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The goal of the present study was to examine the development of semantic and episodic memory in middle childhood. Specifically, we sought to understand the relation between episodic and semantic memory by examining how an aspect of semantic memory—spatial semantic knowledge—may influence children's episodic memory for events and their spatial locations. Children ages 5, 6, and 7 participated in events in 6 exhibits representing locations in a model town in a local children's museum. Events were manipulated by the extent to which the event and the spatial location match. Event conditions included spatially congruent, incongruent, and independent. After a short delay, children were tested for their recognition of the events and the location in which the event occurred. In addition, a novel semantic interview task directly assessed knowledge of the locations represented in the museum exhibits. Most notably, we found older children to exhibit greater semantic knowledge of locations (as measured through the semantic interview task) and, in the experimental manipulation, we found children's semantic memory to influence their memory for the locations of events. Results implicate the nature of the relations of children's semantic and episodic memory as well as the utility of research conducted in naturalistic settings.

RELATIONS IN MEMORY: EXAMINING THE DEVELOPMENT

OF CHILDREN'S EPISODIC AND

SEMANTIC MEMORY

by

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CHAPTER I

INTRODUCTION

Whether one is networking as a business professional or "connecting the dots" to understand a new concept, building and maintaining relationships or connections is an important part of our lives. Similarly, relations in memory serve us well. Remembering collecting seashells may aid in the retrieval of the location of your cousin's birthday party at the beach. The memory of a specific birthday party would be considered an episodic memory, defined by Tulving (1972) as memory for events that have occurred at a particular time and place. Another system of memory, semantic memory, involves our memory for facts or world knowledge, explained by Tulving (1972) as our database of knowledge about the world. In the above example, the knowledge that shells can be found along a beach would be considered a piece of one's semantic memory.

Tulving's (1972) early conception of episodic and semantic memory characterized these memory systems as two parallel but partially overlapping information processing systems. This interaction of episodic and semantic memory is of particular interest to the current study. It is understood that when entering into a new event, we are bringing with us our knowledge about the world. In other words, the episodic memory of a specific event may be influenced (supported or hindered) by one's semantic knowledge. This conceptualization provides opportunity for the examination of these memory systems and their relation. Nelson and Fivush's (2004) prominent model of the development of autobiographical memory—memory for events that occurred in one's personal past—recognizes semantic memory as a contributing factor in the development of memory for the events of one's life. However, the inner-workings of this relation are still relatively unknown. The current study sought to embark upon this challenge by studying the development of children's episodic memory, the development of children's semantic memory, and the relation of the development of these two memory systems in a naturalistic setting.

CHAPTER II

REVIEW OF THE LITERATURE

Episodic Memory Development

Children's episodic memory development has been studied through numerous paradigms. Most characteristically, children are presented with items such as words or pictures and, after a delay, are asked to recognize or recall the items they saw. Children may also be asked to recall events in a story, which may be derived from standardized assessments such as the Children's Memory Scale (Cohen, 1997) or the Wechsler Memory Scale (Wechsler, 1997). In other paradigms, children may personally participate in events in the research laboratory (e.g., Bauer et al., 2012) or in a naturalistic setting such as a museum (e.g., Fivush, Hudson, & Nelson, 1984), and be asked to describe or recall what they remember. These methods make possible the study of children's memory for item (e.g., specific pictures or words) or event (e.g., what happened in the story), but researchers may additionally test children's memory for the individual events and their associated details, most notably temporal (e.g., the sequence of events in a story) and spatial aspects (e.g., where specific events occurred).

Through the various paradigms used in children's memory research, it has been well established that there is significant episodic memory development in middle to late childhood and even in to adolescence (see Bauer, 2007). Improvements in children's memory abilities during this time period are characterized by the increasing ability to encode and retain complex event representations inherent to episodic memories (Ghetti & Bunge, 2012). This development is likely due to continued brain development during this time period; specifically, in the hippocampus, which supports the binding of items or elements presented together (i.e., relational memory binding; Olson & Newcombe, 2014; Cohen & Eichenbaum, 1993) and the prefrontal cortex, which is responsible for controlled, or strategic, processes crucial to episodic memory (Schacter, Norman, and Koutstaal, 1998).

Spatial memory. In the present study, we chose to focus on the spatial details (i.e., location) of events. Prior even to Tulving's (1972) conceptualizations, Underwood (1969) recognized space as a powerful attribute of memory and early work by Hasher and Zacks (1979) argued that the operations that encode the spatial locations of events are automatic. More recently, Rubin (2006) discussed the importance of spatial information in memory as serving functions including acting as a cue to recall (see also Bahrick, 1974 and Bellezza, 1983). Further, studies examining neural activity during episodic retrieval shed light on the prominence of spatial information in memory through activations in the spatial system coinciding with retrieval (Addis, McIntosh, Moscovitch, Crawley & McAndrews, 2004; Cabeza et al., 2004; Piolino et al., 2004). Therefore, with implications ranging from the minute to significant, the study of memory for space holds an important place in episodic memory research and as such has been heavily studied in the adult (e.g., Ciaramelli, Lin, & Moscovitch, 2009; Siedlecki & Salthouse, 2014; Uttl & Graf, 1993) and animal (e.g., Robin, Wynn, & Moscovitch, 2016; Veyrac et al., 2015; Howard & Eichenbaum, 2013) literatures.

Children's memory for space is thought to begin rudimentarily in infancy as infants become increasingly mobile and aware of their surroundings (see Lourenco & Frick, 2014 for a review). Beyond infant work and studies on children's understanding of space (e.g., Learmonth, Newcombe, Sheridan, & Jones, 2008; Newcombe, Ratliff, Shallcross, & Twyman, 2010; Sandberg, Huttenlocher, & Newcombe, 1996), the study of children's memory for the location of personally experienced events is sparse. However, two notable studies centered in middle childhood have contributed to the understanding of children's memory for where events took place. First, Bauer and colleagues (2012) showed an increase between four and eight years of age in children's memory for the location of personally experienced events, implying age related enhances in the ability to reflect on and recreate the event's context. Motivated by these findings, Bauer, Stewart, White, and Larkina (2015) showed an increase in four-year-old's recall of events (in comparison to Bauer et al., 2012) when a location was used as a cue for the activity. In line with Rubin's (2006) emphasis on the role of spatial information in retrieval, Bauer calls this cue a "mnemonic conjunction" that children utilize to reconstruct the event.

Semantic Memory Development

Semantic memory development may be another driving force behind episodic memory development in middle childhood. Although not characteristically labeled semantic memory, literature examining script knowledge may be one way to conceptualize this relation. This line of work resonates with the idea that semantic knowledge, such as scripts or schemata, is carried with us in to novel experiences (which make up episodic memories). Fivush, Hudson, and Nelson (1984) examined children's knowledge of “what happens” during a trip to a museum and “what happened” during a specific field trip to a local museum. These researchers found that children were able to report on general events (“what happens”) and a specific event (“what happened”), and were also able to provide information on the latter even after a six-week delay. Children’s verbal reports were also examined for content and structure. A primary finding from this analysis was that children’s reports of the specific episode differed in both structure and content from the general event representation. This finding led these researchers to posit that children use two different types of event representations: one for specific, one-time events, and a separate representation for general knowledge of events. Further, Fivush, Hudson, and Nelson suggest that events that deviate from the general event representation are specially tagged in a unique memory representation whereas events consistent with previously held event schemata are absorbed into a memory representation used to structure general event knowledge. What Fivush and colleagues referred to as event schemata has elsewhere (e.g., Bar, 2004) been termed “context frames.” Nevertheless, these terms encompass the organized structures representing a particular event or scene that facilitate or guide the processing of events.

Another way semantic memory is measured in childhood is through assessing language and verbal ability. Paradigms employ picture-based tasks in which children are shown displays of photos and asked to either name the photo (as in the Vocabulary Subtest of Wechsler Intelligence Scale, Wechsler, 2003, employed by Lah & Smith, 2014) or identify the photo that represents a word spoken by the examiner (e.g., Peabody Picture Vocabulary Task, Dunn & Dunn, 2007, administered in Wojcik, Moulin, &

Souchay, 2013). However, while it is recognized that language is an aspect of semantic memory, these tasks do not tap the full domain of semantic memory and all that it contains, so more studies, especially with methods that encompass other aspects of semantic memory, are needed.

