An Investigation of Children's Future Thinking and Spontaneous Talk About the Future

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Dissertation submitted to the Faculty of Graduate and Postdoctoral Studies
in partial fulfillment of the requirements for the Ph.D. in Clinical Psychology.

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Acknowledgments

I count myself profoundly fortunate to have had Dr. Cristina Atance as my doctoral supervisor. I have greatly appreciated her mentorship, expertise, flexibility, humour, and warmth.

Thanks to my thesis committee: Dr. Chris Fennell, Dr. Patricia Brosseau-Liard, and Dr. Stuart Hammond. Their kind support has made training in the developmental unit a pleasure.

This research was made possible by *exceptional* research assistants and honours students. They dedicated many weekends and evenings to recruiting participants, collecting data, and watching study videos. I express my heartfelt thanks to Bronwyn O'Brien, Maria Fakhouri, Joana Mukunzi, Katie Cassidy, Hana Ziani-Bey, Katherine Dueck, Lojain Hamwi, Breanne Harper, Isabelle Cossette, Maiziel Serrao, Breanna Bell-Lee, Sam Austin, Stephanie Strahm, and Stephanie Williams. I will also be forever grateful to the many children who lent us their fascinating minds.

It has been a great pleasure to spend the last few years with members of the Childhood Cognition and Learning Lab and our neighbours.

Thank you to my funders, including the University of Ottawa, The Natural Sciences and Engineering Research Council of Canada, and the Government of Ontario.

I dedicate this dissertation to my mother, Diane Thornton; father, Francis Caza; and sister, Charlotte Caza. I could not have asked for a more supportive family.

Content of Dissertation and Contributions of Authors

This dissertation follows a multiple-article format and includes two articles: (1) “Children’s Behavior and Spontaneous Talk in a Future Thinking Task” and (2) “Can Children Represent a Future That Differs From the Present?” The first article was published in the peer-reviewed journal *Psychological Research* (Caza & Atance, 2019). The writer of the thesis (Julian S. Caza) appears as the first author and the thesis supervisor (Cristina M. Atance) appears as a co-author. The second article (Caza, O’Brien, Cassidy, Ziani-Bey, & Atance, in preparation) will soon be submitted to a peer-reviewed journal. The writer of the thesis (Julian S. Caza) appears as the first author and the thesis supervisor (Cristina M. Atance) appears as a co-author. Also included as authors are NSERC Undergraduate Student Research Award summer student Bronwyn M. O’Brien, and honours students Kathleen S. Cassidy and Hana A. Ziani-Bey. Bronwyn M. O’Brien, Kathleen S. Cassidy, and Hana A. Ziani-Bey all contributed to data collection and provided feedback on the manuscript.

For both articles, Julian S. Caza’s contributions included theoretical and methodological formulations for the research, including the research proposal, literature review, collecting and analyzing data, manuscript preparation, and manuscript revision. Dr. Atance offered input and expertise during each phase of the research formulation and manuscript preparation and contributed to the manuscript revisions.

Abstract

This dissertation addresses three novel aspects of children's future thinking:

First is a study of 3- to 5-year-olds' capacity to think about the future across two different conceptual domains. Specifically, children had to think ahead to meet either a future physiological need (desire for food) or psychological need (avoiding boredom). Most future thinking tasks only require children to plan in one domain, this despite that future thinking is presumably domain general in humans. Children were better at addressing a future need for food than a future need for toys, with even 3-year-olds succeeding above chance. This study also served as an opportunity to replicate the results of a previous similar task (Atance et al., 2015) and improve the task by removing unnecessary components (social, pretense).

Second is a study of 3- to 5-year-olds' spontaneous talk (as a proxy for spontaneous thought) about the future and past within the context of a behavioural future thinking task. Spontaneous or involuntary thought about the past and future are ubiquitous in adult cognition. Few developmental studies have investigated past spontaneous thought, and none have investigated future spontaneous thought. Children of all ages spontaneously spoke about the future and past and some children even spontaneously solved the future thinking task. Further, children who spontaneously spoke more about the past and future were more likely to correctly answer an explicit test question.

Third is an attempt at addressing a limitation in all existing behavioural future thinking tasks: That is, tasks used to assess the development of future thinking do not require children to think ahead about a future state of the world that *differs* from the present. Children could potentially be solving behavioural future thinking tasks without having to represent the future. However, representing a future that differs from the present is argued to be core to adaptive future thinking in humans. To overcome this limitation, we modified an existing task so that children could not succeed based on their representation of how the world currently is but, rather, how it *will be* at a future point in time. Four- to 7-year-olds all remembered the information required to solve the modified task; however, only 7-year-olds made a future-oriented decision more often than chance. With the task modification removed (so the correct answer for the present and future matched), even 4-year-olds succeeded above chance. These findings challenge the current accounts that suggest by age 4, children can reliably succeed in future thinking tasks.

Taken together, this research program contributes new insights to the development of future thinking in early childhood and suggests directions for novel research.

Keywords: development, mental time travel, episodic future thinking, representation, spontaneous cognition

Chapter 1: General Introduction

The human capacity to think about the future has remarkable survival implications: We are able to mentally simulate possible futures before taking the risk of acting in the present. Future thinking has likely played an important role in humans' evolution and extraordinary success across diverse environments (Ambrose, 2010; Suddendorf & Corballis, 1997, 2007).

The ability to mentally project oneself to the past and future has been called "mental time travel" (Suddendorf & Corballis, 1997). Mental time travel to the future (or "episodic future thinking"; Atance & O'Neill, 2001) is a cornerstone of adult life, allowing us to flexibly predict likely futures and act accordingly. Humans make frequent mental excursions to the future (even more frequent than our mental trips to the past; Oettingen, Sevincer, & Gollwitzer, 2018). Many human activities—from the mundane trip to the grocery store to the most profound wonderings about what it might be like to be 100 years old—are made possible in part by a capacity to mentally travel to the future.

Despite its role in daily life and the evolution of our species, future thinking has only relatively recently been investigated in young children; thus, many questions about its development remain unanswered. When do children begin mentally projecting themselves into the future to pre-experience events? And at what point do children begin using their mental forays into the future to help make decisions? Although research about children's future thinking is still in its early stages, developmental scientists have already designed several ingenious tasks to track the development of episodic future thinking over the preschool years.

Objectives

This dissertation consists of two large studies in manuscript format, both meant to expand the developmental methodologies used to measure future thinking. The first article (Chapter 2) was recently published (Caza & Atance, 2019), and the second (Chapter 3) will be submitted for publication shortly. These studies addressed three shortcomings of the developmental future thinking literature:

- First, existing tasks have failed to systematically examine children's capacity to think about the future across different domains (Chapter 2).
- Second, existing tasks rely on explicitly prompting children's forethought as opposed to examining *spontaneous* future thinking (Chapter 2).
- Third, existing tasks might be solvable by relying on representations of the present alone (Chapter 3).

Background

Future thinking: A rapidly expanding research focus

Recent years have seen a substantial increase in future thinking research across many subfields, including cognitive neuroscience, developmental science, social psychology, and comparative psychology (Michaelian, Klein, & Szpunar, 2016a; Oettingen et al., 2018). This interdisciplinary interest in future thinking has produced many terms to describe the set of cognitive abilities enabling humans to project themselves into an imagined future, including *episodic future thinking, prospection, episodic simulation, projection, mental time travel into the future, episodic foresight, autobiographical planning, future-oriented cognition* and others (Martin-Ordas, Atance, & Caza, 2014; Szpunar, Spreng, & Schacter, 2014). For the purpose of this proposal, I use the term "episodic future thinking" to describe future-oriented mental time travel.

The episodic-semantic distinction in memory and future thinking

The majority of research about mental time travel has examined humans' ability to re-experience the past (i.e., episodic memory) (Michaelian, Klein, & Szpunar, 2016b). Episodic memory allows humans to travel backwards through subjective time to remember personally experienced events (Tulving, 2005). For instance, remembering a specific birthday party you attended last week—including what you saw, heard, felt, and smelled—would involve your episodic memory system. Tulving (2005) argued that episodic memory is characterized by a particular phenomenology; namely, it is a traveling back in subjective time in the first person to experience situations that are tied to the self. Episodic memory is contrasted with semantic memory, which is a collection of facts about the world. For example, recalling what happens at parties in general—for example, singing "Happy Birthday" and blowing out candles—would be a semantic memory process.

Atance and O'Neill (2001, 2005) have argued that a similar episodic-semantic distinction underlies thinking about the future (i.e., simulating a personal future event vs. generating facts or scripts about the future). For example, when planning the amount of time I need to set aside to prepare my favourite meal—peameal bacon on naan bread—I mainly rely on semantic processing. I have a good sense of how long the bacon usually takes to fry and how long naan bread takes to heat, and the steps are script-like. There is no need for me to mentally simulate and pre-experience all of the steps (e.g., simulating in my mind's eye taking the bacon out of the fridge, turning on the stove, opening the packaging) in order to plan the amount of preparation time I require every time I decide to make bacon and naan. In contrast, when I have to make a recipe for the first time, I am more likely to mentally simulate the various steps (i.e., use episodic future thinking) in order to accurately plan the amount of time I should set aside to make the meal. I might mentally pre-experience cutting the vegetables, using a particular bowl, or setting the stove to a particular temperature. As in this example, episodic processing is generally more likely (and adaptive) when thinking about novel future events, whereas semantic processing is more likely when thinking about habitual future events.

Nevertheless, memory and future thinking researchers have increasingly argued that there is considerable overlap between semantic and episodic processes. For example, the simulation of preparing a novel meal is certainly episodic in nature because I am projecting myself to a specific time and place in the future. However, the episodic simulation is populated with semantic details (e.g., "bowls are used in recipes," "knives are used to cut vegetables"). In this sense, episodic and semantic systems are interrelated (Martin-Ordas et al., 2014). Further, it is possible to hold personal semantic knowledge (e.g., "I am a good cook") and then to project that into the future (e.g., "I want to be a professional chef in the future"). This form of future thinking *is* autobiographical; however, it is not referring to a specific episode in the future, so it may be best characterized as a semantic-episodic hybrid (Szpunar et al., 2014).

Szpunar et al. (2014) have proposed a taxonomy of future-oriented cognition in an effort to harmonize terms used by future thinking researchers across disciplines and to highlight the differences between various forms of future thinking. They described four modes of future thinking, which they argued capture the bulk of the literature on future-oriented thinking. The four modes they described are "simulation (construction of a detailed mental representation of the future), prediction (estimation of the likelihood of and/or one's reaction to a particular future outcome), intention (the mental act of setting a goal), and planning (the identification and organization of steps toward achieving a goal state)" (p. 18415). Instead of positing a hard distinction between episodic and semantic variants of the four modes (e.g., semantic simulation vs. episodic simulation), they instead proposed that semantic and episodic processing are best conceptualized as two ends of a dimension and that semantic-episodic hybrid forms of thinking are possible. The studies I describe in this proposal involve children having to reason about a specific autobiographical future event and likely involve some combination of episodic variants of all four of Szpunar et al.'s modes. Indeed, Szpunar et al. acknowledged that the different modes interact to enable flexible future-oriented cognition. For simplicity, I continue to use the term "episodic future thinking" in this proposal.

Episodic future thinking and episodic memory: Two directions of mental time travel

Increasingly, researchers have begun to conceptualize episodic memory and episodic future thinking as two highly related capacities, allowing humans to mentally re-experience the past and also mentally pre-experience possible futures (Atance & O'Neill, 2001; Martin-Ordas et al., 2014; Michaelian et al., 2016b; Suddendorf & Corballis, 1997, 2007). Klein (2013) has even argued that memory's selective advantage lies in its capacity to allow for planning for future survival challenges; reliving the personal past, then, is conceptualized as a secondary component of episodic memory and not its primary "purpose." Relatedly, Schacter and Addis (2007) have argued that a central role of memory is to provide a "database" of information to use when planning for the future. Brain imaging studies in adults suggest that past- and future-oriented mental time travel involve overlapping brain systems (see Benoit & Schacter, 2015, for a meta-analysis). Moreover, neuropsychological research has highlighted that deficits in episodic memory and future thinking often co-occur in patients with hippocampal damage (Addis & Schacter, 2012; Buckner, 2010).

Research in adults has also begun to investigate the phenomenology of future thinking through the use of interviews meant to induce episodic future thinking. For instance, adults are more likely to think about future events that are temporally near versus distant (Spreng & Levine, 2006), and adults report more details, emotional valence, and familiarity when thinking about the near future compared to the more distant future (D'Argembeau & Van der Linden, 2004). Researchers have also investigated the errors adults are prone to make when simulating the future and making predictions (Gilbert & Wilson, 2007). For instance, Quoidbach, Gilbert, and Wilson (2013) have explored the "end of history illusion" (p. 96), which describes people's tendency to report that they have changed a lot in the past but will change little in the future (in other words, that they have reached the end of their personal history).

