THE DEVELOPMENT OF EPISODIC FORESIGHT IN PRESCHOOLERS

by

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ABSTRACT OF THE THESIS

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How does the ability to think and plan into the future develop? Previous studies suggest that the ability to think about and act upon the future, a process referred to as *episodic foresight*, emerges between the ages of 3 and 4 (Atance, 2008). However, it is unclear what underlying processes change during the development of episodic foresight. We hypothesize that episodic foresight consists of two separate processes: 1) the formation and maintenance of goals, and 2) the construction of simulated scenarios, each of which can be made more or less difficult based on the task at hand. We report an experiment that tested the emergence of these processes. The experiment focused primarily on the effect of the number of features that must be constructed and held in memory (4 or 6) and the goals that must be maintained (Subgoal then Final). The results indicate that four-year-old children are able to envision the future to successfully accomplish future goals, but are subject to working memory demands when there are more features in the future environment. However, three-year-olds are only able to attribute goals when the feature demands are low. When there are fewer features to construct, three-year-olds maintain only the final goal, ignoring the subgoal. Therefore, the development of episodic foresight progresses in conjunction with working memory, simulation and goal maintenance abilities.

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Introduction

Thinking about the future is a remarkable capacity. It allows us to envision and manipulate future scenarios in order to plan for various circumstances. We can project our feelings and desires to hypothetical future states, ranging from the abstract (e.g., finding love and happiness) to the concrete (e.g., what to make for dinner or what car to buy). We can anticipate future needs and carry out actions in the present to satisfy those needs. This profound ability to think into the future has its roots in episodic memory (Tulving, 1985; Tulving, 2002). Accordingly, the ability to envision the future and make choices in the present to satisfy future needs has been referred to as episodic foresight (Suddendorf, 2010). In this thesis, I will first review conceptions of semantic and episodic memory, and the relation between these two forms of memory to episodic foresight ability. I will also draw upon previous studies on the development of episodic foresight to illustrate the findings to date, and the resulting questions the field must address. I will then present a study that examines the role of simulation and goal maintenance in the development of episodic foresight. Finally, I will conclude by drawing some general lessons about episodic foresight and its underlying components through the course of development in preschool-aged children.

Two Main Memory Systems

Tulving (1972) distinguished between two main functions of memory: episodic memory and semantic memory. Episodic memory is described as memory for personal experiences, and semantic memory is thought of as explicit facts about the world, or else general knowledge about the world. Differing levels of consciousness have further elaborated this distinction. While semantic memory draws upon *noetic* consciousness, i.e., a subjective conscious experience in which spatial and temporal information are not needed to understand the world, episodic memory draws upon *autonoetic* consciousness, where spatial and temporal components of past memories are generated as a result of re-living the experience (Tulving, 1985). Clayton and Dickinson (1998) provide a more concrete idea of autonoetic consciousness; they state that in order to classify a memory as episodic, the “what”, “where” and “when” about the memory must be recalled. That is, individuals, through the process of re-living the memory, are able to consciously recall the specific contents (“what”, “where”, and “when”) of the episode. Noetic consciousness does not involve a conscious re-experience of a past episode, but simply understanding the gist of past experiences.

Episodic foresight draws differentially upon both memory systems. In order to make plans for the future, individuals must be aware of the components in the environment of their future goals, as well as the specific time and space in which these goals must be accomplished. Specific past experiences as well as general knowledge about the world helps inform individuals about the nature of the future environment. Therefore, episodic and semantic memory can be thought of as basic elements upon which future scenarios are built.

Distinction between Episodic Memory and Episodic Foresight

A wide variety of methodologies, including neuroimaging, phenomenology, and cognitive tasks, are used to discover similarities in the cognitive processes invoked for episodic memory and episodic foresight. Schacter, Addis, and Buckner (2007) found that the prefrontal cortex and medial temporal lobe, as well as some posterior regions, were activated both when subjects were asked to think about the past and the future. Further, D'Argembeau, Ortoleva, Jumentier, and Van der Linden (2006) found phenomenological similarities in narratives describing past and future events, including similarities in temporal distancing and emotional valence. Busby and Suddendorf (2005) asked children to talk about the past and the future. They found that by the age of four, children who cited accurate events in the past were also able to cite accurate events that would happen in the future (for instance, "play Uno with mommy"). This suggests that the ability to think about the past and future develop together, and rely on similar mechanisms.

However, these similarities conflict with other bodies of empirical evidence. For instance, individuals provide more sensory detail, cohesive, and emotional accounts of the past than the future (D'Argembeau and Van der Linden, 2010). In contrast, individuals tend to view the future more positively than the past in that they exhibit an optimistic bias towards the future (Bernsten & Bohn, 2010; Shao, Yao, Ceci, & Wang, 2010). The phenomenological differences, as well as the positive bias when thinking about the future, highlight a key difference between the purposes for thinking about the past versus that of the future. While recalling the past may help clarify details of an event that cannot be altered, thinking about the future allows individuals to generate goals and motivations, and create plans to enact them. Another distinction between episodic foresight and episodic memory is that although neuroimaging studies have shown overlapping areas of activation, certain areas show heightened activation only when individuals think about the past, and others are more active only when individuals think about the future (Schacter, Addis, & Buckner, 2007). Specifically, the frontopolar and mediotemporal regions are activated more during future thought (Okuda et al., 2003), and the prefrontal cortex is activated to a larger extent during future thinking than thinking about the past (Addis, Wong, & Schacter, 2007). Thinking about the future may require greater construction of the episode, since new details need to be included. This in turn may manifest in a more pronounced neural signal. Therefore, it is clear that episodic foresight and episodic memory refer to two different sets of operations.

