic thinking, temporal cognition, and episodic memory, we conducted a principal-components analysis, followed by regression analyses to explore relationships between episodic memory and measures of diachronic thinking and temporal cognition. It was expected that tasks of diachronic thinking and temporal cognition would measure different underlying abilities, as diachronic thinking tasks require the child to engage in perspective taking skills and think about events as an observer, while temporal cognition tasks require the child to think about personally experienced events. In addition, following Suddendorf and Corballis (2007) who emphasized the role of the episodic memory system in mental time travel, we expected that episodic memory would predict children's performance across diachronic thinking and temporal cognition measures.

Across the various tasks of diachronic thinking, temporal cognition, and episodic memory, we found significant age-related improvements in performance, which replicated the results of others (Boucher et al., 2007; Cycowicz et al., 2001; Friedman, 2000; Montangero, Pons, et al., 1985; 1992; 1995; 1996; 1999; 2000; 2002). Most of the tasks were moderately correlated with both verbal and nonverbal intelligence, after controlling for age. A notably exception was the lack of a correlation between nonverbal intelligence and episodic memory.

Are Diachronic Thinking and Temporal Cognition Distinct Abilities?

We conducted a principal-components analysis, which provided a correlation matrix for the nine measures of diachronic thinking, temporal cognition, and episodic memory. All of the measures were significantly correlated with each other with two exceptions: the measure of synthesis was not significantly correlated with either the spatial or the labeling time concepts tasks. The principal components analysis revealed

two factors. Factor 1 was positively related to all nine tasks. Regression analyses indicated that this factor was linked to both verbal and nonverbal intelligence. Age did not impact this factor, over and above the effects of verbal and nonverbal intelligence. Factor 2 distinguished between the measures of diachronic thinking, temporal cognition, and episodic memory, with measures of labeling time concepts and synthesis being most different from each other. Labeling time concepts was the measurement of children's ability to know the months of the year in which important holidays occur. This is an index of children's grasp of the conventional system for tagging when events take place. Synthesis measured the degree to which children have the ability to view parts of an object and to understand that they comprise a whole, or to think about several moments in time and realize they are part of a bigger event. The three measures of diachronic thinking (tendency, transformation, and synthesis) had positive weights on Factor 2 (ranging from .25 to .50), whereas the episodic memory, spatial, and labeling time concepts tasks had negative weights on Factor 2 (ranging from -.29 to -.41). The three ordering tasks had intermediate weights (ranging from -.12 to .17). Regression analyses indicated that Factor 2 was independent of verbal and nonverbal intelligence, as well as age.

The distribution of weights on Factor 2 would seem to support the view that diachronic thinking and temporal cognition are different abilities, with episodic memory more closely related to measures of temporal cognition (spatial and labeling time concepts tasks) than to measures of diachronic thinking. To further explore the difference between diachronic thinking and temporal cognition, we performed a general linear regression analysis that included the measures of synthesis and labeling time

concepts as predictors of the other tasks. We examined whether performance on the synthesis and labeling time concepts tasks, which were shown to be most distinct with respect to Factor 2, would predict performance on the remaining tasks, over and above the effects of verbal and nonverbal intelligence.

Verbal intelligence predicted performance on two measures of diachronic thinking (i.e., synthesis and transformation), two measures of temporal cognition (i.e., forward order and relative order), and episodic memory. Montengero and Pons (1999) failed to find a correlation between nonverbal intelligence and performance on tasks of diachronic thinking, yet in our study nonverbal intelligence predicted performance on one measure of diachronic thinking (i.e., transformation) and one measure of temporal cognition (i.e., backward order). Thus, our results suggest that verbal and nonverbal intelligence failed to separate the measures along the lines of diachronic thinking and temporal cognition.

Synthesis failed to predict performance on any measure of diachronic thinking or episodic memory, but it did predict the performance on some of the temporal cognition tasks (i.e., forward, backward, relative order). Labeling time concepts failed to predict performance on any of the diachronic thinking tasks. However, it did predict performance on all of the temporal cognition tasks and it marginally predicted performance on the episodic memory task. Thus, labeling time concepts tasks, a measure of children's grasp of the conventional system for tagging when events take place in time, was most successful in separating the measures of diachronic thinking from measures of temporal cognition and episodic memory. However, the lack of a clear pattern of separation between measures of diachronic thinking, temporal cognition, and verbal and non-verbal

intelligence, suggests that these should not be considered as domains that develop independently.