Recent investigations have also highlighted possible adaptive functions of episodic future thinking. For example, inducing episodic thinking is related to improvements in adults' problem-solving, subjective sense of well-being, and positive coping behaviours (Jing, Madore, & Schacter, 2016; Madore & Schacter, 2014). The adaptive potential of episodic thinking is also echoed in the clinical treatment literature, where "imaginal exposure" (which includes mentally exposing oneself to distressing past or future episodes) has been established as an effective treatment for anxiety and related disorders (Abramowitz, Deacon, & Whiteside, 2019). Episodic thinking may also boost performance on creativity (specifically divergent thinking) and imagination tasks (Addis, Pan, Musicaro, & Schacter, 2016; Madore, Addis, & Schacter, 2015; Madore, Jing, & Schacter, 2016). Some recent evidence suggests that engaging in episodic future thinking is associated with reduced delay discounting (i.e., discounting a large future reward for a small immediate reward) (Daniel, Stanton, & Epstein, 2013; Peters & Büchel, 2010).

Developmental researchers in particular have proposed that episodic future thinking may also be associated with (or contribute to) other future-oriented constructs commonly investigated in children, such as delay of gratification, planning, and prospective memory (i.e., remembering to do something in the future, such as remembering to bring your homework tomorrow) (Hudson, Mayhew, & Prabhakar, 2011). In sum, episodic thinking has been associated with a host of adaptive cognitive processes and behaviours, and yet many research avenues remain to be explored, particularly surrounding its development during childhood.

Future thinking in children

While adult future thinking research has examined phenomenology and associated cognitive processes, research with young children has mainly focused on developing methods to capture episodic future thinking in a population with limited capacity to describe inner experiences (Hudson et al., 2011). Future thinking has been investigated in children using diverse methodologies, reviewed in the following sections. Some investigations have employed "verbal" methods, which bear some similarity to the interview procedures used with adults. Others, however, have used "behavioural" methods, which are more similar to methods used with non-human animals (Atance & Mahy, 2016).

Verbal tasks. Verbal future thinking tasks generally require children to generate future-oriented verbal responses to questions about their personal futures. In an early verbal task, Hudson, Shapiro, and Sosa (1995) asked 3- to 5-year-old children to produce scripts or plans for two familiar events: grocery shopping and going to the beach. Before completing the task, children were given a sample script and plan for going to a third location: the zoo. The sample script emphasized typical zoo activities, such as seeing animals, and the sample plan emphasized preparation activities, such as bringing lunch and looking at a zoo map. After hearing the condition-specific zoo example, children in the script condition were asked, "Now can you tell me what happens when you go to the beach [grocery shopping]?" Children in the plan condition were asked, "Now can you tell me a plan for going to the beach [grocery shopping]?" Children's scripts for these two common events did not differ with age. Children's plans, however, were more elaborate and complete with increasing age. Although not directly addressed in this study, the findings are consistent with the idea that plans may (at least partially) draw on later-developing episodic processes, whereas scripts may rely on earlier-established semantic processes. However, it is not clear that plans must *always* rely on episodic processes (Quon & Atance, 2010).

In another verbal task, Busby and Suddendorf (2005) asked 3- to 5-year-olds simple questions about yesterday and tomorrow. More specifically, they asked children "Can you tell me something that you [did/are going to do] [yesterday/tomorrow]?" and "Can you tell me something that you [didn't/are not going to] do [yesterday/tomorrow]?" Children had to generate events, which were rated for accuracy by their parents. Four- and 5-year-olds tended to generate plausible events for tomorrow (69% and 63%, respectively). Although 3-year-olds also generated future events, their events were judged to be unrealistic by their parents (31% generated plausible events). Suddendorf (2010) later replicated these age differences in accuracy and showed they could not be accounted for by age differences in children's ability to answer non-temporal divergent thinking questions, suggesting that the developmental difference could not be accounted for by differences in verbal generativity (i.e., children's capacity to generate non-temporal verbal material). Interestingly, divergent thinking was associated with the number of answers children gave to the tomorrow questions, consistent with Madore et al.'s (2015) findings that divergent thinking and episodic future thinking are related in adults.

Quon and Atance (2010) also asked children about their personal future; however, instead of asking broad open-ended questions, they asked the children to talk about specific events (e.g., breakfast, playtime, bedtime). They asked questions such as, "What are you going to eat for breakfast tomorrow?" and "What are you going to do at bedtime tonight?" They found 3-, 4-, and 5-year-olds provided accurate responses 60, 69, and 81 percent of the time, respectively, suggesting that using these more specific questions scaffolded younger children's performance. Consistent with this claim, Hayne, Gross, McNamee, Fitzgibbon, and Tustin (2011) also asked 3- to 5-year-olds to talk about specific events, but this time events generated by their parents. Children's reports were rated as accurate 90 percent of the time, and there was no effect of age.

Results from these verbal tasks suggest that there is some development in children's ability to reason about the future between ages 3 and 5. Although even 3-year-olds can generate future events, they appear to have difficulty providing *plausible* future events. With increased structure to the tasks, as in Quon and Atance (2010) and Hayne et al. (2011), 3-year-olds' performance improves.

Verbal tasks do have their limitations. Since they rely heavily on children's ability to formulate verbal responses and understand temporal terms (e.g., "tomorrow," "when you're older"), developing verbal abilities could potentially mask children's mental projections into the future. Indeed, Busby Grant and Suddendorf (2011) found that 3- to 5-year-olds are in the midst of mastering many temporal terms (according to parents' report), which could influence their understanding of verbal tasks. Indeed, verbal tasks require that children represent the future *and* describe their thoughts verbally; this second step may be difficult for young children (Hudson et al., 2011). To address these limitations, some researchers have employed "behavioural" future thinking tasks, requiring preschoolers to behave in a future-oriented manner as opposed to simply speaking accurately about the future.

Behavioural tasks. Studying episodic future thinking in children poses a particular challenge because of preschoolers' limited ability to describe their own mental experiences. Hence, developmental researchers have turned to the animal literature for inspiration on developing behavioural tests of future-oriented cognition. Indeed, behavioural tests of mental time travel have been developed for primates and birds (Premack, 2007; Raby, Alexis, Dickinson, & Clayton, 2007). These tests, however, have been controversial (Martin-Ordas, 2016; Osvath, 2016; Redshaw & Bulley, 2018; Suddendorf & Corballis, 2010; Thom & Clayton, 2016). It has been remarkably challenging to design behavioural tasks that could not be solved using strategies other than episodic future thinking (e.g., associative learning, innate response tendencies, reasoning based on representations of the present). Hence, there is still considerable debate in the comparative and developmental literatures around the validity of tasks used to assess future thinking. These literatures are therefore still focussed on the development of novel methods to assess future thinking.

Tulving (2005) proposed a purely behavioural method called the "spoon test," which has been applied as the "gold standard" method for detecting future thinking in non-human animals, and developmental scientists have also used modified versions of the spoon test to detect future thinking in young children. The spoon test is based on an Estonian tale about a young girl who dreamed she was at a party where delicious pudding was served; however, she had forgotten to bring a spoon, so she could have none (it was a bring-your-own-spoon affair). The next night, before going to sleep, the little girl found a spoon and took it with her to bed in anticipation of needing it to eat the pudding in the future. Developmental researchers have tried to create tasks that share features of Tulving's spoon test (i.e., creating scenarios in which future thinking can be inferred by the participant's selection of a specific item, the spoon in the case of Tulving's story).

Suddendorf and Corballis (2010) expanded on Tulving's (2005) spoon test by identifying criteria necessary for behavioural tests of future thinking to meet; this, to rule out alternative explanations for children's performance. First, in order to maximize the likelihood that episodic future thinking—and not some other strategy (e.g., associative learning)—is used to solve a task, single trials should be used to reduce the possibility of participants learning the correct response through a stimulus-reward relationship after repeated exposure to the task. Further, they argued using single trials helps to ensure that participants solve the task based on memory for a specific event (i.e., an episodic memory) as opposed to a general fact about the world (i.e., a semantic memory). Second, tasks should pose a novel problem, which avoids the possibility of participants succeeding based on innate response tendencies (i.e., highly specialized cognitive abilities only useful in a very particular domain and not reflective of a more general capacity to flexibly envision the personal future). Using a novel problem also reduces the effect of individual participants' learning histories. Hence, it decreases the likelihood that script-based or more semantic strategies could be used to solve the task. Third, it is necessary to implement a spatial-temporal separation between the problem and the test question. Spatial separation avoids cuing based on seeing the test materials, and temporal separation ensures that the relevant task information is in long-term memory (and episodic memory in particular), rather than working memory. Finally, the use of multiple domains was recommended, as success across multiple domains suggests a more general cognitive capacity for episodic thinking (which is *flexible*) as opposed to a highly specialized innate behavioural predisposition (which is more rigid).

Some researchers have created “spoon test” tasks in which children must select a certain item (or items) from a group of distracter items in order to solve a future problem (e.g., Atance & Sommerville, 2014; Payne, Taylor, Hayne, & Scarf, 2015; Redshaw & Suddendorf, 2013; Russell, Alexis, & Clayton, 2010; Scarf, Gross, Colombo, & Hayne, 2013; Suddendorf & Busby, 2005; Suddendorf, Nielsen, & von Gehlen, 2011). These “item-selection” tasks satisfy many of Suddendorf and Corballis’ (2010) criteria for future thinking tasks.

In one “item-selection” protocol, Russell et al. (2010) taught 3- to 5-year-old children how to play a novel game: “blow football.” The aim of the game was to use straws to blow a ping-pong ball into the opponent’s goal. The experimenter played the game from the blue side, while children played from the red side. Children could reach the red side by standing on a yellow box, while the blue side was too high for children. After playing from the red side, children were informed that they would come back to play the blow football game tomorrow but from the blue side instead of the red side. Children were shown pictures of six items—two functional (a straw and a yellow box) and four non-functional (cardboard referee, a stuffed animal spectator, a themed necklace, and a pair of football boots)—and asked to point to the two things they wanted the experimenter to save for them so they could play blow football properly on the blue side tomorrow. Only 5-year-olds were able to select the two functional items at a rate higher than chance. Russell et al.'s task satisfied many of Suddendorf and Corballis' (2010) criteria for future thinking tasks, with the exception of spatial separation, as the test question was asked in the same room as the blow football game.

Building on a previously-used item-selection task (Suddendorf & Busby, 2005), Suddendorf et al. (2011; Experiment 2) presented children with a problem (a locked box with a missing key) in one room. Afterwards, in a second room, children were presented with a series of items, only one of which (an intact key) was appropriate for solving the problem in the first room.

More specifically, in Room A ("Tweetie Bird's Room"), children saw a box with a large triangular keyhole. The child saw the experimenter demonstrate how to open the box by sliding a triangle key into the hole. Inside the box were "desirable objects" only obtainable by using the triangle key. Children were able to try the mechanism themselves twice. The box was then removed from the table and a second box, this time with a square keyhole, was placed on the table. The experimenter demonstrated that the triangle key did not fit in the square keyhole, and children were also able to try the mechanism to confirm that the key did not fit. In an Instant condition, children were taken behind a curtain in the corner of the room and shown three keys (circle, star, and square). Children were asked to select one item to bring back (without being allowed to look at the apparatus). In a Delay condition, participants were told that they would play games in a second room (Room B). In Room B, children played with unrelated toys for 15 minutes. Suddendorf et al. then told children that they were going back to Tweetie Bird's Room (Room A). Children were presented with the same three keys as in the Instant condition and asked to select one to bring back to Room A. Both 3- and 4-year-olds succeeded when they were able to select an item right away, but only 4-year-olds succeeded when they had to wait 15 minutes before choosing an item. In the Instant condition, both 3- and 4-year-olds selected the correct key in 87.5 percent of cases, which was significantly above chance (i.e., 33%). In the Delay condition, however, 3-year-olds were at chance, while 4-year-olds were above chance. Suddendorf et al. (2011) also created a food-based item selection task in which children had to select the correct food (instead of the correct key) to bring back to feed a stuffed animal. Children performed similarly on the food item-selection task, with both age groups above chance in the Instant condition and only 4-year-olds above chance in the Delay condition. Suddendorf et al. argued that their protocol satisfied all of Suddendorf and Corballis' (2010) criteria for future thinking tasks.

Despite this claim, some researchers have argued that children's failures (and successes) on item-selection tasks such as Suddendorf et al.'s (2011) and Russell et al.'s (2010) cannot be unambiguously interpreted because children's success or failure could still be explained by variables other than future thinking ability (Atance, Louw, & Clayton, 2015; Hudson et al., 2011). For instance, item-selection tasks require children to choose the correct object from among a set of distracters. Young children's executive control is still developing, which may impair their ability to choose among different items that vary in their desirability (e.g., children could find a star-shaped key more desirable than a square-shaped key). Furthermore, children could potentially solve the task using an associative strategy, rather than an episodic future thinking strategy. For instance, if the problem in the first room is a locked box with a square keyhole, and one of the solution items is a square key, then children could select the correct item simply because they associate square keys with square locks or because they associate a square shape with a reward in the box (and not because they mentally projected themselves into the future).