Development of Episodic Foresight

Studying the development of episodic foresight allows researchers to understand the collection of processes (such as accessing episodic and semantic memory) that are involved in thinking into the future. Further, because it is considered by many to be a uniquely human capacity (Hampton & Schwartz, 2004; Roberts, 2002; Suddendorf & Corballis, 1997; Tulving, 2001), tracking its progression through development also informs the ecological and survival value that is associated with the ability for foresight.

Many tasks require preschool-aged children to generate examples of past and future experiences (Busby & Suddendorf, 2005; Grant & Suddendorf, 2010). These studies compare children's accounts of what did happen and will happen with their mother's reports of the actual events that will and will not occur. Their findings suggest that by the age of 4, children are able to give accurate accounts of the past and future, while younger children have difficulty when given a specific time constraint (e.g., what they will do tomorrow). Other metrics of episodic foresight specifically ask children to construct future scenarios in order to make choices in the present that will satisfy future needs (Atance & Meltzoff, 2005; Atance & O'Neill, 2005; McColgan & McCormack, 2008; Russell, Alexis, & Clayton, 2010; Suddendorf, Nielson, & von Gehlen, 2011; see Hudson, Mayhew, & Prabhakar, 2011 for a review). These tasks each vary different aspects affecting the construction of future episodes, including spatial perspective and memory for past experiences and goals. While five-year-old children are able to successfully plan for the future using episodic foresight, younger children are more limited in their ability to think into the future. Therefore, there is a clear progression of future thinking ability between the ages of 3 and 5.

Many studies have asked young children to describe the past and the future to learn when they can talk about points in time different from the present. Busby & Suddendorf (2005) asked three- and four-year-old children to describe what they did yesterday and what they will be doing tomorrow. They also asked children to describe what they did not do yesterday and what they will not be doing tomorrow. They found that four- and five-year-old children were able to answer the questions about their own past and future events significantly more accurately than three-year-old children. They concluded that episodic foresight emerges between the ages of 3 and 5. However, it is not clear whether children understood that the task called for them to choose accurately. Younger children may have misinterpreted the expectations of the task, and answer based on what they *would like* to do the next day or have already done the day before. Further, it is not clear whether younger children understood the distinction between the temporal tokens used (i.e., ‘tomorrow’ and ‘yesterday’). Grant & Suddendorf (2010) found that when they asked children what they did do and will do instead of using specific temporal terms (‘tomorrow’ and ‘yesterday’), younger children succeeded in the task. This suggests that the discrepancy could have occurred because three- and four-year-old children have not acquired the lexical terms used by the experimenters, and the results therefore suggest that, contrary to the experimenter's conclusions, younger children have the ability to envision temporal states different from the present.

Hudson, Shapiro, and Sosa (1995) asked three- to five-year-olds to make plans and produce scripts for various events (such as, a trip to the beach or to the grocery store). They found that while younger children were successfully able to produce scripts as well as plans that corrected errors in past plans, they faced greater difficulty when they had to create plans that prevented future events from occurring. By 5 years of age, children were able to create scripts as well as plans preventing future situations. This suggests that younger children are able to envision hypothetical scenarios, but have difficulty introducing new elements to an already-formed script or plan.

Atance and O'Neill (2005) asked children to explain their choice of an object to take on a future trip (e.g., a beach). This task required that children construct future episodes of visiting each location, assess specific needs in the future environment, and select the item that will best serve their needs and goals. They found that although three-year-old children were able to make the correct choices for their future self, they were unable to describe why they made that choice. This suggests that young children may have the capacity to self-project and anticipate future needs by making accurate choices in the present for the future state, but struggle when having to verbally express these choices.

Research on children's reference to future time in language show that between the ages of 3 and 7, children begin to distinguish between past, present, and future verb forms and modalities (Herriot, 1969; Harner, 1981). Notably, Harner (1975) found that three-year-old children interpreted “tomorrow” and other future lexical terms as “not-now” or “in-the-future” rather than its actual placement in time. Further, Grant & Suddendorf (2011) corroborated these findings through parental questionnaires, and found that preschoolers are able to use general temporal terms (‘not now’, ‘later’), but the use of lexical terms (‘tomorrow’, ‘yesterday’) emerges over the course of preschool years. These results are meaningful in explaining previous studies mentioned in this paper. Busby and Suddendorf (2005) found that three-year-old children were least accurate when having to recall their experiences yesterday and predict what they would do tomorrow. It is likely that these children interpreted the instructions as generating episodes that occur in a time period different from the present. Further, Atance & O’Neill (2005) found that three-year-old children had trouble when asked to explain their correct choices for the future. It is clear that these children are able to think about the future and face difficulty when having to verbally describe their thoughts.