This dearth of methods used to study semantic memory is especially apparent in the developmental literature and, as such, the trajectory of the development of semantic memory is not well defined. However, the development of semantic memory is sometimes understood through the events of childhood. For example, using a language-based task (specifically, the Receptive Vocabulary and Information subtests of the Wechsler Preschool and Primary Scale of Intelligence-III), Robertson and Köhler (2007) found that semantic knowledge increased with age. These authors argue for the likely influence of the accumulation of knowledge about the world throughout childhood on semantic memory capabilities. One may also consider how these gains in world knowledge are related to the transition to formal schooling by five or six years of age. Thus, middle childhood is a period of significant interest in children's memory research as there is considerable change occurring in multiple memory systems.

Relation Between Episodic and Semantic Memory

The relations between episodic and semantic memory have been conceptualized in many ways. Some have conceptualized episodic memory as the gateway through which semantic memory is acquired (for review see Yee et al., 2013 and Squire & Zola, 1998). This idea considers the fact that semantic knowledge is learned in the context of an event. For example, one may remember that in fourth grade social studies class she learned the fifty states. Thus, while knowledge of the fifty states in the United States is considered semantic, the associated memory of learning this information in a fourth grade classroom is episodic. However, this viewpoint is challenged by studies on atypical populations such as those with neurodevelopmental disorders (e.g., autism; Gaigg, Bowler, & Gardiner, 2014) or brain damage to structures known to be essential to memory that have shown that semantic memory can be acquired or exercised independently of episodic memory (Yee et al., 2013; Kensinger & Giovanello, 2005; Lah & Smith, 2014; Rzezak et al., 2011; Smith & Lah, 2011).

Others have considered a cooperative relationship between semantic and episodic memory (Martin-Ordas et al., 2014). Consider reflecting upon the memory of last spring being rainy. This recollection may include memory of specific events such as buying new rain boots or experiencing flooding, however it may also include general fact-based or semantic knowledge that the spring season is often rainy. Thus, there may be an interaction or cooperation of semantic (the spring season is rainy) and episodic (purchasing rain boots) memories that facilitate in the remembrance of a specific rainy spring season.

Overall, semantic memory as it relates to episodic memory development has not been thoroughly examined in developmental research of typically developing children. While this relation has been studied in atypical child populations, these studies primarily focus on functional relations, or how these systems operate and interact in the presence of brain damage or developmental deficits. For example, the work of Lah and Smith (2014; Smith & Lah, 2011) examines how semantic and episodic memory function in children with temporal lobe epilepsy. Again, while studies of this nature inform our understanding of the functional relations of these two memory systems, it is difficult to gain an understanding of the developmental relation of semantic and episodic memory from this line of work.

To our knowledge, within the developmental literature, just one study has assessed children's semantic memory and how it may relate to their episodic memory. Robertson and Köhler (2007) directly assessed to what extent children's (ages 4-6 years) recognition memory (i.e., memory for item) could be explained by their semantic knowledge, as measured by a language-based task (again, the Receptive Vocabulary and Information subtests of the Wechsler Preschool and Primary Scale of Intelligence-III). Children were administered three separate recognition tests in which target and distracter pictures were manipulated in terms of their semantic and perceptual qualities. For example, in the perceptual recognition test, if a child saw a photo of a black and white cat during encoding, this same black and white cat would be the target at test, and the distracter photo would be manipulated perceptually (a yellow cat), but not semantically (target and distracter are both cats). For this reason, children must successfully encode the perceptual qualities of the photo in order to correctly identify the target photo. In other words, only retrieving the semantic quality of the target photo (i.e., "cat") would not be sufficient as the distracter photo would also be a cat. Interestingly, for all three recognition tests, even the perceptual recognition test in which children do not "need" their semantic capabilities, Robertson and Köhler found semantic knowledge (based on performance on the language-based task) to be a significant predictor of performance.

Building upon this finding, the present study seeks to ask how a different aspect of semantic memory—spatial knowledge—may relate to episodic memory for events and their spatial details.

Research in Naturalistic Settings

Children's museums hold great potential for the study of child development. While this setting is practically fun for children, it also allows for greater ecological validity by studying the learning and interactions of children in the "real world." The study of children's memory in a museum setting has a somewhat surprisingly short history considering this setting's advantages, nevertheless, a handful of research programs have looked to this context to better understand how children learn and remember. Of interest to educators in a museum, even minimal instruction regarding a museum exhibit can enhance learning (Benjamin et al., 2010; Jant et al., 2014) as can drawing (Gross et al., 2008) and object manipulation (Jant et al., 2014). Further, conversation between adult-child dyads (often mother-child) has also been shown to influence children's recall as increases in later recall have been linked to elaborative talk (Benjamin et al., 2010) and joint-encoding (Tessler & Nelson, 1994). In addition, providing dyads with conversation cards regarding the exhibits in a museum can influence conversation within the exhibit, increase cross-exhibit associations, and also improve museum to home transfer (Jant et al., 2014). In sum, studies conducted in children's museums have often focused on variables that may increase later recall of events (i.e., episodic memories) whereas the present study intends to provide a unique examination of both episodic and semantic memory.

A naturalistic setting such as a museum is an ideal environment to examine the questions central to the present study. Most notably, naturalistic settings such as children's museums provide contextual details not available in laboratory-based tasks. As discussed previously, laboratory-based episodic and semantic memory tasks often involve viewing pictures or learning word lists and completing measures of language ability, respectively. Although studies utilizing this method have surely contributed to our understanding of the development of children’s memory, laboratory studies may underestimate children’s memory abilities. For example, Pathman and colleagues (2011) examined children’s autobiographical and episodic memory in a museum environment and found recognition performance of 9 to 11 year-olds to be adult-like in the autobiographical condition. This finding stands in contrast to findings from traditional (i.e., laboratory-based) paradigms and also demonstrates the benefits to children’s memory of personally experiencing an event (in a naturalistic setting) in comparison to passively viewing photos or words on a computer screen (as in a laboratory-based task). Thus, overall, the museum environment may allow for a more accurate portrayal of children’s memory abilities as this environment is more accommodating of the active fashion in which children typically form their memories.

Limitations of Present Literature

Several limitations in the present literature have been alluded to or identified. To summarize, first, though there are several conceptualizations of the relation of episodic and semantic memory, more work is needed to continue to examine this relation. This lack is especially present in the typical development literature. Further, there is a need for a direct measure of semantic memory aside from the use of language-based tasks. Our study aimed to begin to fill this void by using a direct measure of children's semantic knowledge of locations along with testing children's episodic memory for space, about which little is known. Finally, although naturalistic settings have been used in research with children, to our knowledge, no study has looked to this setting to examine the development of both episodic and semantic memory.

Goals and Hypotheses

The primary goal of the current study was to examine episodic and semantic memory in middle childhood, and to understand how semantic memory influences episodic memory for events. Specifically, we were interested in how children's semantic knowledge of locations relates to memory for events and their spatial context. We assessed this in two ways. First, in the primary task (episodic task) we experimentally tested how children's semantic knowledge of locations may relate to memory for events and their spatial context. Children of different ages participated in three types of events at a local children's museum; the events differed in the degree to which the semantic properties of the location matched the event. Event conditions were either spatially congruent (e.g., sorting mail at the post office), or spatially incongruent (e.g., sorting mail in the construction zone). We also included a baseline condition that was spatially independent (e.g., tying a shoe). The second way we tested how children's semantic knowledge of locations may relate to memory for events and their spatial context was by using a semantic interview task. In the semantic interview task, we directly assessed children's semantic knowledge of the locations of interest to this study. We then tested how performance in the semantic interview task related to performance on the episodic task. In sum, we were able to examine the development of the relation of episodic and semantic memory by 1) experimentally manipulating events in regards to spatial semantic properties and 2) directly assessing children's semantic memory and relating these findings to their episodic memory capabilities. In addition, we included a language-based task to parallel how previous literature (e.g., Robertson & Kohler, 2007) examined the relation between episodic and semantic memory in children.