Children could also fail the task by forgetting crucial information before the test questions are asked (e.g., the shape of the keyhole in the first room). In the case of Russell et al.'s (2010) task, children are required to employ spatial reasoning in addition to any future thinking strategies, so developing abilities in spatial rotation could obscure children's true ability to represent the future (Hudson et al., 2011). Furthermore, the test questions in Russell et al.'s (2010) protocol were lengthy, which may have overloaded working memory, especially for 3- and 4-year-olds. The competing explanations reviewed here raise the possibility of either over- or underestimating young children's true future thinking ability. Indeed, Hudson et al. (2011) have argued that "many of the recent methods used to study future thinking in young children often embed tasks of thinking about the future in more complex tasks that may require advanced verbal skills, understanding of temporal language, memory for task instructions or materials, inhibitory mechanisms and working memory capacity" (p. 128).

With respect to memory in particular, both Atance and Sommerville (2014) and Scarf et al. (2013) have demonstrated that children's failures on item-selection tasks are mainly due to their inability to remember crucial information about the task, as opposed to specific deficits in future thinking. Atance and Sommerville (2014) developed an item-selection task based on Suddendorf et al.'s (2011) and explicitly asked children memory questions about the problem. They found that memory failures alone could account for age differences in task performance. Scarf et al. (2013) also employed an item-selection task but systematically varied the delay between the presentation of the problem and the test question. They found that increases in the delay impacted 3-year-olds' performance, which again suggested that memory limitations could account for 3-year-olds' failures on the future thinking question. Clearly, new tasks that minimize extraneous memory demands (as well as tasks that control for memory) are required to better detect the emergence of future thinking in young children.

To reduce the role of children's memory and executive function limitations in future thinking tasks, Atance et al. (2015) created a novel behavioural paradigm based on a task originally carried out by Raby et al. (2007) with birds (western scrub-jays). Western scrub-jays are a member of the corvid family, the same family as crows, ravens, magpies, and blue jays. (As an aside, Grey jays—or Canada jays—are also a member of this family and were recently selected as "Canada's national bird" by *Canadian Geographic*, in part due to their "intelligence" and "friendliness.") The corvid family of birds has been the focus of recent study, as corvids possess a large brain-to-body ratio and display future-oriented behaviour, namely, caching food. Raby et al. wanted to see whether the scrub-jays would modify where they cached food after learning that they would be hungry in a particular location. This preferential caching could be evidence of an episodic-like planning system in scrub-jays (although this claim is controversial) (e.g., Osvath, 2016; Suddendorf & Corballis, 2010).

In Raby et al.'s (2007) protocol, scrub-jays alternated between two compartments for six days. In one compartment, the birds always got breakfast (powdered food), but in the other compartment, the birds never got breakfast. On the test day, the birds were given the opportunity to cache solid food in either compartment. Raby et al. reasoned that putting the food in the no-breakfast compartment would suggest that the birds were anticipating being hungry again in that compartment the next day and planning accordingly. Importantly, the birds were also allowed to eat the to-be-cached food, which suggests that a current state of hunger could not cue or entirely explain caching behaviour. Indeed, the birds cached more food in the no-breakfast compartment than in the breakfast compartment, suggesting that the scrub-jays may have been able to "plan" where a resource would be needed to satisfy a future physiological state (hunger) that differed from a current physiological state (not hungry).

Atance et al. (2015) modified the scrub-jay protocol in several ways before using it with children. Children were informed that they would be visiting two rooms: Big Bird's room and Ernie's room (these rooms were identified with pictures of the *Sesame Street* characters on the doors.) One of these rooms contained toys to play with, while the other did not. Children entered one of the rooms with the experimenter for 3 minutes (there was a timer in the room), where the experimenter opened one of the drawers to find a puppet version of either Big Bird or Ernie. The experimenter asked the puppet whether he had any toys for the child. The puppet then "whispered" the answer in the experimenter's ear. If the puppet had toys, the children were allowed to play with them. If not, children had to wait with nothing to do. The child remained in the room until the timer sounded, while the experimenter pretended to work in the corner. Once the three minutes were up, the experimenter and the child walked to the second room. A puppet was again consulted and children either learned that there were or were not toys in the second room (the opposite of the previous room). The process then repeated (children returned to the first room and then the second room, again for 3 minutes each time).

After visiting each room twice (a total of four 3-minute visits), children were asked two memory questions, followed by a future thinking question. The memory questions were asked to determine whether preschoolers were able to recall the information necessary to correctly answer the future thinking question. Children were led to the hallway outside the two testing rooms and the experimenter said, "This is Ernie's room—what did you play with in Ernie's room?'' and ''This is Big Bird's room—what did you play with in Big Bird's room?'' (order was counterbalanced). Regardless of their responses, children were provided with the correct answers to these two memory questions. If children failed the memory questions, then poor performance on the future thinking question would be difficult to interpret because children's failure could be due to memory limitations as opposed to future thinking limitations. After children were asked the memory questions, they were led to an adjoining hallway, out of view of the two testing rooms, where they were asked the future thinking question. Children were shown a basket with two toys that were slightly different from the toys they had played with in the room that contained toys. Children were then told that they would be returning to the lab when they were 4/5/6 years old (i.e., one year older than their current age) and were asked the following future thinking question: “Where would you like to put these for next time?” (correct answer: no-toy room).

Atance et al.’s (2015) two-rooms task differed from previous item-selection tasks (e.g., Suddendorf et al.’s, 2011) because instead of selecting an item among distracters, children had to select the room where a resource (i.e., toys) would be needed in the future. This difference in the protocol arguably reduced executive control and memory demands, as there were no competing items and the only information children had to remember was which room was lacking the resource.

Indeed, memory performance was above chance for all three age groups, suggesting that memory was not a “limiting factor” in children’s performance on the future thinking question. However, 3-year-olds were not above chance in stating that they would place the toys in the no-toy room (57% correct), whereas 4- and 5-year-olds’ performance was significantly above chance (79% and 88%, respectively). Even when Atance et al. (2015) only included 3-year-olds who passed the memory questions, 3-year-olds were still at chance on the future thinking question, suggesting that 3-year-olds’ poor performance on the future thinking question could not be explained by memory failure alone.

Atance et al.’s (2015) novel behavioural method is promising because it addresses a major shortcoming of existing item-selection tasks: namely, that children’s failures could be explained by memory limitations as opposed to future thinking limitations. However, there is still a possibility that children solved Atance et al.’s task with strategies other than future thinking. Recall that Atance et al. used Big Bird and Ernie to identify the two rooms. Doing so may have led children to answer the future thinking question in part to fulfill social demands as opposed to their own future interests. For instance, children could have reasoned, “I’m going to put the toys in Ernie’s room because he has nothing to play with, and it’s good to share!” This answer, while displaying desirable pro-social behaviour, would not be evidence of episodic future thinking. Further, the puppets are clearly not “real.” Children can see that the experimenter controls the puppets, which adds an unnecessary level of pretense to the protocol.

Nevertheless, Atance et al.’s (2015) protocol satisfied many of Suddendorf and Corballis’ (2010) criteria for future thinking tasks. Children were presented with a novel problem (i.e., a lack of toys in a specific room), which decreases the likelihood that children could have solved the task based on previous learning experiences or innate behaviour. Further, using an associative strategy would presumably result in children offering the incorrect response (i.e., toys go with toys, so put the toys in the toy room). Atance et al. (2015) also aimed for spatial separation between the task stimuli and the test question location, particularly for the future thinking question, which was asked out of sight of the testing rooms. The memory questions were asked in front of the testing rooms, however. Further, the relevant task information (i.e., which room contained toys) was stated to children shortly before they were asked the test question, which raises the possibility that temporal separation was not entirely satisfied. Asking the memory questions before the future thinking question may have primed children, making it easier for them to correctly answer the future thinking question; this, as compared to the memory questions being asked afterwards. Finally, Atance et al. used one domain in their task (i.e., toys), whereas Suddendorf and Corballis (2010) recommended the use of multiple domains to assess the “flexibility” of children’s future-oriented behaviour. To our knowledge, no investigation has unambiguously assessed children’s future thinking across conceptually distinct domains. This is an important issue, however, because it speaks to whether or not children’s future thinking emerges evenly across different domains.

Investigations in this Dissertation

Considering the literature reviewed above, I decided to specifically address some of the open questions in the developmental future thinking literature.

Chapter 2: Children's behaviour and spontaneous talk in a future thinking task

Humans' ability to imagine and plan for the future is a domain-general capacity—it is not limited to a particular situation or context (Suddendorf & Busby, 2005). Although certain non-human animals display impressive future-oriented behaviours in restricted contexts (e.g., Raby et al., 2007), no other species studied possesses forethought as seemingly flexible as humans' (Hoerl & McCormack, 2018; Redshaw & Bulley, 2018; Suddendorf & Corballis, 2007, 2010). Some researchers (e.g., Suddendorf & Corballis, 2007, 2010) have argued that the capacity to plan for the future across many different contexts and conceptual domains may be unique to humans and likely played an important role in human evolution.

Because domain generality is central to adults' future-oriented thought, an important issue to explore is whether this feature also characterizes the future-oriented cognition of young children. Although a number of studies have shown that children can select a tool (e.g., key) to obtain a future reward (e.g., a sticker; Suddendorf et al., 2011), we know little about whether children can do this across different kinds of contexts and also whether their capacity to think ahead varies depending on the conceptual domain under study (Hudson et al., 2011). For instance, might there be some conceptual domains where children reason more precociously than others? Experiments that systematically vary task characteristics such as stimuli and context are required to address this question.

We examined 3- to 5-year-olds' future thinking across two stimulus domains—toys and food—using a modified version of Atance et al.'s (2015) two-rooms procedure. Whereas the toy condition required children to think ahead about a more "psychological" need (i.e., avoiding boredom), the food condition required children to think ahead to satisfy a more "physiological" need. This study served to document the flexibility of future thinking across development.

The toy condition also served as a replication of Atance et al. (2015). Replication is a core component of the scientific method; however many researchers have recently argued that replication—though lauded in theory—has been under-emphasized in practice across many scientific fields, including psychological science (e.g., Lindsay, 2015). Recent failures to replicate high-impact psychological research findings (e.g., Open Science Collaboration, 2015) only continue to highlight the central role of replication in psychology.

We also made a few modifications to Atance et al.'s (2015) procedure to make the task more realistic and minimize pretense to avoid alternative explanations for children's performance. First, the social aspect introduced by using Big Bird and Ernie puppets was removed so that children's success could not be explained by pro-social reasoning. Second, the memory questions were asked *after*, rather than *before,* the future thinking question: Atance et al.'s investigation established that children remembered the key task information, so there was no need to remind children before the test question. Further, placing the memory question after the future thinking question established greater temporal separation between learning the important task information (through visiting the two rooms) and answering the test question, which increased the likelihood that children were using information stored in long-term memory instead of working memory. Both the memory and future thinking question were asked out of sight of the testing rooms, whereas in Atance et al., this was only true for the future thinking question.

Children's spontaneous future talk. Recall that many behavioural future thinking tasks used with children have been based on Tulving's (2005) "spoon test." The spoon test is based on an Estonian tale about a young girl who brings a spoon with her to bed in anticipation of needing it to eat pudding in a dream. Bringing the spoon to bed is thought to be behavioural evidence of future thinking. One notable difference between this story and the item-selection tasks it has inspired is that the little girl "solves" the pudding problem without any external prompts. For example, no one offers the girl options of what to bring (e.g., a spoon, a plate, or a cup) but, rather, she spontaneously engages in future thinking and acts accordingly. Conversely, item selection tasks (e.g., Payne et al., 2015; Russell et al., 2010; Suddendorf et al., 2011) as well as the two rooms task (Atance et al., 2015) offer explicit prompts to elicit children's answers to the future thinking question. In particular, item selection tasks have relied on forced-choice test questions in which children must select a correct item among a set of distracters. Atance et al. (2015) did not ask a multiple-choice question; however, they did explicitly ask children about a future visit to the lab to elicit future thinking. Existing *verbal* future thinking tasks (reviewed above) have also relied on explicitly (and verbally) prompting children to think about the future. Hence, little is known about children's "spontaneous" or "unprompted" future thinking.

This is an intriguing omission in the literature because future thinking in daily life is generally not achieved through answering multiple-choice questions (of course, the omission of spontaneous future thinking is hardly surprising, given the methodological hurdles in implementing designs to test it). There has been at least one attempt to investigate children's more spontaneous future thinking: Mahy, Atance, Moses, and Kopp (unpublished data reported in Atance & Mahy, 2016) gave children a version of Suddendorf et al.'s (2011) item selection task, but before asking children to select the correct item from among distracters, they asked a more open ended, "What would be a good thing to bring to the first room?" Children performed worse in this open-ended version (20%) than the classic forced-choice version (76%). This test question certainly offered less of a prompt than the original, but children's answers to the question were still elicited by a test question. Hence, novel investigations of children's spontaneous future-oriented cognition are required.

As with most of the mental time travel literature, memory studies have again foreshadowed future thinking research: Indeed, there is a literature investigating spontaneous memories that "pop into" people's minds without deliberate retrieval. These "involuntary autobiographical memories" have been written about and studied in adults (e.g., Berntsen, 1996, 2010). Indeed, Berntsen (2010) reviewed evidence consistent with the claims that involuntary autobiographical memories are universal, as frequent as voluntary (or deliberately retrieved) memories, and rely on the same underlying episodic memory system as voluntary memories. Involuntary memories have also been studied in preschoolers, although this work is in its early days.