Previous studies were unable to clearly establish the progression of episodic foresight in preschoolers sans language demands, and so one challenge for the discipline is to create measures of episodic foresight that do not solely rely on language. Many researchers use a choice paradigm to measure episodic foresight. These tasks measure projection of the self into the future by the choices children make in the present for their future needs. These paradigms allow researchers to ensure that future episodes must be constructed in order to do the task, and measure children’s ability to carry out goals and intentions through the choices they make for their future needs. Further, these tasks allow for the possibility of obtaining an implicit measure of children’s future thinking abilities (e.g., item selection) that minimizes the need for language.

Atance & Meltzoff (2005) asked children to select objects in anticipation of physiological states (e.g., hunger, thirst, cold). They found that 5-year-old children selected the items that were of functional use (such as a jacket for the cold) more frequently than those that did not serve a functional purpose, while three- and four-year-old children chose items that were semantically associated with the location (such as an ice cub for the cold location) just as frequently as the functional items. This study suggests that younger children may not implicitly project and simulate themselves in the future. With age, the need to consider various alternatives in the future may become more necessary and automatic. This would explain why older children chose the functional item more often, using a more goal-directed approach simulating the future.

Suddendorf, Nielson, and von Gehlen (2011) assessed goal-directed choices to obtain a reward. They accustomed children to an apparatus that required using a tool to obtain a sticker. After either learning to use the tool or being shown the correct shape of the tool needed, children were removed from the room and asked, either immediately or after a 15 minute delay, to select 1 item out of 3 to take back to the first room in which they played (that the apparatus was in this room was not told to the child). They found that four-year-old children chose the correct tool significantly more than chance during both delay conditions, while three-year-old children were above chance only when asked immediately and when they were in the same spatial location as when they first were shown the tool. This suggests that episodic foresight ability in three-year-old children is affected by temporal and spatial displacements. The result is further corroborated by a study conducted by Russell, Alexis, and Clayton (2010) where the researchers found that both three- and four-year-old children had difficulty in making functional choices for the next day and from a different spatial perspective. Further, they found that while three-year-old children were poor in making future decision both from their own perspective and from another individual's perspective, four-year-old children were more successful when having to make future decisions from another individual's perspective. A common theme in the experiments above is that spatial re-orientation requires additional cognitive processing that diminishes young children's future episodic thinking.

These studies provide evidence that between the ages of 3 and 4, children improve considerably in their ability to think about the future. Four-year-old children are able to flexibly recombine past experiences with knowledge about the world in order to construct future scenarios to act upon their future goals (Grant & Suddendorf, 2010; Suddendorf et al., 2011), but find it difficult when having to construct future scenarios in varying spatial perspectives (Russell et al., 2010). And while three-year-olds do show the ability to construct novel scenarios (Atance & O'Neill, 2005), they have limited capacity to deal with high temporal and spatial demands (Russell et al., 2010; Suddendorf et al., 2011). Therefore, there exists a clear developmental shift that occurs between the ages of 3 and 4.

A Dual-Process Account of Episodic Foresight

Two main components unique to episodic foresight are evident in many of the studies reviewed above. First, the construction of future episodes involves recombining past experiences as well as one's general knowledge about the world to create hypothetical future scenarios (Addis et al., 2007; Corballis, 2003; Szpunar et al., 2007). Information generated to construct future scenarios result in a unique experience. Thinking about the past involves reconstructing events that have already occurred, and does not require individuals to generate new information or details. Second, episodic foresight requires one to enact intentional actions, construct future goals, and optionally act upon those goals (Szpunar, 2010). Construction of details about a future episode follows from the motivation to create them. This motivation comes in the form of goals to be acted upon. We therefore hypothesize that episodic foresight consists of two separate processes: 1) the formation and maintenance of goals, and 2) the construction of simulated scenarios. We accordingly conducted an experiment to test whether the maintenance of goals and the construction of simulated scenarios are vital processes in episodic foresight.

Experiment

In the present experiment, we examined children's ability to use episodic foresight in completing a two-step goal sequence. In particular, we examined the effects of feature demands and type of goal. When constructing future scenarios, individuals must generate and hold in memory features of the future environment that "convey the perceived essence of the events" (Szpunar, 2010; p. 149). By manipulating the features in the environment, we can understand the process of episodic construction in future scenarios, and by giving children two goals to accomplish, we can determine children's ability to hold multiple goals in mind during episodic foresight. Further, by minimizing spatial demands that cause limitations for both three- and four-year-old children and providing children with two goals and a set number of features to construct, we sought to track the developmental course of episodic foresight as a result of episode construction and goal maintenance.

We asked three- and four-year-old children to carry out two goals by choosing locations in a pretend neighborhood (see Figures 1 and 2) to visit that will satisfy each future goal, the first to get a present for a friend, and the second to attend the friend's birthday party. For each goal, children had to project themselves to the future point in time, construct novel scenarios and outcomes for each location, assess whether each scenario satisfies future goals, and if it does, implement the intended actions. By keeping the model in view and without altering the child's perspective, spatial demands were minimized. Further, we adopted similar language constructions used in past studies (Russell et al., 2010; Grant & Suddendorf, 2011), i.e., our instructions used auxiliary verbs in their future tense ("will", "going", "go"). Features were defined as the number of locations in the pretend neighborhood. Feature demands were manipulated by changing the number of features (houses and stores) in the future environment (High versus Low). Children were divided into different perspective group (Self versus Other). The errors children make when choosing which location satisfies each goal in all of these conditions can inform the kinds of limitations they face when constructing future scenarios.