Overall, we expected age-related improvements in children's episodic memory and semantic memory. In the episodic task, in which we experimentally examined the relation between episodic memory and semantic memory, we hypothesized that greater semantic knowledge in older children (7 years) would create large memory differences between the event conditions (spatially congruent versus spatially incongruent). In contrast, we expected that younger children (5 years) would not exhibit robust semantic knowledge of locations. Because of this, we predicted that we would observe smaller memory differences between the event types in young children. Finally, we predicted children in the middle age group (6 years) to show intermediary performance, yet ultimately perform more similarly to the older group of children. We expected these observations in both memory for the events and memory for the location of events. However, we also recognized the possibility that, across ages, children's memory for the events could be high due to the active nature of the events in the museum setting. That is, the nature of personally participating in events (in comparison to laboratory-based paradigms) may bolster children's memory for the events, which would implicate a lack of age and possibly condition differences. For children's performance on the semantic interview task, we expected to observe an effect of age such that children would exhibit greater semantic knowledge with increasing age. Further we expect to see relations between the semantic interview task, episodic memory performance, and the language-based measure of semantic memory. However, given the novelty of this research, we did not make specific predictions about which predictors would best explain episodic memory performance.

CHAPTER III

METHOD

Participants

A total of 103 children took part in this study. Sixteen children were excluded from analyses for the reasons listed in Table 1. An additional participant (7 year old male) was excluded because of high verbal abilities (task and criteria described below). The final sample is comprised of 29 5-year-olds (*M* = 65.03 months, *SD* = 3.62; 15 females), 29- 6 year olds (*M* = 77.76 months, *SD* = 3.76; 13 females), and 28- 7 year olds (*M* = 89.54 months, *SD* = 3.50; 15 females). Table 2 provides additional demographic information for participants included in the analyses. Participants were recruited from a volunteer pool of families who have expressed interest in participating in child development research in the psychology department at the University of North Carolina at Greensboro. In addition, the study was advertised via social media (e.g., Facebook) and paper flyers in the community (e.g., at local coffee shops). Parents or legal guardians gave informed written consent, children age 7 gave written assent, and children ages 5 and 6 provided verbal assent. All procedures were approved by the university Institutional Review Board. In appreciation of their participation, children received a snack and a small toy. In addition, museum admission was provided for families participating in the study and families were able to enjoy the museum at their leisure following completion of the study.

Procedure

The primary setting of this study was the Greensboro Children's Museum, a local museum constructed as a town with exhibits representing locations about the town. Six of these exhibits (hereafter "locations") were chosen for the purpose of the study: the bookstore, the construction zone, "Grandma's house," the market, the medical center, and the post office. Figure 1 depicts these locations as they are displayed at the Greensboro Children's Museum. Construction at the museum midway through data collection implicated minor changes to study procedures. Specifically, the closing of the bookstore exhibit resulted in this location being replaced by the theater exhibit. Additionally, participants in Study "1a" (*prior to* museum construction; $n = 36$) completed all procedures in one session (approximately 2 hours in length) at the Greensboro Children's Museum. Participants in Study "1b" (*after* museum construction began; $n = 50$) completed procedures in two sessions: the first session in a university laboratory setting (approximately 1 hour in length) and the second session at the Greensboro Children's Museum (approximately 1 hour in length). The primary motivation for this change was that many children, especially younger children, were unable to complete all tasks in one session due to fatigue. The specific tasks remained the same across studies; however, the arrangement or order of tasks was altered at the onset of Study 1b in attempts to avoid the issues with fatigue in Study 1a. Figure 2 depicts a comparison of the order of procedures for Study 1a and 1b. Independent samples t-tests revealed that there were no significant differences in accuracy between participants in Study 1a and 1b for any task.

Episodic task. Prior to beginning the episodic task, children took a "tour of the town" with the researcher. The intent of this activity was to briefly familiarize children with each location as represented at the museum. The episodic task included a study phase (approximately 35 minutes) and, after a delay (10-15 minutes), a test phase (approximately 15 minutes). For the study phase of the episodic task, participants visited each of the six locations and at each visit to a location participated in one event that was spatially congruent, spatially incongruent, or spatially independent. Thus, children participated in eighteen events in total, with a short midway activity during which children visited another area of the museum containing real vehicles (e.g., police car, race car, ambulance) occurring after the ninth event. An example of a spatially congruent event would be sorting mail at the post office, whereas a spatially incongruent event would be bagging groceries at the medical center. Spatially congruent and incongruent events were derived from the same bank of events such that what one child experienced as a congruent event (sorting mail at post office) another child may have completed as an incongruent event (sorting mail at the medical center). Examples of spatially independent events are tying a shoe or listening to a joke. Spatially independent events were selected as those that did not have significant ties to any particular location in the museum (i.e., they were events that someone could engage in anywhere). Classification of events as congruent, incongruent, or independent was confirmed by a survey sent to university students and adult volunteers prior to the start of this investigation. For a complete list of events, see Appendix.

Stimuli for each event were purchased or made by the primary researcher prior to the start of this investigation. Stimuli were most often toys or objects similar to those that children could play with at the museum. For example, a brown paper bag and plastic food items were used for the "bagging groceries" event. The objects needed for a given participant's session were kept in a covered rolling cart managed by the researcher throughout the episodic study phase. To determine the specific set of events that participants would complete during a session, fourteen "stimulus sets" were made prior to the beginning of this investigation and each participant was assigned a stimulus set number by the researcher prior to his or her session. In order to construct stimulus sets, the 24 possible congruent/incongruent events were randomly organized into Groups A-D such that each group had one event corresponding to each of the six locations. Likewise, the 12 possible independent events were split into Groups E and F so that six events could be distributed across the locations in the museum. A given stimulus set dictated the classification of groups of events (e.g., "Group A" as congruent events, "Group B" as incongruent events, "Group E" as independent events), the event-location matches of incongruent events (e.g., "bagging groceries" will take place at the medical center), and the overall order of events.

After a short delay (approximately 10-15 minutes), children participated in the test phase of the episodic task. Children's memory for the events in which they participated as well as the events' spatial and temporal details were tested using a laptop computer in a quiet area of the museum, away from the "town" portion of the museum. Children wore noise-cancelling headphones, which also allowed them to hear the test questions. E-prime (E-prime Version 2.0.10.252) software was used to display images and audio and record responses. For each trial, children were presented with a photo of an object (e.g., a pile of colored envelopes) associated with an event, while at the same time they heard a the recognition test question such as “Did you sort colored envelopes?” Children were given the opportunity to answer by key press “yes” (i.e., old) if they remembered doing this event and “no” (i.e., new) if they did not believe they did the event. Two additional questions were asked for events to which children responded “yes.” For these items, children were again shown the photo of the event object. First, children were asked a spatial question, “Where did you do this activity?” The following screen showed the six locations that were visited, and children responded by pressing a key corresponding to one of the six locations. Second, children were asked a time question, specifically, if the event occurred before or after the midway activity. Data from the time question of the test is not included in the present analyses. To ensure the child understood testing procedures, the researcher conducted practice trials prior to beginning the test portion of the episodic task. All relevant keys were labeled and were also differentiated by color to minimize potential confusion. The experimenter also monitored the progress of the test and gave any needed reminders about the locations of particular keys on the keyboard. In total, the memory test was comprised of 36 items, corresponding to the possible 36 events. In other words, 18 of these items were events that the child participated in at the museum that day (i.e., “old”). The remaining 18 “new” items were those not experienced by the child at the museum that day, but may have been experienced by another participant.

Semantic tasks. The present investigation included three tasks intended to directly examine children's semantic memory: 1) A semantic interview task which assessed children's knowledge that would be relevant for the episodic task, 2) A standardized measure of language that assesses semantic knowledge of words, 3) A conventional time knowledge task, that is not relevant for this particular thesis.

Children completed a semantic interview task in order to assess their knowledge of the locations of interest. For each location, three questions were asked: "Who might be at a [location]?" "What kinds of things would you see at a [location]?" and "Why or when would you go to the [location]?" Order of the locations was randomized, but questions for each location always proceeded as indicated above. Children in Study 1a were asked about the "original" six locations listed above. Children in Study 1b were asked about the theater in addition to these six locations; however, scores for this location are not included in analyses. Because this task occurred prior to entering the town area of the museum (Study 1a) or visiting the museum (Study 1b), locations were spoken of in general terms that would be most identifiable to children. For example, rather than asking who might be at a medical center, children were asked who might be at a "medical center or a doctor's office." Researchers took notes on the participant's responses, and this task was also audio-recorded and later transcribed.

The second semantic memory task was a standardized language-based task, the Peabody Picture Vocabulary Test (PPVT; Dunn & Dunn, 2007). In this task, the participant chooses one of four pictures displayed on a page that he or she believes to most accurately represent a word spoken by the experimenter. For example, a child may see an array of shapes and be asked to identify the one that reflects the word “diamond.”