Recently, Krøjgaard, Kingo, Dahl, and Berntsen (2014) investigated 3-year-olds' involuntary episodic memories experimentally. The researchers brought 3-year-old participants back to the lab one month after they had participated in a study with unique props. Children's spontaneous statements about their previous experience in the lab were recorded as they sat in the testing room, ostensibly waiting for the experimenter to return from taking a phone call. Their verbalizations were then compared to those generated by a control group: These children had never visited the lab before and were seeing the unique props for the first time. Krøjgaard et al. analysed the children's spontaneous memories by using a word list as well as a more comprehensive coding scheme, which included language, gestures, reliving, action details, spatial details, social details, and perceptual details from the previous visit. Both of these scoring methods revealed that 3-year-olds in the experimental group produced more spontaneous memories than children in the control group. Involuntary autobiographical memories may occur earlier in development than deliberately retrieved episodic memories, as involuntary memories likely rely more on associative mechanisms. They may also rely less on executive control than deliberately retrieved memories since no strategic or goal-directed retrieval process is required (Krøjgaard et al., 2014). Presumably, some of these features of involuntary memories would also apply to involuntary or spontaneous future thinking.

Another construct relevant to spontaneous future thinking is mind wandering, which is the mind's tendency to jump between thoughts fluidly when there is no external demand for thought (Mason et al., 2007). Research has indicated that the so-called "default network" is active in the brain during mind wandering. Interestingly, the default network has also been implicated in brain imaging investigations of episodic memory and episodic future thinking (Benoit & Schacter, 2015). Benoit and Schacter (2015) have suggested that this core brain network likely supports both deliberate episodic thinking as well as rich spontaneous thoughts occurring during mind wandering.

As I collected data and reviewed the videos from the first study in this dissertation, I noticed that it was common for children to spontaneously talk about the future during the 3-minute periods in the two rooms. For instance, some children spontaneously anticipated returning to rooms they had already visited. Many participants made statements similar to the following: "We're going back to the other room?" and "After, I'm going to the Tree room." A few children even spontaneously "solved" the task before being asked the test question. For example, one 5-year-old said, "I wish I could bring this [toy] to the room" (referring to the room without toys); another suggested, "We should switch some toys." It was also common for children to spontaneously utter memory information well before the memory questions; for example, one 5-year-old said, "In the Tree room, there's no toys." Although the original goals of the study did not include investigating spontaneous talk about the future (or past), it became clear that the two-rooms protocol is actually well-suited for capturing children's spontaneous talk, as children spend a total of 12 minutes with minimal interaction with the experimenter.

We thus completed an exploratory investigation of children's spontaneous statements about the future as well as their spontaneous statements about the recent past within the context of the two-rooms task.

Chapter 3: When can children plan for a future that differs from the present?

Atance et al.'s (2015) original paradigm—as well as the similar paradigm we used in Article 1— has a limitation that I believe characterizes the majority of behavioural future thinking tasks: That is, the correct answer is the same whether children are actually thinking about the future or thinking about the *present*. In the context of Atance et al.'s paradigm (and the paradigm we used in Chapter 2), the most adaptive response is to put the resource in the no-resource room. Hence, children could solve the two-rooms task—or indeed any existing behavioural task—by thinking about the present state of the world instead of mentally projecting themselves into the personal future (Atance & Mahy, 2016; Hoerl & McCormack, 2018). Article 2, therefore, is a modification to the two-rooms paradigm used in Article 1. The modification is such that the correct answer for the present is different from the correct answer for tomorrow. Article 2 therefore serves as an attempt to establish the point in development when children can represent a future that differs from the present *and* make an adaptive decision accordingly.

Consider the following scenario: Where I work, we have a communal kitchen with a cupboard designated for storing snacks. In the morning, I might put some crackers in the snack cupboard for later (I am working late today). However, I know that our vigilant cleaning staff always empty the cupboard at the end of the standard workday at 4 p.m. (they do this to avoid snacks rotting in the cupboard). If I know I'll want a snack after 4 p.m., I must store it somewhere other than the snack cupboard (perhaps hidden in the cutlery drawer) so that it is still available after 5 p.m. In this example, my representation of the future must account for a relevant intervening event (the cleaning staffs' visit). Behaviourally, what I should adaptively do right now (put snack in the cupboard) differs from what I should do for the future (hide snack in the drawer). Unlike the structure of the tasks previously described, there is evidence that the world will undergo a change (due to an intervening event) between "now" and "tomorrow."

Researchers have argued that episodic future thinking offers a selective advantage specifically because it allows individuals to simulate possible futures *that differ from the present* and act accordingly in the present based on these representations (Klein, 2013; Suddendorf & Corballis, 2007). When are children able to form these more complex representations of the future and use them to make decisions?

The importance of establishing children's ability to represent a future that differs from the present state of the world is related to the Bischof-Köhler hypothesis, which has guided future thinking research in non-human animals. The Bischof-Köhler hypothesis states that non-human animals are unable to anticipate future needs/states that differ from their current needs/states (Suddendorf & Corballis, 1997). For example, when a non-human animal is thirsty, it seeks water. However, the animal will not seek water when not currently in need of hydration. Adult humans, on the other hand, are able to envision a future need for water even when they are not currently in a state of thirst. For example, I bring a water bottle with me to my ultimate frisbee game even though I am not thirsty when I fill the bottle at home. As Suddendorf and Corballis (1997) bluntly put it, "a full-bellied lion is no threat to nearby zebras, but a full-bellied human may be" (p. 14). If the Bischof-Köhler hypothesis is true, future-oriented behaviours displayed by non-human animals are assumed to be highly-specialized fixed action patterns (e.g., squirrels caching nuts) or somehow cued by current states (e.g., thirst, hunger). Comparative psychologists have sought to design tasks that test the Bischof-Köhler hypothesis (e.g., Raby et al., 2007, discussed above). These attempts to falsify the hypothesis have not yet resulted in consensus among future thinking researchers (Martin-Ordas, 2016; Osvath, 2016; Suddendorf &

Corballis, 2010). Nevertheless, since representing a future that differs from the present is hypothesized to be a defining feature of human future oriented cognition, it is important that developmental researchers begin to investigate the emergence of this ability in children.

There are reasons to predict preschoolers would have difficulty representing a future that differs from the present and acting accordingly. For example, reasoning correctly in the snack example above would require the ability to reason about the temporal order of future events. McCormack and Hanley (2011) investigated 4- and 5-year-olds' ability to reason about the temporal order of past and future events. They found that 4-year-olds had more difficulty reasoning about the order of future events than past events; moreover, only 5-year-olds could reason consistently about future event order. Understanding the order of intervening events (e.g., when the cleaning staff will visit relative to when I will need the snack) is necessary to make an adaptive plan for my snack this evening.

Conflict between current and future states has been investigated with a task examining children's ability to anticipate future physiological states that conflict with current states (Atance & Meltzoff, 2006; Mahy, Grass, Wagner, & Kliegel, 2014). In Atance and Meltzoff's (2006) pretzel task, children were given a bowl of 30 pretzels and told they were allowed to eat them while being read a story (for about 5 minutes). After the story, children were asked what they would want to consume the next day: water or pretzels. The correct answer was pretzels, as this was the preferred snack for children in the study. However, children were currently thirsty due to the many salty pretzels they had just eaten and were prone to answering "water." Mahy et al. (2014) ran the pretzel task with 3- and 7-year-olds. There was no difference in performance between the age groups: a third of children correctly answered "pretzels," whereas two-thirds showed evidence of being biased by their current state of thirst and answered "water." This task is difficult even for 7-year-olds and the difficulty persists into adulthood (Kramer, Goldfarb, Tashjian, & Lagattuta, 2017), suggesting that conflicting present and future physiological states are especially challenging to reason about. It is not clear, however, that other examples of present-future mismatches would produce the same level of conflict. The snack example above, for instance, does not involve conflict between present and future physiological states and would likely require less inhibitory control to solve.

In the second study in this dissertation (Chapter 3), children alternated between two rooms, one with candy and one without, but then learned that every night, "John the Garbage Man" enters the room that does not (currently) contain candy and throws out any candy he may find. Four- to 7-year-olds were then told they would be returning tomorrow and asked where they wanted to put a container of novel, highly desirable candy. Here, unlike in Atance et al. (2015), the correct response is to put the novel candy in the room that already contains some: This is because putting it in the room where there currently is none will result in the novel candy being thrown out. Similar to the snack scenario that I described earlier, the Garbage Man's visit sets up a context in which the current and future states of the world differ, and an adaptive future-oriented response ("put the candy in the room where there is *some*") cannot be based on one's current representation of the world (which would be more consistent with "put the candy in the room where there is *none*"). Accordingly, if children are representing a future that *differs* from the present, they should choose to put the novel candy in the room where the Garbage Man will not visit even though it is the room that *currently* contains candy.

Chapter 2: Children's Behavior and Spontaneous Talk in a Future Thinking Task

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This manuscript was published in the journal *Psychological Research* in 2019:

http://dx.doi.org/10.1007/s00426-018-1089-1.

Minor changes were made to the published manuscript to address committee comments. Additions appear in footnotes formatted as "i, ii, iii, etc." Footnotes formatted as "1, 2, 3, etc." appeared in the published manuscript.

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We thank Breanne Harper, Maiziel Serrao, and Isabelle Cossette for help with data collection. Thanks to Bronwyn O'Brien and Maria Fakhouri for video transcription. Thanks to Katherine Dueck for reliability coding. Thanks to Angeline Tsui, Patricia Brosseau-Liard, Alexandre Gareau, Benjamin Schellenberg, and Laurence Boileau for statistical consultation. Thank you to the children and parents who participated.

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Data availability statement: The data analyzed during the current study are available from the corresponding author on reasonable request.

Abstract

We explored 3-, 4-, and 5-year-olds' (*N* = 120) "explicit" and "spontaneous" future-oriented cognition. Specifically, children had to think ahead to meet a future physiological need (desire for food) or psychological need (avoiding boredom). One group of children alternated between a room with candy and a room without candy, spending 3 minutes per visit. Children were explicitly asked which room they wanted to put extra candy in for a future visit to the lab (correct answer: room without candy). A second group of children underwent the same procedure but with toys as the resource instead of food (a replication of Atance, Louw, & Clayton, 2015). In the food condition, 3-, 4-, and 5-year-olds all placed candy in the correct room above chance, but only 4- and 5-year-olds were above chance in the toy condition. Overall, 4- and 5-year-olds outperformed 3-year-olds, and children performed better in the food condition than the toy condition. Children's spontaneous (or "involuntary") future thinking was assessed by coding their utterances while in the two rooms. Children who solved the explicit task uttered more task-relevant future and past statements than children who failed. Examining spontaneous talk also allowed us to explore children's spontaneous "solving" of the task before being asked an explicit test question. This research highlights the importance of varying stimuli in future thinking tasks and developing methods to capture spontaneous/involuntary future thinking in young children.

Keywords: development, mental time travel, episodic future thinking, spontaneous cognition

Children's Behavior and Spontaneous Talk in a Future Thinking Task

Imagine that you are a member of two research labs. In Lab A's weekly meetings, delicious snacks are always provided, but in Lab B's meetings, you always find yourself pining for fuel. Before long, you start bringing a snack to Lab B in anticipation of feeling hungry. This capacity to draw on past experiences to make adaptive choices for the future is commonly referred to as "mental time travel" (Suddendorf & Corballis, 1997). Mental time travel to the future (or "episodic future thinking"; Atance & O'Neill, 2001), in particular, is a cornerstone of human cognition that allows people to tailor their current behavior as a function of how they envision the future unfolding. Recent years have seen a substantial increase in research about future thinking across many subfields, including cognitive, social, comparative, and developmental psychology (see Michaelian, Klein, & Szpunar, 2016). With respect to development, specifically, we now know that children's future thinking improves considerably between ages 3 and 5 (e.g., Atance, 2015; Suddendorf & Moore, 2011).

Humans' ability to imagine and plan for the future is a domain-general capacity—it is not limited to a particular situation or context (Suddendorf & Busby, 2005). Although certain non-human animals display impressive future-oriented behaviors in restricted contexts (e.g., Raby, Alexis, Dickinson, & Clayton, 2007), no other species studied possesses forethought as seemingly flexible as humans'. Some researchers (e.g., Suddendorf & Corballis, 2007, 2010) have argued that the capacity to think and plan for the future across many different contexts and conceptual domains may be unique to humans and likely played an important role in human evolution.

Adults think ahead to address challenges as diverse as upcoming social situations (e.g., thinking about what to say in an important meeting), inclement weather (e.g., bringing an umbrella in anticipation of rain), or physiological needs (e.g., bringing a granola bar to satisfy hunger). In the earlier lab meeting example, you envisioned where food would be needed to satisfy future hunger; however, if one of the lab meetings tended to be especially boring, you might have instead decided to bring something to entertain yourself.