Our account predicted that when the feature demand is low, younger children would benefit from having fewer features to construct in the future scenario and be able to choose the correct locations for both goals. When the feature demand is high, we predicted that only four-year-olds would succeed in accomplishing both goals.

Method

Participants. 124 children participated in the study: 60 3-year-old children (mean age = 42 months; 25 males, 35 females) and 64 4-year-old children (mean age = 54 months; 34

males, 30 females). Participants were predominantly white native-English speakers from middle-class backgrounds. They were recruited from preschools near New Brunswick, NJ. Parents of the children in these schools provided consent for their children to participate, and children were given stickers and certificates for participation.

Materials. Materials included a 36” x 48” model of a neighborhood (see Figures 1 and 2). Each model contained different numbers of miniature houses and stores around a black road. The same street layout was used in all conditions, but the number of houses and stores positioned in the neighborhood varied by feature demands. Each child was given one of two dolls: boys were shown a boy doll; girls were shown a girl doll. These dolls were used to move from one location to another in the neighborhood, based on the children’s choices. A video camera was also used to record each session.

Procedure and design. Children in all conditions were introduced to the model neighborhood, the toy houses, and stores. All children were given two goals (a Subgoal and a Final goal) and were asked to move a doll to the locations that satisfied each goal. Half of the children were randomly assigned to the Low Demand condition and were shown two target locations and two distractor locations (see Figure 1); the remaining children were assigned to the High Demand condition and were shown two target locations and four distractor locations (see Figure 2). Thus, the memory demands varied between conditions. Children in the high demand condition had to consider more locations (specifically, twice the number of distractors) than did children in the low demand condition.

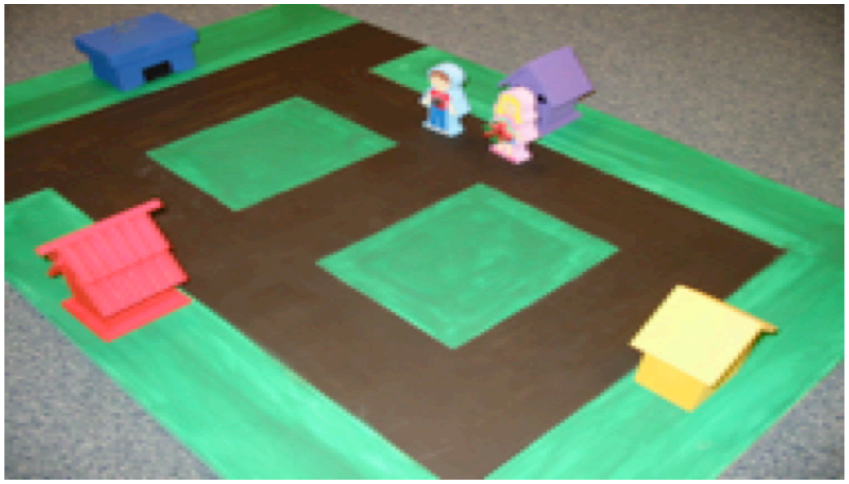

Figure 1. Image of the 3-D Neighborhood in the Low Demand condition, with two target locations and two distractor locations.

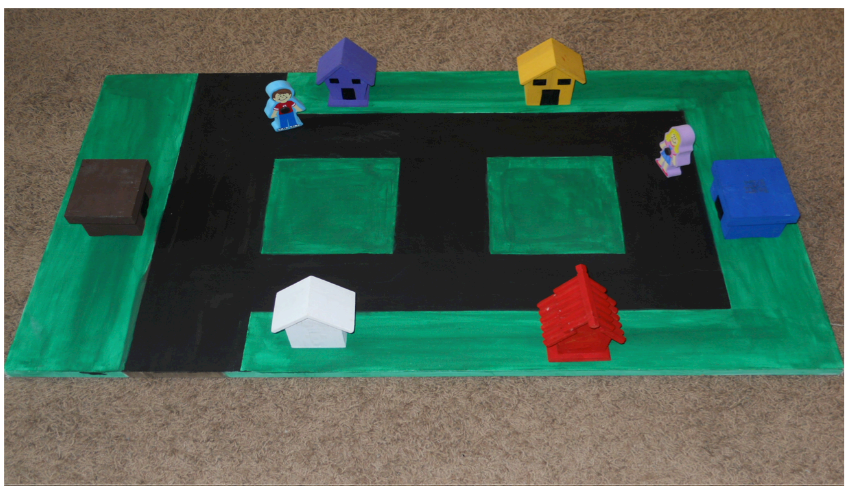

Figure 2. Image of the 3-D Neighborhood in the High Demand condition, with two target locations and four distractor locations.