The Relationship Between Language Abilities and Mental Time Travel

All of the measures of diachronic thinking and temporal cognition were significantly predicted by either verbal intelligence (i.e., as measured by receptive vocabulary) or labeling time concepts. This finding provides direct support for the view that mental time travel and developments in language are closely linked. Nelson (1996; 2007b) contends that it is through verbally sharing information about one's experience that children acquire language related to the significance and timing of events in their lives. When children are around 18 months, they begin to use words that refer to the past (Nelson & Ross, 1980). As parents talk about experienced events, their children begin to learn the words that describe their experiences. By age three, children are able to give more extended and coherent accounts of their past experiences (Fivush, Gray, and Fromhoff, 1987), but the adults in their lives continue to frame the questions and provide prompts for the children's answers (Eisenberg, 1985, Fivush et al., 1987; Hudson, 1990). Fivush and Hamond (1990) found that pre-school children do not pay attention to the same things as adults, and adults frame conversations with their children in a way that teaches children what is important to remember about events in their lives.

There is strong evidence that reminiscing about personal experiences facilitates the development of autobiographical memory, defined as "an explicit memory of an event that occurred in a specific time and place in one's personal past" (Nelson & Fivush, 2004). As children repeatedly experience events and verbally share information about their experiences, they develop scripts, or general event representations (Nelson, 1996).

These scripts help children to organize information about previously experienced events and to anticipate what will happen in the future, by providing a framework for familiar activities. Berntsen and Bohn (2010) provide support for the idea that scripts play a role in the development of mental time travel. They investigated the role of cultural life scripts for both episodic past events and episodic future thinking. The results of their study suggested that participants relied on information from cultural life scripts when thinking about the past and the future and that "cultural life scripts may be especially important for guiding mental time travel across longer temporal distances" (p. 275).

Through reminiscing about events with children, adults provide children with information to add to their scripts, guide children's ability to think about events in temporal order, and teach about conventional labels and systems for keeping track of time (Nelson, 1996; 2007a; 2007b). Reminiscing about experienced events provides children with a vocabulary for talking about events in time, and for tagging when events took place or will take place (e.g., in an hour, tomorrow, Wednesday, July). It is through conversations about the events in their lives that children acquire the conventional systems for tagging events and keeping track of when events occurred or will occur; such conversations also encourage children to think about their personal pasts and futures.

Episodic Memory and its Relationship to Verbal and Nonverbal Intelligence

Nelson's view (1996; 2007b) of the interrelated development of language and memory is supported by the results of our regression analyses showing positive relationships between verbal intelligence, labeling time concepts, and improvements in episodic memory. In contrast, episodic memory was unrelated to our measure of nonverbal intelligence. To our knowledge, no one has previously tested for a correlation

between nonverbal intelligence and episodic memory in children; however, such a link has been shown in adults (Aizpurua & Koutstaal, 2010). Although Cycowicz and colleagues (2001) did not include a measure of nonverbal intelligence, they did utilize several neuropsychological tests as predictors of episodic memory. These included the Wechsler Memory Scale, verbal fluency, and the competing programs task (a measure of executive functioning Luria & Homskaya [1964]). Of these measures, only the competing programs task was a significant predictor of episodic memory. Cycowicz and colleague's results suggest a relationship between episodic memory and nonverbal intelligence, given the extensive literature on general intelligence and its relationship to executive functioning (e.g., Ceci & Bruck, 1993; Roebers & Schneider, 2001; Schneider, Perner, Bullock, Stefanek, & Ziegler, 1999). Given that we did not use any of the same assessments as Cycowicz and colleagues (2001), it is difficult to draw any firm conclusions regarding the source of this apparent discrepancy in our findings. Future studies should use a variety of assessments of verbal and nonverbal intelligence, including measures of executive functioning, as predictors of episodic memory development in children to further understand the relationship between episodic memory and intelligence. Our finding of a link between knowledge of conventional labels for keeping track of time and episodic memory also warrants replication due to its marginal significance in the statistical analysis.

Temporal Order and its Relationships to Labeling and Synthesis

Previous studies have shown that the ability to sequence pictures of familiar events in forward and backward order begins to emerge at around age 4 years (Fivush & Mandler, 1985), and the ability to order the days of the week, seasons, and months of the

year emerges between the ages of 6 to 8 years (Friedman, 1977; 1989). Our regression analyses showed that children's ability to order events in time was linked to their knowledge of temporal labels, and thus, supports Friedman's (1993) view that children may utilize locations in natural, personal, or conventional time patterns to pinpoint events in time. In addition, over and above the effects of the labeling task, the diachronic task of synthesis (a measure of children's ability to imagine how discrete actions make up an event) predicted performance on the temporal order tasks. Whereas verbal intelligence predicted performance on the forward and relative order tasks, nonverbal intelligence predicted performance on the backward order task.