Because domain generality is central to adults' future-oriented thought, an important issue to explore is whether this feature also characterizes the future-oriented cognition of young children. Although a number of studies have shown that children can select a tool (e.g., key) to obtain a future reward (e.g., a sticker; Suddendorf, Nielsen, & von Gehlen, 2011), we know little about whether children can do this across different contexts and also whether their capacity to think ahead varies depending on the conceptual domain under study (Hudson, Mayhew, & Prabhakar, 2011). For instance, might there be some conceptual domains where children reason more precociously than others? Experiments that systematically vary task characteristics such as stimuli and context are required to address this question. In what follows, we review work that explores children's ability to act in the present to secure a future need. We then outline how our study builds upon and extends our knowledge in this area.

Behavioral Methods to Examine Future Thinking in Children

Children's limited capacity to describe their inner experiences has led researchers to develop behavioral methods to investigate future thinking. Some of these methods are similar to those used with non-human animals. For example, in some tasks, children's prospection (or lack thereof) is inferred by whether or not they select an item that will be useful in the future (e.g., Atance & Sommerville, 2014; Payne, Taylor, Hayne, & Scarf, 2015; Redshaw & Suddendorf, 2013; Russell, Alexis, & Clayton, 2010; Scarf, Gross, Colombo, & Hayne, 2013; Suddendorf & Busby, 2005; Suddendorf et al., 2011). Accordingly, such tasks do not rely heavily on children's verbal ability, which could mask or inflate their developing capacities for mental time travel (Atance & Mahy, 2016; Jelbert & Clayton, 2017; Suddendorf & Busby, 2005).

Many of these behavioral tasks are modelled on Tulving's (2005) "spoon test" (see also, Suddendorf, 1994; Suddendorf & Busby, 2005). This test is based on an Estonian tale about a young girl who dreamed she was at a party where delicious pudding was served; however, she had forgotten to bring a spoon, so she could have none (it was a bring-your-own-spoon affair). The next night, before going to sleep, the little girl brought a spoon to bed with her in anticipation of later needing it to eat the pudding. Developmental researchers have strived to create tasks that share features of Tulving's spoon test (i.e., creating scenarios in which future thinking can be inferred by the participant's selection of a specific item—the spoon—in the case of Tulving's story).

In one behavioral task, Suddendorf et al. (2011) presented 3- and 4-year-olds with a problem in one room (a locked box with a missing key). The box contained stickers. Children were then brought to a second room where they saw a set of items. Only one item—an intact key—was appropriate for solving the problem in the first room. When immediately asked to select an item to solve the problem, both 3- and 4-year-olds succeeded. However, only 4-year-olds succeeded when they had to wait 15 minutes before choosing an item. Indeed, across behavioral future thinking tasks, children as young as 4 are able to act in the present to secure an item relevant to a future need (Redshaw & Suddendorf, 2013; Scarf et al., 2013; Suddendorf & Busby, 2005; Suddendorf et al., 2011)

These kinds of behavioral tasks all require children to think about a tool's future use. Children's capacity for future thought has thus largely been inferred by their performance on tasks that use tool or tool-like stimuli. By focussing almost exclusively on tool selection, however, researchers may be missing important insights about the development of future thinking. It is possible that results would differ if the tasks in question were more conceptually diverse. For example, might children reason more precociously about future physiological needs (e.g., food to address hunger)? There is some indication in the theory of mind literature that children are particularly attuned to physiological states and talk about such states (e.g., hunger, thirst) prior to talking about emotional and mental states (Bretherton & Beeghly, 1982). As such, it is conceivable that children may engage in certain forms of reasoning in the physiological domain before they do so in other domains (psychological; see also, Wellman & Gelman, 1992). This may be particularly true when the task in question is structured so as to be highly motivating and/or memorable to the child. Indeed, events with emotional impact or distinctiveness appear to elicit better performance than less engaging tasks (Payne et al., 2015). Given the generalizability that characterizes future thinking in adults, behavioral methodologies used with children should be similarly diverse to accurately capture the emergence and potential breadth of future thinking early in development.

Relevant to this point, Suddendorf et al. (2011) also addressed children's ability to reason for the future in a second context: Instead of selecting a key, children selected the appropriate plastic fruit to feed an elephant (puppet) in the first room. The same pattern of results was obtained, suggesting that children's ability to think ahead is not merely tied to one particular kind of stimulus (e.g., tool) or domain (e.g., obtaining a material reward) but, rather, generalizes across at least two different contexts. Redshaw and Suddendorf (2013) also demonstrated that 4-year-olds perform similarly across the tool and fruit versions of this task. Nonetheless, before drawing firm conclusions based on these data, several potential limitations are worth considering.

First, unlike the key-and-stickers version of the task, the "fruit" version required children to think about satisfying another's future need, as opposed to their own. As a result, children may have needed to use their imaginative and perspective-taking capacities to a different extent. Although some research indeed suggests that children reason similarly about their own and others' future needs (e.g., Payne et al., 2015), this is not true in all cases (e.g., Bélanger, Atance, Varghese, Nguyen, & Vendetti, 2014; Prencipe & Zelazo, 2005). Thus, ideally, different versions of a task should keep the perspective (i.e., "future self" or "future other") constant to determine the role of context on children's future thinking. Another difference between Suddendorf et al.'s (2011) two tasks is that the key-and-stickers version pertained to a real and immediate future, whereas the fruit version—though similar along the "immediacy" dimension—involved considerable pretense (e.g., toy fruits and stuffed animals). Despite these limitations, Suddendorf et al.'s approach is helpful as it suggests children can apply their emerging future thinking ability to two scenarios that differ on surface details.

An important complementary approach to address the generalizability of children's reasoning is to systematically vary the particular future need (e.g., food) children are required to address, while keeping other task features constant. In this way, the specific role of varying stimuli and conceptual domains can be examined more systematically. A task developed by Atance, Louw, and Clayton (2015) is particularly well-suited to this aim. Atance et al.'s (2015) behavioral paradigm is based on a task originally developed by Raby et al. (2007) with birds (western scrub-jays). In the original animal study, scrub-jays alternated between two compartments for six days. In one compartment the birds always got breakfast (powdered food), whereas in the other they did not. On the test day, the birds were given the opportunity to cache solid food in either compartment. The birds cached more food in the no-breakfast compartment than in the breakfast compartment suggesting, as Raby et al. argued, that they were caching food in anticipation of "tomorrow."

Atance et al. (2015) adapted Raby et al.'s (2007) paradigm for use with children as follows. Children arrived at the lab and were told that they would be visiting two rooms: Big Bird's room and Ernie's room. These rooms were identified with pictures of the *Sesame Street* characters on the doors. One of these rooms contained toys to play with, while the other did not. Children entered the first room with the experimenter and were given toys by a puppet (corresponding to the room name) and played until the timer rang (3 minutes). In the second room, children were told by a second puppet that there were no toys and had to wait for 3 minutes with nothing to do. This process was repeated, with a second visit to the toy room and no-toy room (the order of presentation and room names were counterbalanced).

After this experience, children were led out of the rooms into an adjoining hallway where they were asked memory questions about which room had toys and which room did not. Children were then presented with a basket with two toys that were slightly different from the toys they had played with in the toy room. Children's ability to think/plan ahead was assessed by first telling them that they would be returning to visit the two rooms when they were 4/5/6 years old (i.e., one year older than their current age) and then asking them where they wanted to put the toys for this future visit (correct answer: no-toy room). Whereas 4- and 5-year-olds chose to place the toys in the "no-toy" room at rates significantly higher than chance (79% and 88%, respectively), the 3-year-olds did not (57%). These findings suggest that only the older children had thought ahead about where the toys would be needed in the future and are thus consistent with a number of previous behavioral tasks that show a shift in performance between ages 3 and 4 (though see Boden, Labuschagne, Hinten, & Scarf, 2017, and Payne et al., 2015, for exceptions). However, like most other research in this area, Atance et al. (2015) only examined children's future thinking in a single domain, which again raises the issue of the generalizability of preschoolers' future thinking.

Spontaneous Behavior and Talk About the Future

Another limitation of behavioral tasks is that they fail to take into account children's more "spontaneous" behavior and/or talk about the future. For example, one notable difference between Tulving's spoon test and the behavioral future thinking tasks is that the little girl "solves" the pudding problem without any external prompts (Atance & Mahy, 2016). That is, no one offers the girl options of what to bring (e.g., spoon, key, or pencil) but, rather, she spontaneously engages in future thinking and acts accordingly. Conversely, item selection tasks (e.g., Payne et al., 2015; Russell et al., 2010; Suddendorf et al., 2011) as well as the two rooms task (Atance et al., 2015) "prompt" children's response by explicitly asking them which item to choose (with the correct item visible amongst distracters) or in which location to place an item. Although these studies have advanced our understanding of children's future-oriented behavior, additional methods (e.g., spontaneous talk/behavior) may help to bridge the gap between more "explicit" and "spontaneous" forms of future thought of the kind described in Tulving's (2005) original spoon test (see also Moffett, Moll, & FitzGibbon, 2018, for a similar argument).

Importantly, little is known about children's spontaneous or unprompted future thinking. In adults, at least, involuntary mental time travel to the future and past appears to be universal, as common as voluntary (or deliberately generated) episodic thinking, and may rely on the same underlying episodic system (Berntsen, 2010; Berntsen & Jacobsen, 2008). Interestingly, recent experimental evidence suggests that involuntary mental time travel (at least to the past) may emerge earlier than its voluntary counterpart, as fewer executive control demands are required due to the lack of deliberate retrieval (Krøjgaard, Kingo, Dahl, & Berntsen, 2014; Krøjgaard, Kingo, Jensen, & Berntsen, 2017). Although one experimental study has examined involuntary future thinking in adults (Cole, Staugaard, & Berntsen, 2016), to our knowledge, there have been no investigations of involuntary future thinking in young children.

Early on in data collection for the current study, we noticed that children spontaneously talked about the future (and the past) during the 3-minute periods in the two rooms. For example, some children spontaneously anticipated returning to the room they had already visited and a few children spontaneously "solved" the task by saying, for example, "I wish I could bring this (toy) to the room" (referring to the room without toys), even before being asked the explicit test question about which room they wanted to place the resource for a future visit. We thus developed a coding scheme (described in the Methods section) to capture these kinds of spontaneous utterances about both the future and the past.

Current Investigation

We examined 3- to 5-year-olds' future thinking across two stimulus domains—toys and food—using a modified version of Atance et al.'s (2015) two-rooms procedure. Whereas the toy condition required children to think ahead about a more "psychological" need (i.e., avoiding boredom), the food condition required children to think ahead to satisfy a more "physiological" need. We predicted a replication of Atance et al.'s (2015) age-related improvement in children's ability to place the resource (i.e., toy or food) in the correct room. However, we had competing predictions with respect to the effect of condition (i.e., toy vs. food). On the one hand, we reasoned that children's performance may be equivalent across both resources reflecting the domain generality of humans' future thinking. On the other hand, in line with the arguments presented earlier, children appear particularly attuned to physiological states and thus may be especially motivated to consider where food will be needed in the future, resulting in superior performance in this condition.

We hypothesized that even the youngest children would spontaneously utter statements about the past and future, consistent with the claim that spontaneous temporal thinking is less cognitively demanding than strategic retrieval. Given the wide age range, we predicted age-related improvements, while also recognizing that previous investigations of spontaneous memories (with narrower age ranges) have failed to find robust age differences (Krøjgaard et al., 2017; Martin-Ordas, Atance, & Caza, 2017). We hypothesized age-related improvement in children's likelihood to spontaneously suggest bringing extra resource to the no-resource room (in effect, spontaneously "solving" the task). Further, mirroring the predictions for the explicit test questions, we considered the possibility that performance could differ between the conditions. Finally, we expected children who solved the task to generate more spontaneous utterances about the past and future than children who failed the task. We reasoned both past and future to be important because children must use the information they learn from the task (i.e., memories) in order to anticipate a solution, in line with Schacter and Addis' (2007) argument that we recombine elements of the past to simulate our futures (known as the *constructive episodic simulation hypothesis*).

Method

Participants

Prior to data collection, we used G*Power 3.1.9.2 (Faul, Erdfelder, Lang, & Buchner, 2007) to conduct power analyses (binomial tests, two-tailed) based on effect sizes observed by Atance et al. (2015). They found 4-year-olds succeeded in 79% of cases (effect size $g = .29$). Based on this effect size, we required a minimum cell size of 23 to achieve power of .80 with alpha set to .05. We conducted a second power analysis for 5-year-olds, who succeeded in 88% of cases (effect size $g = .38$). The power analysis indicated we required a minimum cell size of 12 to achieve power of .80 with alpha set to .05. These minimum cell sizes were met.

Participants ($N = 120$) in the toy condition were 23 3-year-olds (10 females; $M_{age} = 42.39$ months, $SD = 2.79$), 23 4-year-olds (11 females; $M_{age} = 54.00$ months, $SD = 4.07$), and 14 5-year-olds (6 females; $M_{age} = 66.43$ months, $SD = 3.39$), and in the food condition were 23 3-year-olds (11 females; $M_{age} = 43.30$ months, $SD = 2.67$), 23 4-year-olds (13 females; $M_{age} = 54.48$ months, $SD = 3.38$), and 14 5-year-olds (5 females; $M_{age} = 64.07$ months, $SD = 4.01$). Within each age group, children's mean age in months did not significantly differ between the toy and food conditions (all *p*s > .105). Participants were predominantly White and middle class and were fluent in English. They were recruited from a large university city using posters, pamphlets, online ads, and advertising at children's fairs. Ten additional participants were tested, but not included in the analyses. Of those, nine could not finish the procedure and therefore were not asked the test question, and one participant did not eat any candy. An additional 12 participants had slight variations from the standard protocol (e.g., extra time in the room due to experimenter error, brief break to "check in" with parent, etc.), but were included in the final analyses because these variations were deemed to maintain the validity of the task. We ran analyses both with and without these 12 participants and the general pattern of results remained the same (see Results section).