Within each demand condition, half of the children were asked to make future choices for themselves (Self condition) and the remaining children were asked to make future choices for another individual (Other condition). This allowed us to manipulate perspective-taking in the future. The manipulation was added to form a basis for comparison between drawing on one's own experiences to inform one's own future and another individual's future. Three-year-old children are successful in many Theory of Mind and Intention Attribution tasks and are able to attribute mental states to others (Phillips, Baron-Cohen, & Rutter, 1998; Russell & Hill, 2001; Russell, Hill, & Franco, 2001; Wellman, Cross, & Watson, 2001). However, while some studies suggest that thinking about the self will be easier for children (Harris, 1991), others suggest that thinking about the self in the future is more difficult (Russell et al., 2010). Therefore, the perspective condition was also included to tease apart this difference.

All children were first given practice trials to test their memory for the locations in the neighborhood, and as well as their understanding of how to move the doll from one location to the next. Children were then provided with the goals. Children in the self condition were told:

> *Today is Mary's birthday and Mary is going to have a birthday party at her house. You want to give Mary a birthday present. Where will you go first?* [Prompt for the Subgoal]. *You now have a present for the birthday party. Where will you go next?* [Prompt for the Final Goal].

Children in the other perspective condition were told:

> *Today is Mary's birthday and Mary is going to have a birthday party at her house. Charlie/Jill wants to give Mary a birthday present. Where will he/she go first?* [Prompt for the Subgoal]. *Charlie/Jill now has a present for the birthday party. Where will he/she go next?* [Prompt for the Final Goal].

Children had to correctly identify goals by pointing to and naming the subgoal (the toy store) and final goal (Mary's house). In both cases, children were corrected if they chose the wrong location. For every correct answer, children were given 1 point, with a possibility of obtaining a total of 2 points. Therefore, in this study, we were interested in the effect of Age (3 vs. 4-year-old children), Feature demands (Low vs. High), Goal (Subgoal vs. Final) and Perspective (Self vs. Other) in children's ability to choose the correct location to satisfy future needs.

Results

A series of ANOVAs were run to determine the effect of each of the independent variables on overall accuracy, subgoal accuracy (choosing the toy store), and final goal accuracy (choosing Mary's house). Additional analyses were conducted to understand the choices children gave for the subgoal question.

Preliminary analyses found no effects of gender, so analyses were collapsed across this variable.

Overall accuracy. A 2 (Age group: 3 vs. 4) x 2 (Feature Demands: High vs. Low) x 2 (Perspective: Self vs. Other) x 2 (Goal: Subgoal vs. Final) Mixed Factorial Analysis of Variance (ANOVA) was performed on children's accuracy in selecting the correct location. This analysis produced significant main effects of Age, $F(1,116)=19.87$, $p<0.001$, and Goal, $F(1, 116) = 14.00$, $p< 0.001$, and significant two-way interactions between Demand and Goal, $F(1, 116) = 5.04$, $p< 0.05$, and between Age and Goal, $F(1, 116) = 14.93$, $p< 0.001$. Four-year-old children were significantly more accurate in selecting the correct location for both goals than were three year-old children. Three-year-old children were more accurate in selecting the correct location for the final goal than for the subgoal. Further, all children were most accurate in selecting the correct final goal when the demand was low. These effects are shown in Figures 3 and 4. To further examine these interaction effects, separate analyses were performed on children's responses to the subgoal and final goal questions.

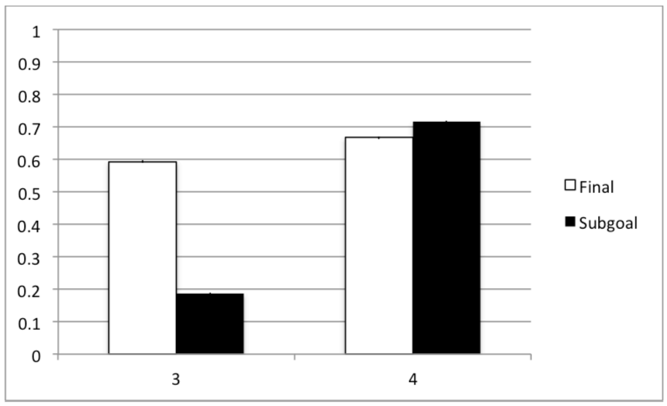

Figure 3. Mean number of correct responses by age and type of goal question.

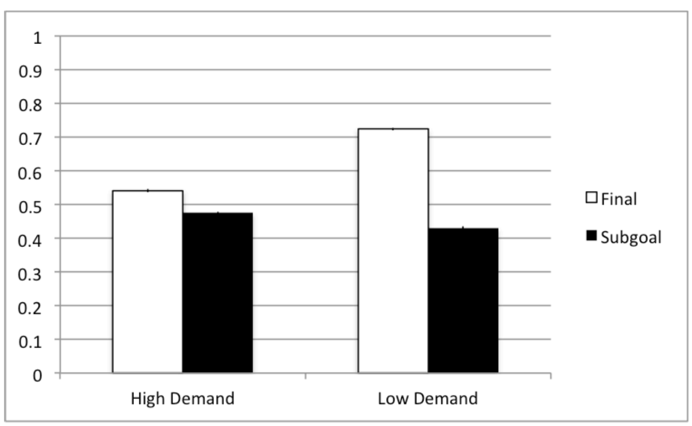

Figure 4. Mean number of correct responses by goal question (final and subgoal) and demand condition (high and low)

Subgoal accuracy. A 2 (Age group: 3 vs. 4) x 2 (Feature Demands: High vs. Low) x 2 (Perspective: Self vs. Other) between-subjects analysis of variance (ANOVA) was performed on the number of correct responses to the subgoal question (correct answer was the toy store). Four-year-olds were significantly more accurate (67% correct) than three-year-olds (18% correct), and so the analysis yielded a significant main effect of Age, $F(1, 116) = 38.37$, $p < 0.001$, but no other significant main or interaction effects.