The final semantic memory task was an adapted version of the Conventional Time Knowledge (CTK) task (Friedman, 1989; see also Friedman, Reese & Dai, 2011; Pathman & Ghetti, 2013). CTK is intended to assess both semantic knowledge of time (e.g., months of the year) as well as an individual’s ability to flexibly represent time. The present study used the task created by Scales and Pathman (in preparation) which adapted the original CTK task for use with young children by incorporating picture cards and using knowledge that would be appropriate for younger children. First, children are asked to order a set of cards depicting a sequence (e.g., spring, summer, fall, winter) from beginning to end on a table. This portion of the task assesses semantic knowledge of time. Next, children are asked questions such as “If it is spring, what season comes next?” and “If it’s winter, what season is next going backwards?” These questions are intended to tap into children’s flexible retrieval of time scales. Like the temporal question in the episodic task (described above), the examination of children’s semantic memory for time is not the focus of the current study and thus will not be discussed in further detail in the present document.

Scoring

Episodic task. Of the three questions involved in the episodic task, analyses include children’s memory for item (i.e., events) and memory for location of the event (i.e., spatial context). Scoring of children’s memory for location of events involved computation of the proportion of correct responses for each of the conditions (congruent, incongruent, independent). Scores from the item portion of the episodic task were computed using standard protocol for tests of old/new recognition. For tests of old/new recognition there are four possible types of responses: hits, misses, false alarms, and correct rejections. A hit is an event that is correctly identified as one that occurred. A miss is an event that did occur, but the participant regards as one that they did not do. A false alarm is an event that did not occur, but the participant incorrectly identifies as one that they did do. Finally, a correct rejection is an event that the participant did not do and correctly identifies as such. Corrected recognition scores were computed for each participant for each condition by subtracting the proportion of false alarms from the proportion of hits. It is recognized that authors of one study (i.e., Lloyd, Doydum, & Newcombe, 2009) raised caution for using corrected recognition scores in developmental studies because of the potential to overlook false alarm rates as the driving force behind any age-related differences. However, we found no significant effect of age ($F(2,82)$, $p >$ .8) when false alarms were analyzed in a one-way ANOVA, and therefore used corrected recognition scores in analyses.

Semantic interview task. Responses of the semantic interview task were first transcribed, then were coded and scored following considerations for using narratives in research set out by Haden and Hoffman (2013). Prior to scoring, the beginning and end of children's responses to each of the three questions (i.e., "who" and "what" might be at a location and "why/when" one would visit the location) were identified so that an accurate representation of word count could be drawn. This protocol was especially pertinent for children that may have deviated from the task at hand. For example, while answering

"What kinds of things might be at a market or grocery store," a child may have been reminded of buying a birthday cake and then tell the researcher about her last birthday party. Any "off task" talk was removed from the word count in addition to filler words (e.g., um, uh, etc.), phrases that buy more time (e.g., "Let me think about that…"), and phrases that signal completion (e.g., "That's all I can think of"). These steps were used to compute an "adjusted" word count for each location. Analyses make use of this adjusted word count summed across the original six locations.

The semantic interview task was scored in two ways: for quality of response and for the amount (i.e., quantity) of response given. Table 3 provides example responses scored both qualitatively and quantitatively. First, responses to each of the three questions for each location were scored for overall content and correctness, or quality. Each response was given a score of zero, one, or two. Thus, there were a possible two points per question, three questions per location, and six locations for a total of 36 points possible overall. This scoring procedure (e.g., possible scores of zero, one, or two for each response) is modeled after the scoring used for established measures (e.g., Wechsler Adult Intelligence Scale; Wechsler, 1997). In scoring our semantic interview task, a score of zero was only given if the response is incorrect or if the child responded "I don't know." A score of one was given for responses that were accurate overall, but lacked true depth. For example, "a person" is an accurate response to "Who might be at a library?" yet should be differentiated from a response in which more specific details (e.g., "librarian," "the media specialist" etc.) are given (in which case the response is given two points). Likewise, when responding to why or when someone may go to the market or grocery store, the response “to buy stuff” would be given one point. To aid in differentiating one point versus two point responses, “defining features” for each location were determined. Table 4 provides defining features for each question for each location. In order to receive a score of two points, the child must have given at least one defining feature. “Qualitative scores” used in analyses refer to a participant’s proportion of total points possible (i.e., 36) for this aspect of scoring.

Secondly, responses to each question were scored for quantity by identifying what are termed central and peripheral facts. A central fact is considered an element of the location that is central or normative to that location. For example, books are regarded as central to the bookstore. Likewise, doctor’s tools are central to the medical center. A peripheral fact is considered an element of the location that may be present, but does not necessarily have to be present in order to preserve the identity of the location. For example, some markets or grocery stores may have toys, however, toys do not necessarily contribute to the prototypical representation of a market. Thus, the scoring of central and peripheral facts was intended to not penalize children who may only provide somewhat accurate (i.e., peripheral) responses, but to nevertheless be able to differentiate between these responses and responses that are more accurate (i.e., central) to the elements of each location. Weighted quantitative scores for each location were computed by multiplying the number of central facts given by two and adding to this value the number of peripheral facts given. “Quantitative scores” used in analyses make use of the weighed score summed across the “original” six locations.

CHAPTER IV

RESULTS

Preliminary Analyses

Standardized PPVT scores were first used to identify outliers in our sample. Participants were considered outliers (and were therefore excluded from analyses) if their standardized PPVT scores were +/- 2.5 standard deviations from the sample mean. Additionally, this criterion was used to determine if any participants deviated from the mean of their particular age group. All participants in the 5- and 6- year old age groups fell within their respective intervals as well as the interval around the sample mean. As previously mentioned, this criterion did exclude one seven year from analyses. Descriptive statistics for this task are shown in Table 5.

Analyses of Episodic Task

As a reminder, the episodic task analyses allow us to track children's recognition memory for events and the events' locations. This task also allowed us to test the impact of spatial semantic knowledge on children's episodic memory (recognition and memory for location). The congruent and incongruent conditions are directly compared in the analyses. The independent condition events had no significant tie to any one location as represented in the museum, thus, these events may be considered or likened to a baseline condition.

No significant effect of age ($F(2, 82) = 0.330$, $p = .720$) was found when recognition scores for independent events were analyzed in a one-way analysis of variance (ANOVA). Likewise, no significant effect of age ($F(2,83) = 1.207$, $p = .304$) was found when spatial accuracy scores for independent events were analyzed in a one-way ANOVA.

Next, two 3 (age: 5, 6, 7) x 2 (condition: congruent, incongruent) repeated measures (RM) ANOVAs were used to investigate the influence of developmental changes (i.e., age) and the spatial semantic manipulation (i.e., condition) on memory. The first of these RM ANOVAs assessed recognition scores and returned non-significant results for both age ($F(2,82) = 1.684$, $p = .192$) and condition ($F(1, 82) = 0.005$, $p = .945$). Thus, for children's memory for the events there were no significant accuracy differences between age groups, and no differences between conditions. For reference, Table 6 provides descriptive statistics for each age group's recognition of events in the episodic task. For children's memory for the location of events (i.e., spatial test), there was also no main effect of age ($F(2,83) = 1.019$, $p = .365$). However, this analysis did reveal a significant main effect of condition ($F(1,83) = 46.334$, $p < .001$, $\eta^2 = .373$) such that, across age groups, the locations of congruent events ($M = .912$, $SE = .017$) were identified more accurately than those of incongruent events ($M = .736$, $SE = .024$). Figure 3 depicts the results of the memory for location scores, separated by each age group. The pattern of results for the episodic task holds when using hits (rather than corrected recognition scores) and when a "difference score" is computed for spatial accuracy by subtracting accuracy for the location of independent events from each of the other two conditions (e.g., difference score for congruent events equals the proportion of correct responses for the location of congruent events minus the proportion of correct responses for the location of independent events).

Exploration of errors. In order to examine the errors that were made in children's memory for the location of incongruent events, we separated errors into "match" and "non-match" errors. A match error is made by incorrectly choosing the location that is congruent to the event. For example, responding that setting a place setting took place at Grandma's house when it actually took place at the construction zone. A non-match error is incorrectly responding that an event took place anywhere other than the correct location or the congruent location. For this analysis, we compared the proportion of match and non-match errors to what we would expect by chance. With six possible locations for an event, chance responding for match and non-match errors is 1/6 and 4/6, respectively, summing to the five possible errors. Across all participants that made errors on incongruent trials ($n = 67$), we found that match errors differed significantly from what we would expect by chance ($t(66) = 3.323$, $p = .001$). Non-match errors did not significantly differ from what would be expected by chance ($t(66) = -0.220$, $p = .827$).