Procedure

The setup for this experiment was similar to Atance et al.'s (2015) and involved two rooms—one with a resource (toys or food) and one without (see Figure 1). We used a between-subjects design and thus children were randomly assigned to either the toy or food condition. The conditions were identical save for the fact that the toy condition involved toys (Play-Doh, a coloring book and crayons, and a slinky) and the food condition involved a large Tupperware container ¾-full of Smarties candy.

To distinguish between the two rooms, one was called the tree room, and the other was called the sun room. A picture of a tree was affixed to the tree room door and also to the plastic container that contained the resource (i.e., toys or food). Similarly, a sun was affixed to the sun room door and container. Each room was furnished with a child-sized table and two child-sized chairs in addition to a plastic box that either contained the resource or not.

The experimenter (E) began by showing the child both rooms and saying, "We're going to visit two different rooms today. This is the tree room. Look! There's a picture of a tree on the

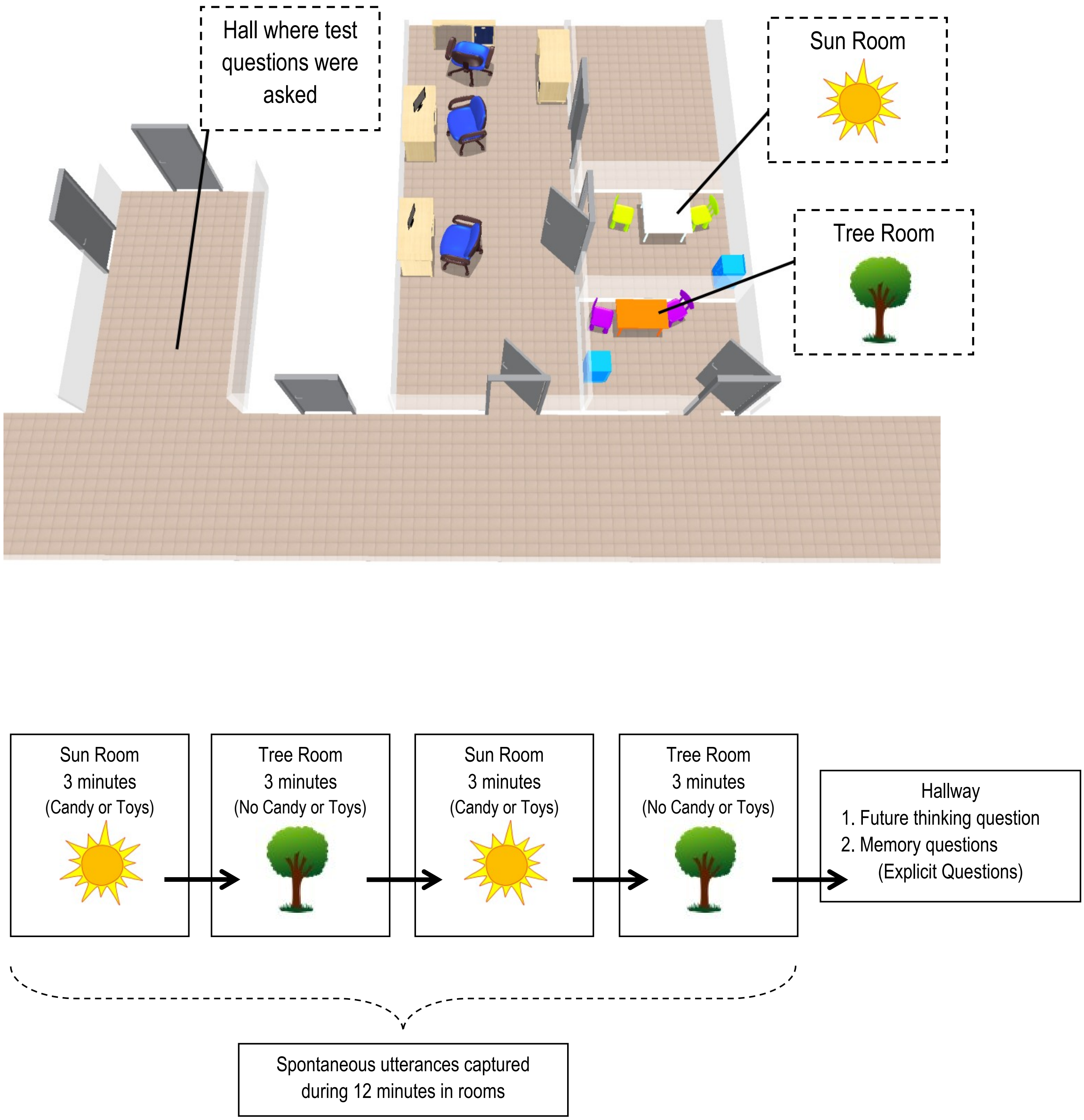

Figure 1. Schematic representation of the experimental setup.

door. And this is the sun room. Look! There's a picture of a sun on the door." The E then said, "Let's start in the [tree/sun] room." Upon entering the room, the E directed the child to check the plastic container for the resource: "Let's check the box to see if [there's some candy for you to eat/there are some toys for you to play with]. Wow! There [is candy for you to eat/are toys for you to play with]." In the food condition, the E then used a spoon to transfer six candies from the Tupperware container into a smaller bowl for the child. If the resource was lacking, the E said, "Let's check the box to see if [there's some candy for you to eat/there are some toys for you to play with]. Oh no! There isn't anything for you to [eat/play with]."

In either case, the E then placed a digital timer on the table at which the child was seated and said, "I have some work to do until this timer rings" (timer set to ring in 3 minutes). The E then put on headphones and pretended to work to reduce the likelihood that the child would interact with him/her. In the toy/food room, the child was free to play/eat six candies for the 3 minutes. In the no-toy/no-food room, the child had to wait with nothing to do for the 3 minutes. If the child attempted to interact with the experimenter, the E reminded the child that he/she had a little work to do until the timer rang.

Children visited each room twice. This was done to allow children to learn that one room contained the resource while the other room did not. After alternating between the two rooms twice, the child and E walked down the hall for the test questions, which were recorded on a digital audio recorder. The child was unable to see either of the rooms during the test questions. Once the E and child had walked down the hall, the E said, "You got to visit the tree room and the sun room today. You're going to visit the tree room and the sun room again tomorrow. Look what I have: [candies/toys] (E showed the child a Tupperware ¾-full of Smarties or container of toys, namely, a different color of Play-Doh and a different coloring book). These are for when you visit the tree room and the sun room again tomorrow." The E then asked the *future thinking* *question*: “Which room do you want to put these in?” The correct answer (i.e., the no-toy/no-food room) was coded as 1; all other responses were coded as 0. Children were then asked, “Why do you want to put these in the [tree/sun] room?” and responses were recorded (See Table 1 for a list of all dependent variables).

Table 1

Dependant Variables

	Variable	Possible Score
Explicit		
	Room choice (future thinking)	0-1
	Memory questions	0-2
Spontaneous		
	Future utterances	0 or >
	Past utterances	0 or >
	Other utterances	0 or >
	Spontaneous solves	0-1

Children were then asked the following *memory questions*: (1) “[Was/were] there any [candy/toys] in the tree room?” and (2) “[Was/were] there any [candy/toys] in the sun room?” If children provided the response to one of the memory questions in their explanation of their room choice, the corresponding explicit memory question was not asked if it directly followed the explanation in the counterbalanced order. For example, if the child said she would put the food in the tree room “because it doesn’t have any food,” the experimenter did not then ask, “Was there any food in the tree room?” In this case, the child was credited with having answered that memory question correctly.

The future thinking question was always asked before the memory questions to reduce the possibility that answering the memory questions first would prompt the correct response to the future thinking question. Because Atance et al. (2015) and other pilot investigations in our lab have established that remembering the key information is not a limiting factor in the two-rooms task (even for 3-year-olds), the memory check questions served as a secondary control as opposed to a main focus of the current investigation.

The following task features were counterbalanced: whether children started in the tree or sun room, the location of the sun and tree room, whether the tree or sun room was mentioned first in the test questions, and whether children started in the toy/food room or the no-toy/no-food room.

Coding for Spontaneous Talk About the Future and Past

All participants' video recordings were transcribed by a research assistant. A second research assistant also watched all video recordings and verified the transcriptions. Disagreements were noted by the second research assistant and were resolved through discussion with the first author and the original transcriber. Six participants were excluded due to video recording errors ($N = 114$).

We developed a coding scheme to capture children's future utterances, past utterances, and those instances in which children spontaneously solved the task. For our purposes, an "utterance" was defined as a stand-alone idea/topic/subject, separated by a pause in speech. However, to count as a future or past utterance, the child's statement also needed to be task-relevant. That is, if a child said "I'm going to the park tomorrow," this would not count as a future utterance; in contrast, the statement "Are we going to the tree room next?" would. However, the former utterance, along with any other task-unrelated utterances, were captured under a category that we called "other." Finally, each child was assigned a "total utterance" score that included their future, past, and other utterances. See Table 2 for the criteria for each category and examples of coded utterances.

Table 2

Coding Scheme for Children's Spontaneous Utterances

	Future[a]	Past	Spontaneous Solve
Utterance coding criteria	An anticipation of a future event related to the task	A reference to knowledge that originates from visiting one of the two rooms (no reference to future)	A spontaneous suggestion to bring extra resources to the no-resource room
Examples	"After you do this work, can we go back in the room with toys?" "Now where will we go?" "Gonna beep soon." [referring to timer]	"The tree always has no candies." "Is on the other side of this wall is the tree room?" "And there no toys again?"	"Maybe you guys can fill it with lots of Smarties again." "Can I bring this [toy] into where we're going? I wanna bring this in the sun room." "You never know—maybe someone will bring some candy to the tree room."

[a]Spontaneous solves were also counted as future utterances.

All participant transcriptions were randomized and coded by the first author, who was blind to the age, condition, and performance of the child on the explicit test questions. For inter-rater reliability, a research assistant (not one of the transcribers) was trained on the coding scheme with 12 randomly selected participants and then independently coded 36 randomly selected participants (32% of included sample). Inter-rater reliability was computed based on standards outlined by Hallgren (2012). For total utterances, future utterances, and past utterances, reliability was assessed using two-way random, absolute agreement, single-measures intra-class correlations (ICC; McGraw & Wong, 1996). For total utterances, there was complete agreement, *ICC* = 1.00. For future utterances, the *ICC* = .82 (95% CI = .68-.90), suggesting good to excellent reliability (Cicchetti, 1994). For past utterances, the *ICC* = .81 (95% CI = .67-.90), suggesting good to excellent reliability. Inter-rater reliability for spontaneous solves (a dichotomous variable) was calculated using Cohen's (1960) kappa (κ), and indicated complete agreement, κ = 1.00.

Results

Memory Check Questions

A series of one-sample *t*-tests showed that all three age groups scored significantly higher than chance (i.e., 1/2) on the two memory check questions in both conditions (see Table 3). Moreover, a 3 (Age: 3, 4, 5) × 2 (Condition: toy, food) ANOVA showed no effects of age, $F(2, 114) = 1.98$, $p = .143$, $\eta_p^2 = .034$, condition, $F(1, 114) = 0.23$, $p = .633$, $\eta_p^2 = .002$, and no Age × Condition interaction, $F(2, 114) = 0.63$, $p = .535$, $\eta_p^2 = .011$, suggesting equivalent memory performance across ages and conditions.

Table 3

Memory Question Scores by Age and Condition

Age (Years)	Mean Score (0-2)	Standard Deviation	One-Sample *t*-test[i]
Toy Condition			
3 (n = 23)	1.70*	0.70	4.75 ($p < .001$)
4 (n = 23)	1.83*	0.49	8.07 ($p < .001$)
5 (n = 14)	2.00[a]	0.00	--
Food Condition			
3 (n = 23)	1.87*	0.46	9.11 ($p < .001$)
4 (n = 23)	1.78*	0.52	7.24 ($p < .001$)
5 (n = 14)	2.00[a]	0.00	--

[a]Ceiling performance (one-sample *t*-test cannot be computed)

* = significantly above chance according to one-sample *t*-test (test value = 1)

Future Thinking Question

Preliminary analyses. Our main outcome variable (children's room choice) was dichotomous, so we adopted a non-parametric approach to preliminary data analyses. A series of Mann-Whitney U tests revealed that children's responses to the future thinking question did not vary significantly as a function of whether the first or second room contained the resource, U = 1611.00, $p = .212$, $\eta^2 = .013$, or whether the resource or no-resource room was mentioned first in the test question, U = 1711.00, $p = .637$, $\eta^2 = .001$. There was no effect of gender, U = 1708.00, $p = .541$, $\eta^2 = .003$.