Final goal accuracy. A 2 (Age group: 3 vs. 4) x 2 (Feature Demands: High vs. Low) x 2 (Perspective: Self vs. Other) between-subjects analysis of variance (ANOVA) was performed on the number of correct responses to the final goal question (correct answer was Mary's House). All children were more accurate in the low demand condition (73% correct) than in the high demand condition (55% correct), and so the ANOVA yielded a significant main effect of feature demand, $F(1,116) = 4.20$, $p < 0.05$, but no other significant main or interaction effects.

To examine whether responses to the final goal question were dependent on performance on the subgoal location question, two correlations were performed on the correct response scores for the subgoal and final goal questions. No significant relationship was found between accuracy on the subgoal location and final goal questions in the high demand, $r = 0.14$, $p = 0.29$, or low demand conditions, $r = 0.21$, $p = 0.10$.

Responses to subgoal location questions. To further explore age differences in children's responses to the subgoal question, specific responses to this question were examined to determine the source of younger children's errors. Did younger children perform randomly or did they display a response bias to select particular distractor items?[1]

Table 1.
Percentage of children selecting each of the possible options for the Subgoal location.

		Incorrect	Incorrect	Correct
Age	Demand	Chose Mary's House	Chose Distractor	Chose Toy Store
3	High	14	66*	21
3	Low	53*	30	17
4	High	6	22	72*
4	Low	18	11	71*

Note: * means different from chance (1/3) by Binomial test, $p < 0.05$

Table 1 reflects the number of children who chose each possible location for the subgoal in each demand condition. In response to the question asking for the subgoal location, 53% of three-year-olds in the low demand condition (N = 30) erroneously chose the final goal location (Mary's house), but only 14% percent of three-year-olds in the high demand condition (N = 29) erroneously chose the final goal location, a difference that was statistically significant (Mann-Whitney test, z=3.18, p=0.001). In addition, three-year-old children in the low demand condition chose the final goal location (N = 30) significantly more than chance (binomial test, $p < 0.05$). In the high demand condition, three-year-old (N = 29) chose the distractor location significantly more than chance (binomial test, $p < 0.001$). Three-year-old children were at chance when choosing all other locations. Four-year-old children (N = 60) chose the correct target location in all perspective and feature demand conditions (significantly more than chance by binomial test, $p < 0.01$). Since we did not find any differences in the perspective condition, this is not reflected in the table. These results indicate that while four-year-old children successfully chose the toy store for the subgoal, three-year-old children faced difficulty in selecting the correct location. Specifically, when the demand was low, they skipped the subgoal and selected the location that satisfies the final goal. Further, when the demand was high, children were unable to assess both goals, and chose the distractor most often.

Discussion

This study examined preschoolers' ability to envision the future in order to achieve two goals, a subgoal and a final goal. Past studies have shown differential future thinking abilities between three- and four-year-old children (Atance & O'Neill, 2005; Grant & Suddendorf, 2010; Russell et al, 2010; Suddendorf et al., 2011), and our aim was to determine the changes in this ability that occur between 3 and 4, and to assess the capacity of episodic foresight in four-year-old children. We predicted that children in the younger age group would succeed when given two goals in the low demand condition, and children in the older age group would succeed when given two goals in both demand conditions.

Results indicated that four-year-old children are better able to construct future scenarios than are three-year-old children. When the feature demands were low, younger children tended to skip the subgoal location, and selected the final goal location significantly more than chance. Four-year-old children accurately satisfied the subgoal, and were only able to choose the correct final goal location when the demand was low.

The development of Episodic Foresight in Preschoolers

These results suggest that the episodic foresight hinges on two vital functions: the ability to form and maintain goals, and the ability to simulate features in the environment. Through the preschool years, children gain the ability to hold multiple goals and features in memory. These basic functions are necessary in order for children to be able to draw inferences from their choices and correct errors in their judgments. Four-year-olds can infer the correct location to buy a toy and are able to remember Mary's house as the birthday party location, but only when the demand is low. When the demand is high, they are less accurate in remembering the correct location of the birthday party. This suggests that four-year-old children have trouble maintaining several goals when their working memory is also taxed with simulation of six environmental features (high demand). Three-year-old children fail to infer the location to buy a birthday present, both in high and low demand. In the low demand condition, three-year-olds skip the subgoal, and are able to attribute the final goal. Their difficulty in inferring the correct location to buy a present, and difficulty in successfully meeting both goals in the high demand can either be a result of goal maintenance demands, simulation demands, or both. Therefore, goal maintenance and simulation occurs simultaneously during episodic foresight, and improvements in working memory capacity lead to better and more accurate performance.