Analyses of Semantic Interview Task

Scores from the semantic interview task were used to assess children's semantic knowledge of locations. Significant effects of age were found for both quantitative ($F(2,83) = 4.696$, $p = .012$) and qualitative scores ($F(2,83) = 5.336$, $p = .007$) in separate one-way ANOVAs. Post-hoc comparisons using Tukey's Honestly Significant Different

(HSD) test revealed similar patterns for each scoring method. For quantitative scores, 7 year olds (*M* = 57.04, *SD* = 18.12) provided more facts than 5 year olds (*M* = 40.38, *SD* = 15.98), however, 6 year olds' performance (*M* = 47.48, *SD* = 26.12) did not differ from either 5 or 7 year olds. Likewise, for qualitative scores, 7 year olds (*M* = 0.84, *SD* = 0.12) gave responses of higher quality than 5 year olds (*M* = 0.70, *SD* = 0.19), but again, 6 year olds (*M* = 0.75, *SD* = 0.17) did not differ from either of the other age groups. Table 5 provides additional descriptive statistics for the semantic interview task. Intuitively, one would expect that scores on the semantic task interview would relate to or be driven by word count. Because of this, we also examined scores from this task using partial correlations controlling for word count. A significant relation between age (in months) and score was found for both quantitative (p*r* = .330, *p* = .002) and qualitative scores (p*r* = .301, *p* = .005) even when controlling for word count.

Analyses of Relations Between Episodic and Semantic Tasks

We assessed which variable(s) best predicts individual differences in children's episodic memory for location. This step involved two separate regressions. Predictors for both of these regressions included: age (in months), scores from the baseline recognition measure of the episodic task (specifically, corrected recognition scores for independent events) and scores from semantic tasks (specifically, standardized PPVT scores and qualitative scores from the semantic interview task). Qualitative scores from the semantic interview task are included instead of quantitative scores in this analysis due to the defined nature of the qualitative scoring method (i.e., scores were constrained to the limits 0-36). When spatial accuracy scores from the congruent condition were used as the outcome, the model was not significant (R^2 = .055, $F(4, 80)$ = 1.158, p = .336). The regression on spatial accuracy scores from incongruent events narrowly missed the accepted standard of significance (R^2 = .100, $F(4, 80)$ = 2.232, p = 0.073). However, significant predictors in this model include age (β = .263, t = 2.127, p = .037) and PPVT score (β = .310, t = 2.317, p = .023). Table 7 displays results of the regression on children's memory for location of incongruent events.

CHAPTER V

DISCUSSION

The primary goal of this study was to examine the developmental relations between episodic and semantic memory—two memory systems that display changes in early to middle childhood. We examined these relations in a museum setting by having children participate in short events manipulated in terms of their spatial semantic congruency and then testing their memory for the events as well as their spatial details. We expected to observe age related changes in children's episodic and semantic memory. Results partially support this first piece of our hypotheses in that an effect of age was found in a novel narrative interview task assessing children's semantic memory. On the other hand, we did not find an effect of age in children's memory for item in our baseline measure of episodic memory (i.e., independent condition) nor across experimental conditions (i.e., congruent and incongruent conditions) for either item or location. Additionally, we predicted that the age-related changes would implicate large memory differences between experimental conditions for older children and relatively smaller memory differences between conditions for younger children. Despite the lack of an effect of age, we did find an effect of condition in children's memory for location of events such that spatially congruent events were remembered more accurately than spatially incongruent events.

Age in Relation to Episodic and Semantic Memory

This study provided a novel contribution to literature examining children's memory development in that, to our knowledge, the current study design was the first of its kind. Although previous studies (e.g., Fivush et al., 1984; Jant et al., 2014; Pathman et al., 2011) have looked to naturalistic settings to examine children's memory, the present study is unique in that it was able to capitalize upon rich contextual details of a model town represented in our local children's museum in order to study both episodic and semantic memory. Studies conducted in naturalistic settings have the chief benefit of bringing research into the active, social context in which learning most organically occurs. Furthermore, pioneers of developmental psychology (i.e., Piaget, 1970; Vygotsky, 1978) established the learning benefits inherent to hands-on interaction long ago. These ideas are perhaps most apparent in the present study in children's recognition memory for events. Across all ages and event conditions children were at ceiling in their recognition of events in which they participated. Moreover, children of all ages were able to correctly reject events that they did not participate in (i.e., "new" events) at nearly ceiling levels (see Table 6: "Correct Rejections"). Thus, the fact that children personally or actively participated in events likely allowed for strong memory of these events. One may also compare this active study paradigm to relatively more passive laboratory-based paradigms to consider this idea.

Aside from the active nature of the events that children participated in, there are several reasons that children may have performed well in the event recognition portion of the episodic task. First, the nature of the recognition test in some ways "set participants up for success." Specifically, memory probes were distinct and were accompanied by a photo representing an object that was used for the event. For example, for the "tie a shoe" event, children heard "Did you tie the laces on this shoe?" accompanied by a photo of the exact red shoe that they would have tied the laces on. In this way, high recognition performance was foreseen as a possibility. However, the ease of this aspect of the memory test was somewhat deliberate, as the testing software was intentionally programmed to only advance to space and time questions if the child responded "yes" to the event question. In other words, in order to adequately assess children's memory for the details of events, we needed them to be able to advance beyond simply recognizing the event. High recognition memory performance may have also been due to a short delay between the study phase and test. Future work in this line of research could include a longer delay (e.g., days) that could possibly bring out expected memory differences across age groups. Of course, if a longer delay is used in future work, considerations should be made regarding the nature of assessing children's memory for the spatial details of events. For example, a study of this design may be wise to test children's memory for the events and their locations separately, as in Bauer et al. (2012), rather than the current study's test design in which children had to "pass" the recognition question in order to be asked the spatial question.

As discussed, we would expect age related improvements in children's episodic memory during middle childhood (Bauer, 2007). However, the primarily statistical implication of children's high recognition memory is a difficulty in identifying any differences between groups. Due to the novelty of the present study, power analysis was based upon Bauer et al. (2012). This study was chosen as a model for the current investigation because it incorporated children's memory for events that took place around a laboratory space and their respective locations. In this way, it may be likened to a smaller scale examination of the current study. However, a notable difference between the work of Bauer and colleagues and the present study was choice of age groups. Specifically, 4-, 6-, and 8- year olds participated in Bauer's study, while the present study included a narrower age range (5-7 year olds). While we believe there are important changes occurring in episodic memory during the 5-7 age range, it may be that the changes are more gradual than distinct through these years and therefore we were unable to capture significant differences between these age groups.

Additional differences between the study by Bauer and colleagues (2012) and the present study include: number of trials (4 versus 18), length of delay (1 week versus 10-15 minutes), and testing method (free and cued recall versus recognition). As noted by Bauer, tests of recall are often more sensitive to developmental differences than are recognition tests (see also Ackerman, 1985; Mandler & Stein, 1974; Perlmutter, 1984). Considering these differences, it may also be that the present study was not adequately powered to find effects of age. Additional data collection is perhaps the only means to determine if more power is needed in the present study. Still, we believe these findings contribute an understanding of the memory capabilities of children in early to middle childhood and, as discussed by Pathman et al. (2011), support for the idea that the nature of traditional laboratory paradigms may underestimate children's memory abilities whereas research in naturalistic settings allows for an examination of the active fashion in which children typically learn and remember. Thus, we would continue to advocate for research that looks to naturalistic settings to examine children's memory development.

Our examination of children's semantic memory was also, to our knowledge, the first of its kind. Previous developmental studies (e.g., Robertson & Köhler, 2007) of children's semantic memory have most often utilized language-based measures. As such, little is presently known about children's memory for an important aspect of semantic memory—that is, their knowledge of locations. We used a novel interview task to specifically examine what children know about the locations of interest in this study. This assessment was especially pertinent for the present study as our experimental manipulation relied upon spatial semantic knowledge of locations, in other words, the knowledge of what happens at a grocery store or doctor's office. Using this novel method, we found effects of age in both the quantity of children's knowledge as well as the quality of their responses. Further, these effects held even when controlling for the number of words spoken.