Chance analyses. A series of binomial tests across ages and conditions revealed that 4-

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[i] See Appendix C for a non-parametric analysis approach to the memory questions. The pattern of results is the same.

and 5-year-olds were significantly above chance (0.5/1) in the toy and food conditions. Three-year-olds were above chance in the food condition[1], but no different from chance in the toy condition (see Table 4 and Figure 2).

Table 4

Future Thinking Question Performance by Age and Condition

Age (Years)	Correct	Incorrect	Percentage Correct	Binomial Test
Toy Condition				
3 (*n* = 23)	11	12	48	*p* = 1.00
4 (*n* = 23)	18	5	78*	*p* = .011
5 (*n* = 14)	13	1	93*	*p* = .002
Food Condition				
3 (*n* = 23)	17	6	74*	*p* = .035
4 (*n* = 23)	20	3	87*	*p* < .001
5 (*n* = 14)	14	0	100*	*p* < .001

* = significantly above chance according to binomial test (test proportion = 0.5)

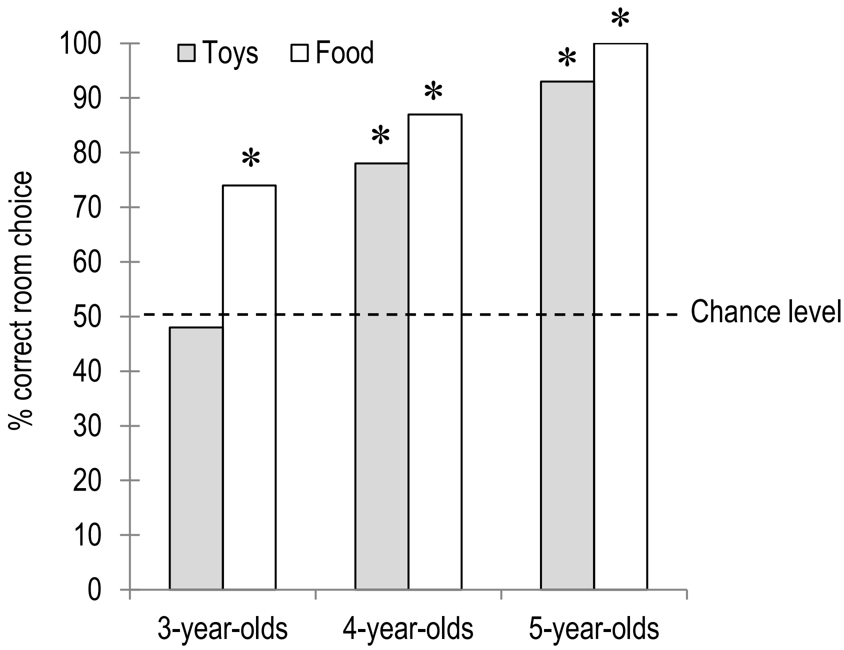

Figure 2. Percentage of children who correctly responded that they would place extra resource (i.e., toys or candy) in the no-resource room.

* = significantly above chance (0.5/1) according to binomial tests

Comparison of performance across ages and conditions. To further investigate the effects of age and condition on children's task performance, we conducted a binary logistic regression, with children's room choice as the dichotomous outcome variable, and condition (food, toy) and age (3, 4, 5) as categorical predictor variables. We selected 3-year-olds as the reference group because we were particularly interested in comparing 3-year-olds' performance with 4- and 5-year-olds'. The resulting model was significant, $\chi^2(3) = 19.69$, $p < .001$, Nagelkerke $R^2 = .231$, Cox and Snell $R^2 = .151$. The effect of condition was significant[2]: Children in the food condition were more likely to select the correct room than children in the toy condition, $OR = 2.73$, 95% CI [1.05, 7.14], $p = .040$. The overall effect of age was also significant, $p = .004$, so we examined differences between age groups. Both 4- and 5-year-olds outperformed 3-year-olds, $OR = 3.22$, 95% CI [1.20, 8.69], $p = .021$, and $OR = 18.91$, 95% CI [2.32, 154.42], $p = .006$, respectively. A follow-up Mann Whitney U test revealed no difference between 4- and 5-year-olds, $U = 555.00$, $n_1 = 46$, $n_2 = 28$, $p = .080$, $\eta^2 = .041$. Taken together, these results show that future thinking performance improves with age and that resource type impacts performance[3].

Spontaneous Talk About the Future and Past

Preliminary analyses. A 3 × 2 ANOVA for total utterances revealed no significant main effect of age, $F(2, 108) = 0.99$, $p = .374$, $\eta_p^2 = .018$, or condition, $F(1, 108) = 0.31$, $p = .580$, $\eta_p^2 = .003$. Although the Age × Condition interaction was significant, $F(2, 108) = 3.19$, $p = .045$, $\eta_p^2 = .056$, follow-up analyses (Bonferroni-adjusted alpha levels of .025) revealed no simple main effects of age in the food, $F(2, 108) = 1.69$, $p = .187$, $\eta_p^2 = .030$, or toy, $F(2, 108) = 2.49$, $p = .087$, $\eta_p^2 = .044$, conditions. There were also no significant simple main effects of condition (Bonferroni-adjusted alpha levels of .017) for 4-year-olds, $F(1, 108) = 1.23$, $p = .269$, $\eta_p^2 = .011$, or 5-year-olds, $F(1, 108) = 0.02$, $p = .881$, $\eta_p^2 < .001$. The simple main effect of condition for 3-year-olds likely drove the significant interaction, but it did not meet the Bonferroni-adjusted criterion for significance, $F(1, 108) = 5.65$, $p = .019$, $\eta_p^2 = .050$. We also ran this analysis adjusting two outliers[ii]. After doing so, the simple main effect of condition among 3-year-olds met the .017 criterion for significance (3-year-olds made more total utterances in the food vs. toy conditions), $F(1, 108) = 7.47$, $p = .007$, $\eta_p^2 = .065$.

Future and past utterances. As predicted, children of all ages spontaneously talked

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[ii] Interquartile range rule = 3.00; outliers adjusted to next highest value plus one (Tabachnick & Fidell, 2007)

about the past and future during the task (see Table 5)[iii]. To examine whether there were age or condition differences for future utterances, we conducted a 3 × 2 ANOVA. There were no significant effects of age, $F(2, 108) = 2.84$, $p = .063$, $\eta_p^2 = .050$, condition, $F(1, 108) < 0.01$, $p = .966$, $\eta_p^2 < .001$, and no Age × Condition interaction, $F(2, 108) = 0.84$, $p = .434$, $\eta_p^2 = .015$.

A 3 × 2 ANOVA for past utterances revealed a significant main effect of age, $F(2, 108) = 3.52$, $p = .033$, $\eta_p^2 = .061$, but no main effect of condition, $F(1, 108) = 0.69$, $p = .409$, $\eta_p^2 = .006$, and no interaction, $F(2, 108) = 0.12$, $p = .884$, $\eta_p^2 = .002$. A follow-up Tukey HSD revealed that 4-year-olds produced more past statements than 3-year-olds ($p = .026$).

Table 5

Mean Utterances by Age and Condition (Standard Deviation in Parentheses)

Age (Years)	Total Utterances	Future Utterances	Past Utterances	Frequency of Spontaneous Solves
Toy Condition				
3 (*n* = 23)	21.78 (23.20)	1.91 (2.97)	0.74 (0.81)	2
4 (*n* = 21)	40.10 (31.16)	5.48 (5.60)	1.86 (2.20)	5
5 (*n* = 14)	26.57 (23.46)	3.79 (4.15)	1.64 (1.74)	4
Food Condition				
3 (*n* = 21)	41.71 (33.54)	3.38 (3.60)	1.24 (1.51)	0
4 (*n* = 21)	30.57 (26.21)	4.48 (6.10)	2.14 (2.03)	1
5 (*n* = 14)	25.00 (25.82)	3.43 (3.72)	1.71 (2.34)	2

[iii] 79/114 children (69%) contributed at least one future utterance; 70/114 children (61%) contributed at least one past utterance

Spontaneously solving the task. To determine whether age and condition affected children's ability to spontaneously solve the task we conducted a binary logistic regression, with children's spontaneous solves as the dichotomous outcome variable, and age (3, 4, 5) and condition (food, toy) as categorical predictor variables (reference group was 3-year-olds; see Table 5). The resulting model was significant, $\chi^2(3) = 10.73$, $p = .013$, Nagelkerke $R^2 = .171$, Cox and Snell $R^2 = .090$. Although the overall effect of age was not significant ($p = .107$), the effect of condition was: Children in the toy condition were more likely to spontaneously solve the task than children in the food condition, *OR* = 4.52, 95% CI [1.16, 17.65], $p = .030$. The spontaneous solve rate was 5% in the food condition and 19% in the toy condition. And, of the 14 children who spontaneously solved the task, 13 (93%) also correctly answered the explicit future thinking question.

Do spontaneous past/future utterances differ as a function of task performance? We ran independent samples *t*-tests to compare number of past/future utterances between children who successfully answered the test question ($n = 88$) and those who did not ($n = 26$). Levene's Test for Equality of Variances was significant for both past and future utterances (*p*s < .016), so we ran unequal variances independent *t*-tests. Children who passed the test question had significantly more future utterances ($M = 4.11$, $SD = 4.94$) than children who failed ($M = 2.42$, $SD = 2.83$), $t(73.27) = 2.21$, $p = .030$, $d = 0.42$. Past utterances also differed significantly between children who passed ($M = 1.68$, $SD = 1.92$) and failed ($M = 1.00$, $SD = 1.36$), $t(57.60) = 2.03$, $p = .047$, $d = 0.41$. To determine whether simply talking more in the two rooms—regardless of whether or not this talk was "temporal"—is related to task success, we calculated an "other" utterances score for each child by subtracting future and past utterances from total utterances. We then ran an unequal variances independent *t*-test (Levene's Test was significant, *p*

= .009) comparing number of "other" utterances between children who passed and failed. Interestingly, "other" utterances not captured in the future and past coding categories did not differ significantly between children who passed (n = 88, M = 27.55, SD = 26.17) and failed our task (n = 26, M = 21.54, SD = 14.61), t(75.38) = 1.50, p = .137, d = 0.28.

Discussion

A main goal of our study was to examine the generalizability of children's future thinking across domains. In the food condition, children had to think ahead about satisfying a future physiological need (desire for food), whereas in the toy condition, children had to think ahead about a more psychological need (avoiding boredom). We found that 4- and 5-year-olds placed extra resource in the correct room more often than 3-year-olds and, overall, children were significantly more successful in the food condition than the toy condition.

Why might children's reasoning be more "precocious" when thinking about a future need for food versus toys? As mentioned in the Introduction, there is evidence that young children are quite attuned to physiological states (e.g., hunger, thirst) and verbally refer to such states before they refer to mental states, for example. Food, in particular, has been referred to as a "privileged domain" of reasoning given its relevance to survival (Cassidy et al., 2005). Although children in our study were likely not particularly hungry or deprived of food, food is nonetheless extremely reinforcing across species, and food acquisition, selection, and consumption are major activities for most animals (Rozin, 1996). Given the centrality of food to survival, some researchers have proposed that humans are particularly well adapted to reasoning about food. For example, Siegal (1995) found that young children were more likely to succeed at theory of mind tasks when the task details specifically related to food safety as opposed to the usual survival-irrelevant themes. It is perhaps no coincidence that the child in Tulving's (2005) Estonian fairy-tale plans to bring a spoon to bed to later satisfy her want for pudding!

In a related vein, children are likely predisposed to pay particular attention to—and be motivated by— information within a domain with which they are familiar. Although Smarties are considered a "treat" for many children and, as such, may have been particularly motivating, the arguments put forth by Rozin (1996) and Siegal (1995) outlined above suggest that higher performance would hold true for other food items and not just those that are highly desirable. Testing this specific claim by comparing Smarties and a less desirable food (e.g., crackers) would be interesting, as would modifying future thinking tasks to include other kinds of "survival" themes. For example, a task that involves planning ahead to keep kin safe from threat could be used to further explore the possibility that children are biologically prepared to plan more accurately in evolutionarily-relevant domains. More broadly, the condition difference that we obtained underscores the need to consider the particular domain of reasoning in making conclusions about children's future-oriented thinking.

Another important goal of our study was to examine children's spontaneous future thinking via their unprompted talk during the two-rooms task. Researchers have identified involuntary/spontaneous mental time travel as an important avenue for investigation given the ubiquity of unprompted mental time travel in daily life (Atance & Mahy, 2016; Berntsen, 2010). As expected, children of all ages spontaneously anticipated events related to the task (future utterances) and verbalized knowledge gained during their visits to the two rooms (past utterances). Although we speculated that older children would be more likely to make such future and past statements, we also acknowledged that previous studies of spontaneous memories in young children (with narrower age ranges) have not found robust age differences (Krøjgaard et al., 2017; Martin-Ordas et al., 2017). Although we found that 4-year-olds produced significantly more past utterances than 3-year-olds, the frequency of children's future talk in our task was not statistically different across ages and conditions. The absence of a clear developmental difference in future utterances over the ages we examined is in contrast to the developmental difference obtained in children's performance on our explicit future thinking question (i.e., 4- and 5-year-olds performed significantly better than 3-year-olds). This pattern of findings is consistent with the argument that fewer executive control demands are required in spontaneous mental time travel due to the lack of deliberate retrieval or generation of future possibilities (Krøjgaard et al., 2014, 2017).