Nelson's work (1996; 2007b) leads us to expect that the various time travel abilities would be strongly interrelated. As children develop scripts for familiar events, they begin to grasp that individual moments in time are parts of familiar events (i.e., synthesis), they learn the conventional systems for keeping track of time (i.e., labeling time concepts), and they develop the ability to order the subparts of events in temporal order (i.e., forward, backward, and relative order). From this perspective, the odd result is that performance on the synthesis task was unrelated to the language measures (verbal intelligence and labeling time concepts). Perhaps our findings are most readily reconciled with Friedman's (2000; 2010) view that children utilize multiple strategies to keep track of time, and that these strategies may be partially independent of each other.

Labeling Time Concepts and Children's Ability to Use Space to Think About Time

One of the strongest relationships observed was between the labeling time concepts and spatial tasks. A trivial reason for the strong relationship between the labeling time concepts and spatial tasks is that both tasks were about holidays and months

of the year; therefore, there was heavy overlap in the content of the questions. Further research is needed to explore whether the close link between use of space to structure time and knowledge of conventional temporal labels is replicated in a task with less content overlap.

Does Episodic Memory Predict Mental Time Travel Ability?

Suddendorf and Corballis (2007) view mental time travel as intimately linked to the episodic memory system; therefore, in our final regression analysis, we explored the extent to which performance on the episodic memory task was predictive of children's performance on measures of diachronic thinking and temporal cognition over and above the effects of verbal and nonverbal intelligence. Surprisingly, our measure of episodic memory proved to be a poor predictor of temporal cognition, with only its relationship to labeling time concepts approaching significance, and it showed no hint of a relationship to any of the measures of diachronic thinking. This pattern of findings seems to contradict Suddendorf and Corballis's (2007) assertion that developments in episodic memory underlie mental time travel abilities. Rather, our findings link mental time travel to growth in verbal intelligence (i.e., vocabulary size) and, to a lesser extent, with nonverbal intelligence. From an evolutionary perspective, our findings suggest that mental time-travel abilities should not be viewed as arising independently of capacities for language and flexibility in information processing.

Recent research by Reese, Haden, and Fivush (1993) suggests that specific conversation styles between parents and children support growth in language acquisition and episodic memory. Children of parents who use a more elaborate conversation style may remember more information about experienced events. Elaborative parents ask

children more questions about the past and related information across experiences, in contrast to non-elaborative parents who tend to be more repetitive when talking about past experiences with their children. Future research along these lines is needed to elucidate how parental conversation styles support other aspects of mental time travel.

Conclusion

Suddendorf and Corballis (2007) argue that mental time travel has played an important role in human evolution by facilitating changes that have allowed humans to think in more cognitively flexible ways. They view mental time travel as intimately linked to the episodic memory system that allows one to recall personally experienced events. Monteangero, Pons, and colleagues (1985; 1992; 1995; 1996; 1999; 2000; 2002) view mental time travel abilities as naturally evolving over time through the interaction of biological changes in children's brains and their construction of the world around them. Friedman (2007), on the other hand, contends that there are multiple representations and processes involved in humans' memory of the past and ability to think about the future, and Nelson (1996; 2007b) outlines the roles of experience and language acquisition in the development of autobiographical memory and temporal ordering abilities. Supporting Montangero, Pons, and colleagues (1985; 1992; 1995; 1996; 1999; 2000; 2002), our results suggest developmental increases in mental time travel abilities, with older children outperforming younger on tasks of diachronic thinking, temporal cognition, and episodic memory. In support of Friedman (2007), we failed to find a consistent relationship between episodic memory, diachronic thinking, and temporal cognition. Children's ability to label temporal concepts predicted measures of temporal cognition but not diachronic thinking; this pattern suggests that these two aspects of mental time travel are

distinguishable. The observed links between task performance and vocabulary growth appear to fit Nelson's (1996; 2007b) view that language acquisition underlies developments in mental time travel as well as episodic memory. In particular, through participation in verbally mediated transactions, children develop strategies for keeping track of moments in time, for remembering their own personal past, and for projecting themselves into the future.

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