Along with contributing a novel task to the literature, our findings from the semantic interview task allow us to further understand or chart the trajectory of children's semantic memory development. Likely contributors in the development of this memory system include the transition to formal schooling during our age range of interest as well as accumulating world experiences throughout childhood (Murphy, 2002). The local school district's age requirements for entering school as well as the timeline of data collection for the present study implicated that the majority of participating 5-year-olds either had not begun formal schooling (i.e., Kindergarten) or had been in school for less than one year. The importance of the transition to formal schooling may be especially reflected in results from the semantic interview task. Specifically, 5-year-olds differed from 7-year-olds in the both the quantity and quality of their responses. Six-year-olds performed intermediately and did not differ from either group. However, 6-year-olds did differ from 7-year-olds when qualitative scoring was made more stringent. Specifically, when scores were based solely on the production of “defining features” of each location, 5- and 6- year olds performed similarly, but each differed significantly from 7-year-olds. In other words, while our two scoring methods (quantitative and qualitative) indicate a gradual change in children’s semantic memory across these years, such that only 5- and 7- year olds differ, when we consider only the “highest quality” of responses, the knowledge of 5- and 6- years olds is comparable followed by a sharp increase by 7 years of age. Moreover, these changes are not accounted for by increasing verbal abilities alone as an association between scores and age remains even when the influences of word count and PPVT scores are removed.

Memory for Space

The effects of age found in our analyses of children’s responses from the semantic interview task are also important when considering children’s memory for the location of events. Again, our experimental conditions allowed us to assess the extent to which children’s semantic memory influences their episodic memory for events by manipulating the degree to which the event matched the spatial semantic properties of the location. Therefore, we expected a relation between children’s semantic knowledge on the interview task and children’s memory for the location of events such that children who exhibited greater semantic knowledge of these specific locations would perform differently than those that had relatively less knowledge. The results of our two regressions indicate that this idea describes only a piece of the narrative of the present study. While semantic competency (as measured by a picture-naming task) was found to be a significant predictor of children's recognition memory performance in a similar study conducted by Robertson and Köhler (2007), our semantic measures (i.e., semantic interview task and PPVT) were not significant predictors of children's memory for the locations of congruent events. Moreover, the model containing these aforementioned variables in addition to children's age (in months) and baseline episodic scores was non-significant. On the other hand, the model (containing the same predictors) predicting children's accuracy for the location of incongruent only approached significance, thus we interpret findings with caution. Still, this analysis suggests there may be relations between standardized PPVT scores, age, and children's memory for the location of incongruent events. Therefore, our results are consistent with those of Robertson and Köhler in that children's semantic memory (as measured by a standardized language task) influenced their recognition memory performance, but only for incongruent events. In sum, an aspect of semantic memory (i.e., language ability) does appear to differentially relate to our experimental conditions even though children's performance on the semantic interview task specifically did not predict memory for location.

Curiously, children's baseline score from the episodic task was not a strong predictor of their memory for the location of events. On one hand, it's likely that any influence of this variable on children's memory was overshadowed by the influences of

PPVT and age. However, one can also identify the presence of children's episodic memory by considering how children would have performed if recruiting only one memory system or another as in situations where damage to structures in the brain hinders the efficiency of specific systems in memory. If children only used their semantic memory to identify the locations of events, we would likely see an effect of condition, but scores for congruent events would be at ceiling whereas scores for incongruent events would be at floor. In other words, regardless of where the event actually took place, the child would "default" to answer with the location that most matched the specific event. On the other hand, if children only recruited their episodic memory in this task, an effect of condition would likely not be found as the spatial semantic manipulation would have no bearing on whether or not the child was able to correctly recognize the location of the event. Thus, both memory systems were clearly at work, but how were they working?

Based on their study of children's memory for events that took place in a trip to a museum, Fivush, Hudson, and Nelson (1984) postulated separate encoding processes for events consistent with a general schema and for events that are specific or deviate from the schema. Although there are some notable differences between this study and the current (e.g., duration of events and delay to test), the work of Fivush and colleagues perhaps provides one framework through which to consider memory differences between congruent and incongruent events. Specifically, we may liken our congruent events to these researchers' assessment of "what happens" on a trip to a museum. In this model, the general event representation guides the encoding of events consistent with event schemas. Guided encoding of congruent events is reminiscent of ideas set out by Bar (2004) regarding what he refers to as "context frames." In the current study, memory performance for congruent events may reflect a "boost" from children's semantic memory. In other words, the existing semantic knowledge that children held might have served to support the encoding of congruent events through the perception of additional "matching" semantic details that could be absorbed consistently into their schema. For example, consider the difference in spatial details when setting a place setting at the kitchen table (in "Grandma's house") versus at a workbench (in the construction zone). Then, at test, these additional details could also be recruited and used to identify the correct location and reject incorrect locations. This interpretation of the current study falls in line with the work of Robertson and Köhler (2007).

These ideas are also reminiscent of the study of relational binding, which may be one mechanistic means of the influence of children's semantic memory on their memory for locations. Relational binding is a process inherent to forming episodic memories, and a source to credit with changes in episodic memory in childhood (Lee et al., 2016; Olson & Newcombe, 2014). Relational binding is conceptualized as the act of forming relational memories, which are the associations among elements presented together. When an item is encoded into memory, it is bound to a number of contextual features, these features could then be used to compare and contrast the individual items in memory (Olson & Newcombe, 2014). In laboratory, computer-based paradigms (such as the work of Lee and colleagues, 2016), two items may be presented together on a computer screen as a means to assess one's memory for items bound to other items. Similarly, items may be bound to space. Computer-based tasks will also often assess individual's ability to bind item to space by manipulating where (e.g., top left, bottom right, etc.) an item is presented. However, relational binding also has "real world implications." For example, it is important to remember which of your three children was at soccer practice when you asked your children to clean their rooms. In this example, the two children that were present would be likened to an item-item combination. Similarly, it is important to remember what room you were in when you last saw your car keys (an item-space combination). Likewise, in the present study, the events or actions were tied to the locations in which they occurred. Results of children's memory for congruent locations seems to suggest that event and location were "bound more tightly" in memory than event-location combinations of incongruent events.

Like relational binding, controlled processes may be another source of light into children's memory for the location of events. Changes in controlled, or strategic, memory processes are to credit, in part, with developments in episodic memory during childhood as enlisting controlled processes such as semantic or organizational memory strategies can support encoding and retrieval of episodic memories (Bjorklund, Dukes, & Brown, 2009). In the developmental literature, Robertson and Köhler (2007) discuss the influence of elaborative semantic encoding processes on later recognition of items. In other words, children who were able to utilize their semantic competencies at encoding displayed more accurate recognition at test. Results of the congruent condition in the present study indicate that children may have likewise applied a semantic strategy of encoding events.

If semantic memory gave congruent events a “boost” can it be said that this memory system “hindered” incongruent events? Current interpretations would suggest that this is not the clear answer for a few main reasons. First, the regression on children’s memory for the location of incongruent events indicates tentative relations between semantic memory and children’s memory for these events. Specifically, we found a positive relation to PPVT scores in this regression. As discussed, language is only an aspect of semantic memory, but this finding is also perhaps reminiscent of Robertson and Köhler’s (2007) perceptual recognition test in that children do not necessarily “need” their semantic memory to remember the location of incongruent events. Therefore, one possibility is that children can efficiently employ their semantic memory during incongruent test trials.

In support of this idea, it could be argued that just as the congruent semantic spatial details are perceived and utilized in congruent trials, the incongruent semantic spatial details could be used to create memory flags of these events. In other words, “It’s weird that I’m setting a place setting at a work bench in a construction zone. I should be doing this at Grandma’s house. I’m going to remember this because it’s kind of odd.” Indeed, this was qualitatively observed in the study phase as some children, especially 6- and 7- year-olds, would note that incongruent events “should have actually taken place at [location X].” These qualitative observations fall in line with Fivush, Hudson, and Nelson’s (1984) view that events that deviate from the general event representation are specially tagged in memory. In the study by Fivush and colleagues, children could remember a specific event up to a year later; however, a cue was needed to remember the events motivating these authors to conclude that the distinctive tag (i.e., cue) was needed to retrieve the event from memory. All trials in our episodic test were equivalent in that no cues were given as to the location of events. However, had the current study given a test of free and cued recall (as in Fivush et al., 1984 and Bauer et al., 2012) rather than recognition, we may have observed different patterns in our results, particularly for older children who may have been more attuned to the oddity of the incongruent events.