Three-year-old children and Episodic Foresight

Our study shows that three-year-old children are not entirely limited in future thinking capabilities. When task demands are minimized, they are able to accomplish goal-directed decisions using episodic foresight. According to Suddendorf (2010), abilities crucial to episodic foresight involve envisioning future states by re-combining general knowledge and past experiences into novel future scenarios, and evaluating them based on their likelihood to satisfy future goals. Three-year-old children in this study were able to effectively combine these elements to satisfy a single goal. Their problem with multiple goal sequences may be attributed to encoding errors. Specifically, younger children may be unable to encode and store multiple goals in memory when there are many environmental features to be considered. Instead, they may encode either the goal with more activation cues or the one that requires fewer simulation demands.

The final goal was mentioned more frequently in the script, so younger children may have focused on the final goal, and as a result, ignored the subgoal. This explanation is consistent with recent research on goal maintenance that reveals that a subgoal receives higher activation with greater frequency or primes that cue goal retrieval, and is therefore maintained with greater ease than competing subgoals (Anderson et al., 2004; Trafton, Altmann, & Ratwani, 2011; Borst & Taatgen, 2007). In our experiment, younger children may have preferred the final goal to the subgoal because in the script, they were told about Mary's birthday party twice but were only told that they needed to buy a present once. The script began with "Today is Mary's birthday and Mary will be having a birthday party at her house." Here, Mary's birthday party receives two activation cues, while the need to buy the present is only mentioned once when the subgoal is given: "You would like to buy Mary a birthday present." The final goal has both a higher frequency and greater number of primes to aide goal retrieval when the first prompt is asked, "Where will you go first?"

Another reason that could have made younger children erroneously select the final goal is that the simulation of the location that satisfied the final goal required children to simply locate Mary’s house. This task is less demanding than simulating the subgoal, which requires children to infer where to buy a toy and whether each location would satisfy that need. Younger children may have had a more difficult time holding several mental states in mind to draw the necessary inference. While the final goal draws more upon episodic memory (remembering the location of each house and store), the subgoal draws equally upon both episodic memory and semantic memory (to determine whether a toy can be bought at the location).

The influence of both greater activation cue and fewer simulation demands could have influenced three-year-olds to correctly attribute the final goal, skipping the subgoal. Further research is required to understand the influence of each of these contributing factors.

When feature demands were high, younger children chose the distractor significantly more than by chance, suggesting that when there are more features in the environment to construct in a future scenario, younger children ignore the future goals and choose solely on the locations that were more frequent in number (the distractors).

Four-year-old children and Episodic Foresight

It is evident that four-year-old children were able to act upon goals in the tasks presented in this study. Four-year-olds were able to construct accurate future scenarios, select the proper locations to satisfy each goal, and enact each goal in the correct order both when there were high and low demands. However, with high memory demands, memory for the final goal may have been compromised and four-year-old children, as well as three-year-old children, were less accurate in selecting the final goal in high versus low demand.

General conclusions

Four-year-old children were able to mentally represent intermediate steps to achieve a final goal, while three-year-old children had difficulty mentally representing multiple goals. Three-year-old children may have been unable to hold multiple states in memory. When feature demands were minimized, however, three-year-olds demonstrated a limited ability to consider future goals; although they provided an incorrect response to the question regarding the subgoal location, their response patterns indicated that they were nevertheless considering one of the goals (the final goal) and not responding in a random fashion. This suggests that they have a nascent, but tenuous ability to mentally simulate future goals, but that the ability is highly influenced by the cognitive demands required to understand an unfamiliar task.

Unlike results reported by Russell et al. (2010), children's overall performance was not affected by perspective. In Russell et al.'s (2010) study, children had to make choices from a spatial perspective different from their past experience. In our study, we did not vary the spatial perspective between present and future. Therefore, we were able to show that with minimal spatial demands, children as young as 3 are able to construct future scenarios and maintain goals for themselves and for other individuals.

The development of episodic foresight hinges on two vital functions: the ability to maintain goals, and the ability to simulate multiple features in the environment. This research suggests that four environmental features are optimal for emerging episodic foresight ability in three-year-old children. Further research is needed to understand whether more familiar or less demanding situations can better support young children's emerging abilities to mentally simulate future event goals.

References

Addis, D. R., Wong, A. T., & Schacter, D. L. (2007). Remembering the past and imagining the future: Common and distinct neural substrates during event construction and elaboration. *Neuropsychologia, 45(7)*, 1363–1377.

Anderson, J. R., Bothell, D., Byrne, M. D., Douglass, S., Lebiere, C., & Qin, Y. (2004). An Integrated Theory of the Mind. *Psychological Review, 111(4)*, 1036-1060.

Atance, C. M. (2008). Future thinking in young children. *Current Directions in Psychological Science, 17(4)*, 295-298.

Atance, C. M., & Meltzoff, A. N. (2005). My future self: Young children's ability to anticipate and explain future states. *Cognitive Development, 20(3),* 341–361.

Atance, C. M., & O'Neill, D. K. (2005). Preschoolers' talk about future situations. *First Language, 25(1)*, 5-18.

Bernsten, D. & Bohn, A. (2010). Remembering and forecasting: the relationship between autobiographical memory and episodic future thinking. *Memory & Cognition, 38,* 265-278.