On the other hand, in support of the idea that semantic memory did hinder memory for the location of events, is a notable difference in the results of Fivush et al. (1984) and current study regarding intrusions between event types. Even after a six-week delay, children participating in the study by Fivush and colleagues were able to recall the general event representation ("what happens on a trip to a museum") without intrusions from the specific event they had experienced ("what happened on the trip to the museum"), and vice versa. In the current study, curiosity over children's performance for incongruent trials motivated an examination of the errors that children made in responding to the locations of these events. Again, a match error is made when a child incorrectly responds that an event occurred at the location that would be congruent to the event. A non-match error is made when a child responds that the event occurred in any location other than the congruent location or the correct location. The examination of these errors may be one way to consider intrusions between event types. Specifically, if there were no intrusions of the general event representation on the specific events as in Fivush et al. (1984), we would expect that match errors would be rare and incorrect responses on these trials would be random (non-match errors) in nature. However, the finding that match errors differed from chance provides support for the idea that semantic memory, or the general event representation of what children would expect, perhaps played a hindering role in how children responded in recognizing the locations of events.

One may also consider the errors made on incongruent trials by returning to controlled processes. Just as semantic strategies provided a benefit to congruent events, the nature of errors on incongruent trials tells us that these strategies at times led children astray. For example, leveraging semantic information to guide retrieval of the location of the "bagging groceries" event would be a benefit if the event took place at the market, but not if the event took place at the medical center. However, our analysis of the errors made in the locations of incongruent events should be interpreted with caution as it is recognized that there are statistical limitations (e.g., limited number of trials, lack of independence across trials) of these analyses, and thus more work is needed to investigate the influence of semantic memory on incorrect responding in incongruent trials. Future studies should also examine whether older children are more likely to make these errors compared to younger children because of their greater semantic knowledge.

Conclusion

In conclusion, we looked to a naturalistic setting to examine the development of the relations of children's semantic and episodic memory. Although age effects were not found in the present investigation, our experimental manipulation allowed us to understand the contribution of semantic and episodic memory in children's memory for different types of events, particularly the location of these events. Future work could consider these findings from a developmental perspective perhaps using a different testing paradigm (i.e., recall rather than recognition) or a longer delay between study phase and test (e.g., days or weeks rather than minutes). We have also contributed a novel examination of children's semantic memory with a narrative task designed to assess what children know about locations. This contribution is important as semantic memory has most often been assessed with language-based tasks and little is known about children's knowledge of space. Finally, while the lack of a controlled laboratory environment may be seen as a limitation of the current investigation, we would continue to advocate for research that takes place in children's museums or science centers, as these settings provide an environment in which children can naturally experience learning and memory.

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APPENDIX A

TABLES

Table 1

Reasons for Excluding Participants from Analyses

	5		6		7		Totals	
Reason for Exclusion	M	F	M	F	F	M	*Study 1a*	*Study 1b*
Did not participate in all tasks (e.g. PPVT) due to fatigue or lack of time		4	1		1		6	
Did not participate in session 2	4	1		1				6
Software error; Unsaved data	2						2	
Did not understand or follow directions on episodic test	1					1	1	1
Totals	7	5	1	1	1	1	16	

Table 2

Participant Demographic Information

	Frequency (N)	Percentage
Visited Museum in Past Year		
Yes	55	64.0%
No	31	36.0%
Ethnic Background		
Not Hispanic or Latino	70	81.4%
Hispanic or Latino	12	14.0%
Racial Background		
Caucasian/White	58	67.4%
African American or Black	11	12.8%
Asian	2	2.3%
American Indian or Alaska Native	1	1.2%
More than one race indicated	9	10.5%
Yearly Household Income		
Less than $25,000	5	5.9%
$25,000 - $40,000	11	12.8%
$40,000 - $60,000	15	17.4%
$60,000 - $90,000	19	22.1%
Greater than $90,000	26	30.2%

Note. Demographic categories that do not sum to $N = 86$ are accounted for by situations in which the parent/guardian chose not to disclose information.

Table 3

Sample Responses from the Semantic Interview Task

Question	Response	Quantitative Score		Qualitative Score
		Raw	Weighted	
Who would be at a post office?				
	"Police"	0 CF 0 PF	0	0
	"Persons$_{CF}$"	1 CF 0 PF	2	1
	"The mailman$_{CF}$"	1 CF 0 PF	2	2
What kinds of things would you see at a post office?				
	"Robbers"	0 CF 0 PF	0	0
	"A box$_{CF}$. Trees, there might be… some trees outside"	1 CF 0 PF	2	1
	"You see mail$_{CF}$…and mail trucks$_{CF}$, boxes$_{CF}$, hm, magazines$_{PF}$…things that carry letters…oh, envelopes$_{CF}$!"	4 CF 1 PF	9	2
Why or when would you go to a post office?				
	"I don't know"	0 CF 0 PF	0	0
	"Sometimes you need to do things$_{CF}$ there"	1 CF 0 PF	2	1
	"To mail something off$_{CF}$…or, to make sure you get your mailbox fixed$_{PF}$."	1 CF 1 PF	3	2

Notes. CF = Central Fact. PF = Peripheral Fact. Responses in underline denote "defining features" (see Table 4).

Table 4

Qualitative Scoring of Semantic Task: Defining Features

Location		Defining Feature (1)	Defining Feature (2)
Bookstore/Library			
	Who	Bookseller OR librarian	People/shoppers buying, dropping off, or picking up books
	What	Books	
	Why/When	To get a book or drop off a book	To read a book
Construction Zone			
	Who	Construction workers	
	What	Building materials or equipment (may name specific materials or equipment, e.g. "trucks")	Tools (may name specific tools, e.g. "hammers")
	Why/When	To build something	To watch or check on building progress
(Grandma's) House			
	Who	Members of a family (may name specific family members, e.g. "a mom and dad")	
	What	Rooms (may name specific rooms in a house, e.g. "bedrooms")	Household items (may name specific items, e.g. "couches")
	Why/When	To live there	To visit someone who lives there
Market/Grocery Store			
	Who	Store workers	People/shoppers buying food
	What	Food	
	Why/When	To buy food	
Medical Center/Doctor's Office			
	Who	Doctor or nurse	Patients
	What	Exam rooms (may name specific items, e.g. "beds")	Medical tools (may name specific medical tools, e.g. "stethoscope")
	Why/When	If you are hurt, sick, or need a check up	To take someone who is hurt, sick, or needs a check up
Post Office			
	Who	Mail man or mail woman	Customers (buying mail supplies) OR people getting or sending mail
	What	Mail	Materials for mail (e.g. envelopes, packages, stamps, boxes)
	Why/When	To pick up or send mail	To buy supplies to mail something
Theater			
	Who	Actors OR theater workers	People watching a show
	What	Stage	Movies, movie screen OR movie theater seats
	Why/When	To watch a show OR movie	

Note. In order to receive 2 points for a question, the participant must have shared at least one defining feature. This one defining feature could have come from either category (1) or (2).

Table 5

Descriptive Statistics of Semantic Tasks

	Minimum	Maximum	Mean	Std. Deviation
PPVT				
5-year-olds	80.0	138.0	113.03	14.94
6-year-olds	82.0	131.0	112.72	12.31
7-year-olds	85.0	132.0	109.07	11.80
		(151.0)	(110.52)	(13.96)
All participants			111.64	13.07
			(112.09)	(13.67)
Semantic Interview Task				
Quantitative Scoring				
5-year-olds	16.0	91.0	40.38	15.98
6-year-olds	12.0	137.0	47.48	26.12
7-year-olds	32.0	95.0	57.04	18.12
All participants			48.20	21.48
Qualitative Scoring				
5-year-olds	.39	.97	.70	.19
6-year-olds	.33	1.0	.75	.17
7-year-olds	.58	1.0	.84	.12
All participants			.76	.17

Notes. PPVT = Peabody Picture Vocabulary Test, standardized scores given for this task. PPVT statistics for 7-year-olds and all participants given as: excluding outlier (including outlier). Semantic interview task: weighted scores given for quantitative scoring, proportion of total points possible (36) given for qualitative scoring.

Table 6

Response Classifications of the Episodic Task Recognition Question and Descriptive Statistics of Performance in Each Age Group

		Trial			
		Old			*New*
Panel a Participant Response	*Old*	Congruent Hit (H_C)	Incongruent Hit (H_{Inc})	Independent Hit (H_{Ind})	False Alarm (FA)
	New	Miss (M_C)	Miss (M_{Inc})	Miss (M_{Ind})	Correct Rejection (CR)
Panel b					
5-year-olds					
Participant Response	*Old*	.960 (.115)	.970 (.067)	.989 (.062)	.029 (.046)
	New	.040 (.115)	.030 (.067)	.012 (.062)	.971 (.046)
6-year-olds					
Participant Response	*Old*	.983 (.052)	.983 (.052)	.989 (.043)	.034 (.049)
	New	.017 (.052)	.017 (.052)	.012 (.043)	.966 (.049)
7-year-olds					
Participant Response	*Old*	1.00 (0)	.988 (.044)	.994 (.032)	.026 (.041)
	New	.00 (0)	.012 (.044)	.006 (.032)	.974 (.041)

Notes. Statistics given as: M (SD).

Table 7

Results of Regression on Children's Memory for Location of Incongruent Events

	Unstandardized Coefficients		Standardized Coefficient
Variable	B	Std. Error	β
Constant	-.322	.422	
CR baseline score	.251	.372	.074
Age in months	.005	.002	.263*
Standardized PPVT score	.005	.002	.310*
Semantic interview qualitative score	-.218	.182	-.169

Notes. R^2 = .317 (*ns*). *ps* < .05

APPENDIX B

FIGURES

Figure 1

Exhibits at the Greensboro Children's Museum.
Top (L-R): Bookstore, Construction Zone, Grandma's House; *Middle*: Market, Medical Center, Post Office; *Bottom:* Theater

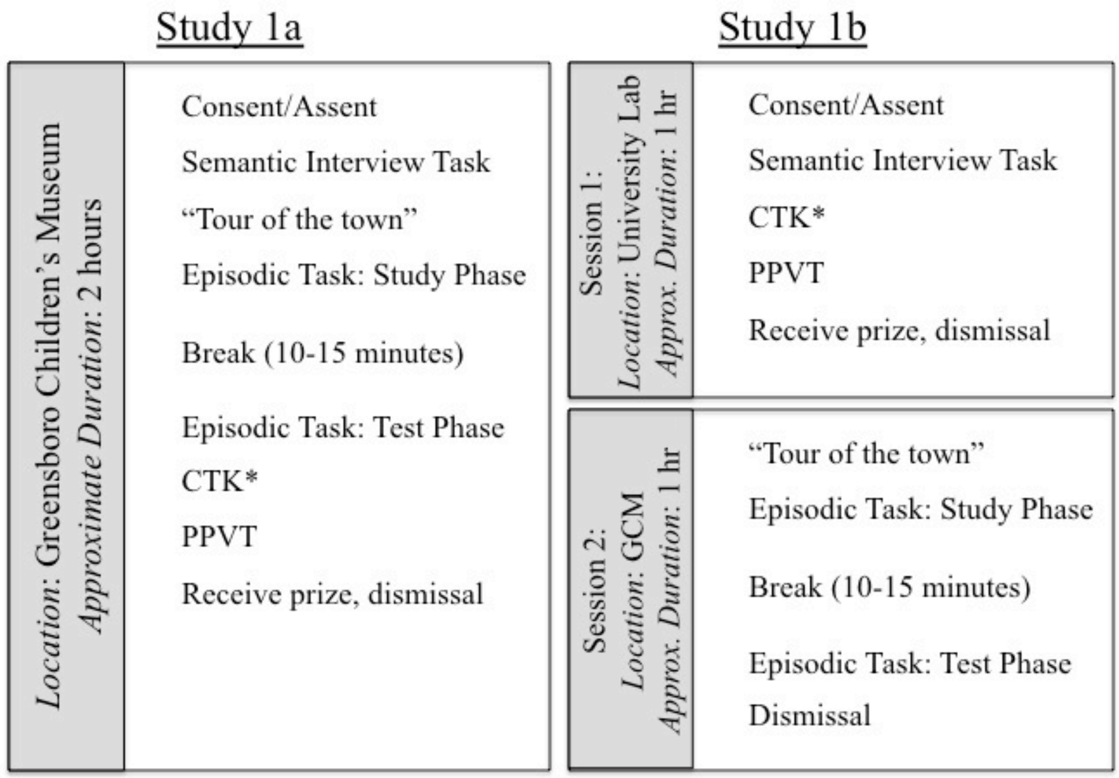

Figure 2

Order of Tasks in Study 1a and Study 1b. CTK = Conventional Time Knowledge task. *Task is not included in present analyses. PPVT = Peabody Picture Vocabulary Test.

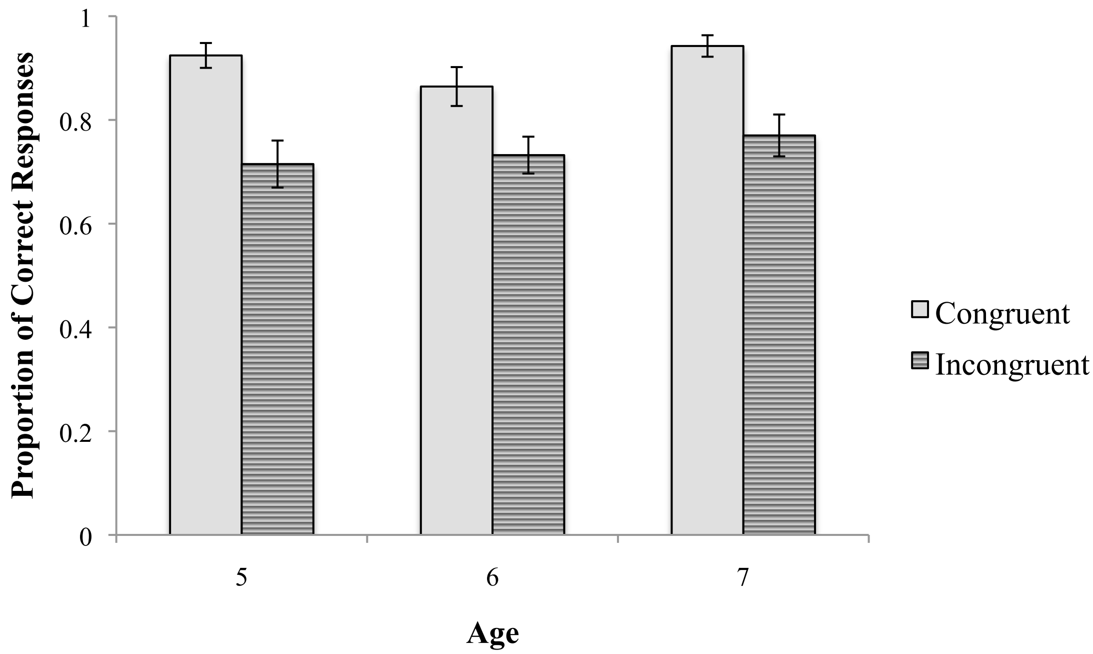

Figure 3

Children's Memory for Location. Effect of condition: $F(1,83) = 49.334$, $p < .001$, $\eta^2 = .373$

APPENDIX C

EVENTS

Spatially Congruent Events and Locations

Bookstore

A. Find a certain book among a stack of books
B. Collect books and put them into a bag
C. Read a book
D. Find a specific animal within the pictures in the book and place a bookmark on this page

Medical Center

A. Put a bandage on a teddy bear
B. Try on a white doctor's coat
C. Use a stethoscope
D. Check a baby doll's eyes with a tool

Construction Zone

A. Examine wires
B. Hammer a peg
C. Try on a construction belt
D. Tighten a screw on a tool box

Grandma's House

A. Set up a tea party
B. Set a place setting
C. Use an oven mit to take the lid off of a "hot" pan
D. Iron a shirt

Post Office

A. Get a package ready to be sent
B. Put a stamp on a letter
C. Sort mail (by colored envelopes)
D. Receive a package

Market

A. Put a price sticker on a box of cereal
B. Put groceries in a bag
C. Stack cans
D. Pay for groceries at a cash register

Theater

A. Try on a magician's cape
B. Put on a puppet show
C. Play a guitar
D. Pick out a costume

Spatially Independent Events

E. Twirl in a circle
E. Pretend to make a call with a phone
E. Play with a yo-yo
E. Researcher tells child about an activity
E. Using sense of touch, describe an item hidden in a box
E. Unwrap a piece of gum

F. Answer a question
F. Spin a top
F. Hear a joke
F. Touch toes
F. Tie a shoe
F. Researcher tells child about her family