Borst, J., & Taatgen, N. (2007). The costs of multitasking in threaded cognition. In *Proceedings of the 8th International Conference on Cognitive Modeling*. Ann Arbor, Michigan, USA.

Busby, J., & Suddendorf, T. (2005). Recalling yesterday and predicting tomorrow. *Cognitive Development, 20(3),* 362–372.

Clayton, N. S., & Dickinson, A. (1998). Episodic-like memory during cache recovery by scrub jays. *Nature, 395,* 272-274.

Corballis, M. C. (2003). From mouth to hand: Gesture, speech, and the evolution of right-handedness. *Behavioral and Brain Sciences, 26,* 199-260.

D'Argembeau, A., & Van der Linden, M. (2006). Individual differences in the phenomenology of mental time travel: The effect of vivid visual imagery and emotion regulation strategies. *Consciousness and Cognition: An International Journal, 15(2),* 342–350.

Grant, J. B., & Suddendorf, T. (2010). Young children's ability to distinguish past and future changes in physical and mental states. *British Journal of Developmental Psychology, 28,* 87-95.

Grant & Suddendorf (2011). Production of temporal terms by 3-, 4-, and 5-year-old children. *Early Childhood Research Quarterly, 26,* 87-95.

Harner, L. (1975). Yesterday and tomorrow: Development of early understanding of the terms. *Developmental Psychology, 11,* 864-865.

Harner, L. (1981). Children talk about the time and aspect of actions. *Child Development, 52(2),* 498–506.

Herriot, P. (1969). The comprehension of tense by young children. *Child Development, 40,* 103–110.

Hudson, J. A., Shapiro, L. R., & Sosa, B. B. (1995). Planning in the real world: Preschool children's scripts and plans for familiar events. *Child Development, 66(4),* 984–998.

Hudson, J. A., Mayhew, E. M. Y., & Prabhakar, J. (2011). The development of episodic foresight: Emerging concepts and methods. *Advances in Child Development and Behavior, 40,* 95-137.

McColgan, K. L., & McCormack, T. (2008). Searching and planning: Young children's reasoning about past and future event sequences. *Child Development, 79(5),* 1477-1497.

Okuda, J., Toshikatsu, F., Ohtake, H., Tsuklura, T., Tanji, K., Suzuki, K., … Yamadori, A. (2003). Thinking of the future and past: the roles of the frontal pole and the medial temporal lobes. *NeuroImage, 19(4),* 1369-1380.

Phillips, W., Baron-Cohen, S., & Rutter, M. (1998). Understanding intention in normal development and in Autism. *British Journal of Developmental Psychology, 16(3),* 337-348.

Russell, J., Alexis, D., & Clayton, N. (2010). Episodic future thinking in 3- to 5-year-old children: The ability to think of what will be needed from a different point of view. *Cognition, 114(1),* 56-71.

Russell, J., & Hill, E. L. (2001). Action-monitoring and intention reporting in children with Autism. *Journal of Child Psychology and Psychiatry, 42,* 317-328.

Russell, J., Hill, E. L., & Franco, F. (2001). The role of belief veracity in understanding intentions-in-actions: Preschool children's performance on transparent intentions task. *Cognitive Development, 16(3),* 775-792.

Schacter, D. L., Addis, D. R., & Buckner, R. L. (2007). Remembering the past to imagine the future: The prospective brain. Nature Reviews. *Neuroscience, 8(9),* 657-661.

Shao, Y., Yao, X., Ceci, S. J., & Wang, Q. (2010). Does the self drive mental time travel? *Memory, 18,* 855-862.

Suddendorf, T. (2010). Episodic memory versus episodic foresight: Similarities and differences. *WIREs Cognitive Science, 1,* 99-107.

Suddendorf, T., Nielson, M., & von Gehlen, R. (2011). Children's capacity to remember a novel problem and to secure its future solution. *Developmental Science, 14(1),* 26-33.

Szpunar, K. K. (2010). Episodic future thought: An emerging concept. *Perspective on Psychological Science, 5(2)*, 142-162.

Szpunar, K. K., Watson, J. M., & McDermott, K. B. (2007). Neural substrates of envisioning the future. *Proceedings of the National Academy of Sciences of the Unites States of America, 104(2)*, 642-647.

Trafton, J. G., Altmann, E. M., & Ratwani, R. M. (2011). A memory for goals model of sequence errors. *Cognitive Systems Research, 12*, 134-143.

Tulving, E. (1972). *Episodic and semantic memory*. Oxford, England: Academic Press.

Tulving, E. (1985). Memory and consciousness. *Canadian Psychology, 26*, 1-12.

Tulving, E. (2002). Episodic memory: From mind to brain. *Annual Review of Psychology, 53(1)*, 1-25.

Wellman, H. M., Cross, D., & Watson, J. (2001). Meta-Analysis of Theory-of-Mind development: The truth about false belief. *Child Development, 72(3)*, 655- 684.

Endnotes

[1]Due to experimental error in video recording, the specific choice made by four four-year-old children and one three-year-old child for the subgoal location was missing. Therefore, this portion of the results section reflects 59 three-year-old children and 60 four-year-old children.