We were also interested in children's capacity to spontaneously "solve" the task and found that 14 of 114 children did so, with no significant age effect. These spontaneous solves are noteworthy because, in everyday life, humans often make decisions for the future without an explicit question/prompt of the sort commonly used in behavioral tasks. Again, this lack of age difference is consistent with the idea that deliberate retrieval/generation may drive age differences on explicit test questions but not on more spontaneous forms of talk/thought. However, given the low base rate of spontaneous solves, this interpretation must remain tentative until further replications that directly compare explicit and spontaneous dimensions of future thought are undertaken.

A somewhat unexpected finding is that children were more likely to spontaneously solve the task in the toy condition (19%) than in the food condition (5%), a result that is opposite of what would be expected based on children's superior performance on the future thinking question in the food condition. Although merely speculative, this may be because children are more accustomed to moving toys to different locations within the home (e.g., bringing toys from their bedroom to the family room), as opposed to doing so with food (i.e., food is typically limited to certain locations in the house). This may have resulted in children being reluctant to spontaneously suggest that the candy be moved to another room. Alternatively, it is possible that children were hesitant to suggest moving food so as not to appear that they wanted more than was being offered to them[iv].

Importantly, children who solved our task spontaneously produced more statements about the past and the future than those children who failed. This finding is consistent with the claim that such utterances facilitated or otherwise primed children's more "explicit" or "prompted" future thinking. Interestingly, the number of "other" utterances (i.e., those utterances not coded as past or future) did not differ significantly between children who passed and failed our task. This finding suggests that it is not simply the quantity of talk that is related to solving our task but, rather, talk about the past and the future more specifically. However, we also recognize the importance of replicating this finding and further exploring the specificity of spontaneous "temporal" talk on children's explicit future-oriented responses in our task. Moreover, it should be noted that our design does not allow us to draw a causal inference between number of temporal utterances and task success. Designs with an experimental manipulation to induce spontaneous future utterances are required to further explore any causal role of spontaneous talk/thinking to task success.

Our findings with respect to children's spontaneous utterances suggest new avenues for research on young children's mental time travel abilities. For instance, it would be interesting to determine the task characteristics that set the stage for spontaneous/involuntary future thinking. For example, children at different ages are likely unevenly influenced by social pressures that could affect their likelihood of speaking spontaneously during the task. Older or more temperamentally inhibited children might perceive it as inappropriate to talk to the experimenter when he/she is working, which could obscure the true presence of spontaneous thought/talk,

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[iv] Another alternative explanation: Children in the toy condition may have had to verbalize the solution more because the condition was more difficult, as evidenced by 3-year-olds' chance performance on the explicit test question.

while younger or less inhibited children may be more likely to speak during the experiment. This observation also highlights that spontaneous talk—though interesting—is an imperfect proxy for spontaneous thought. Other behavioral variables (e.g., gestures, facial expressions, eye gaze) that might reflect children's mentally reliving/pre-experiencing scenarios could also be explored in future investigations (see also Krøjgaard et al., 2017). On a methodological note, future investigations of spontaneous/involuntary future cognition in children should also include a measure of general vocabulary/verbal ability to control for age differences in expressive/receptive vocabulary. This was not possible in our study, given our post-hoc decision to explore children's utterances.

Conclusion

Although future thinking is domain general in humans, it may emerge unevenly across domains in early development. In particular, our study provides preliminary evidence that children may first succeed when they are thinking ahead about how to satisfy a need/desire for food. Further, 3- to 5-year-olds' language during the task suggests that they spontaneously anticipate events related to the task and remember task-relevant details. Importantly, these utterances are more numerous in children who succeed at the task, as compared to those who fail. New behavioral investigations of young children's future thinking might consider incorporating both explicit and spontaneous future thinking measures to better capture the full range of future-oriented cognition.

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Footnotes

[1]Without the 12 children who experienced slight variations from the standard protocol (see Participants), the pattern of results remained the same (17/23 = 74% vs. 14/19 = 74% of 3-year-olds placed candy in the correct room); however, for the binomial test, $p = .064$, reflecting the decrease in power due to smaller cell size.

[2]51/60 = 85% of children selected the correct room in the food condition and 42/60 = 70% of children selected the correct room in the toy condition. Without the 12 children who experienced slight variations from the standard protocol, the pattern of results between conditions remained very similar (46/54 = 85% correct in the food condition; 39/54 = 72% in the toy condition). However, the effect of condition is no longer significant reflecting lower power, $OR = 2.37$, 95% CI [0.86, 6.51], $p = .094$.

[3]Although we did not predict an Age × Condition interaction, we ran a second, exploratory, binary logistic regression with age, condition, and the Age × Condition interaction included in the model. However, since 5-year-olds in the food condition were at ceiling (no variability), the interaction statistics and resulting model were uninterpretable.

Chapter 3: Can Children Represent a Future That Differs From the Present? Only by Age Seven

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Thanks to Joana Mukunzi for help with participant recruitment. Thank you to the children and parents who participated.

This research was supported by a Doctoral Postgraduate Scholarship from the Natural Sciences and Engineering Research Council of Canada and an Ontario Graduate Scholarship to Julian S. Caza and a Discovery Grant from the Natural Sciences and Engineering Research Council of Canada (RGPIN/ 06446-2015) to Cristina M. Atance.

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Abstract

Future-oriented thought is ubiquitous in humans but challenging to study in children. Adults not only think about the future but can also represent a future state of the world that *differs* from the present. However, tasks to assess the development of future thought have not traditionally required children to do so. Existing tasks can be solved based solely on representations of the present. To overcome this limitation, we modified an existing task such that children could not simply rely on a representation of the present to solve the task (i.e., the correct answer for “right now” was different than the correct answer for “tomorrow”). Four- to 7-year-olds remembered the information required to solve the modified task, but only 7-year-olds made an adaptive future-oriented decision more often than chance. With the task modification removed (so the correct answer for the present and the future was the same), even 4-year-olds were above chance. Our work challenges the notion that, starting at age 4, children solve behavioral tasks of future thinking by acting on their representations of the future.

Keywords: development, mental time travel, episodic future thinking, representation

Can Children Represent a Future That Differs From the Present?: Only by Age Seven

Our capacity to mentally pre-experience the future allows us to modify our current behavior in highly adaptive ways (Klein, 2013; Suddendorf & Corballis, 2007). This capacity, sometimes referred to as "episodic future thinking" (Atance & O'Neill, 2001) has likely played an important role in humans' evolution and remarkable success across diverse environments (Ambrose, 2010; Suddendorf & Corballis, 1997, 2007). There has been a growing interest in future thinking in many sub-fields of psychology (for reviews see Michaelian, Klein, & Szpunar, 2016; Oettingen, Sevincer, & Gollwitzer, 2018). Developmentalists, in particular, have studied this ability with an eye to its emergence, its measurement, and whether it forms the basis of uniquely human capacities such as saving, planning, and deliberate practice (Atance, 2015; Brinums, Imuta, & Suddendorf, 2017; Suddendorf, 2013, 2017; Suddendorf & Corballis, 2007).

Future thinking in young children (and in non-human animals) has most often been measured using variants of Tulving's (2005) "spoon test" (see also Suddendorf, 1994). This test is based on an Estonian fairy tale: A young girl dreams about attending a party where a delicious chocolate pudding is served, but because she has not brought a spoon, she cannot have any. The next night, the little girl brings a spoon to bed with her. This behavior not only reflects the little girl's ability to mentally travel back in time, but also her ability to pre-experience the future and act accordingly. Tulving argued that such behavior (and underlying thought processes) develops around age 4 and is likely absent in non-human animals.

So far, Tulving's (2005) developmental prediction appears to (mostly) have been borne out. For example, Suddendorf, Nielsen, and von Gehlen (2011) implemented one of the first versions of the spoon test. They showed 3- and 4-year-olds a locked box containing stickers. Children were then taken to a second room. After a delay, children were told they would be returning to the first room and were asked to select one item to bring back with them. In this and similar spoon test tasks, selecting the item that will be useful in the future (e.g., a key to unlock the sticker box) is taken as behavioral evidence of future thinking. Most studies demonstrate that, by age 4, children select the correct item significantly more often than would be expected by chance (Atance & Sommerville, 2014; Moffett, Moll, & FitzGibbon, 2018; Redshaw & Suddendorf, 2013; Scarf, Gross, Colombo, & Hayne, 2013). Some variants of this task have, however, resulted in success in children as young as age 3 (e.g., Payne, Taylor, Hayne, & Scarf, 2015; Scarf et al., 2013).

In a related task, rather than have children select an item that would be useful in the future, children are required to think ahead about *where* an item will be needed (Atance, Louw, & Clayton, 2015). Three- to 5-year-olds alternated twice between one room that contained toys and one room that did not. Children were then told they would be returning to the rooms in the future. They were presented with extra toys and asked, “Which room do you want to put these in?” Four- and 5-year-olds, but not 3-year-olds, chose to place the toys in the correct room (the room without toys) above chance, suggesting that they had thought ahead about where toys would be needed.

Spoon tasks and their variants have made important contributions to the study of future-oriented cognition by showing that children can draw on past experience to make an adaptive choice for their futures. However, while this choice is in itself adaptive, does it require that children actually represent the future or reason about time itself? For example, in Suddendorf et al.’s (2011) spoon test, a particular key is the correct choice whether children go to the room with the locked box immediately, tomorrow, or even next week (Atance & Mahy, 2016). In other words, children need not represent the *future* to solve the task but, rather, work off of a representation of the present state of the world (e.g., “this key is needed to unlock the box”). This is because there is no indication that the world will change between “now” and the future time when the child's choice will take effect. A similar limitation applies to Atance et al.'s (2015) task. This limitation in current tasks is not trivial given that researchers have argued that episodic future thinking offers a selective advantage specifically because it allows individuals to simulate possible futures *that differ substantially from the present* and act based on those representations (Klein, 2013; Suddendorf & Corballis, 2007).

Hoerl and McCormack (2018) recently argued that temporal cognition may involve two systems: the *temporal updating* system and the *temporal reasoning* system. The former is said to be more primitive than the latter, but both are present in adult human cognition. The more primitive temporal updating system operates by updating representations of the present as opposed to representing and reasoning about time itself: In other words, it operates by "*changing representations*, rather than by *representing change*" (Hoerl & McCormack, 2018, p. 6). The temporal reasoning system operates by representing events at specific times in the future and past as well as temporal order. Animals and young children can certainly solve tasks that "involve things unfolding over time in a certain way" (p. 5); however, these tasks could be solved based solely on representations of the present (and therefore, solely with the temporal updating system). This may be the case for many of the behavioral future thinking tasks used with children. Hoerl and McCormack argued that children first use the temporal updating system and then the more sophisticated temporal reasoning system emerges gradually over the course of development.

One way to address this limitation in existing future thinking tasks is to produce a task where what one ought to do right now is different from what one should do in the future.

Consider the following scenario: Where I work, we have a communal kitchen with a cupboard designated for storing snacks. In the morning, I might put some crackers in the snack cupboard for later (I am working late today). However, I know that our vigilant cleaning staff always empty the cupboard at the end of the standard workday at 4 p.m. If I know I will want a snack after 4 p.m., I must store it somewhere other than the snack cupboard (perhaps hidden in the cutlery drawer) so that it is still available after 5 p.m. In this example, my representation of the future must account for a relevant intervening event (the cleaning staffs' visit). Behaviorally, what I should adaptively do right now (put snack in the cupboard) differs from what I should do for the future (hide snack in the drawer). Unlike the structure of the tasks previously described, there is evidence that the world will undergo a change (due to an intervening event) between "now" and "tomorrow."

Can children take into account an intervening event in their reasoning such that they cannot simply solve a task/problem based on how the world is right now? This is precisely the kind of scenario we sought to test in children using a modified version of Atance et al.'s (2015) procedure. Children alternated between two rooms, one with candy and one without, but then learned that every night, "John the Garbage Man" enters the room that does not (currently) contain candy and throws out any candy he may find. Four- to 7-year-olds were then told they would be returning tomorrow and asked where they wanted to put a container of novel, highly desirable candy. Here, unlike in Atance et al. (2015), the correct response is to put the novel candy in the room that already contains some: This is because putting it in the room where there currently is none will result in the novel candy being thrown out (and, hence, not being able to enjoy it). Similar to the snack scenario described earlier, the Garbage Man's visit sets up a context in which the current and future states of the world differ. As such, an adaptive future-oriented response ("put the candy in the room where there is *some*") cannot be based on one's current representation of the world (which would be more consistent with "put the candy in the room where there is *none*"). Accordingly, if children can represent this *future* state of the world, they should choose to put the novel candy in the room where the Garbage Man will not visit even though it is the room that *currently* contains candy.

Study 1a

Method

Participants. Prior to data collection, we used G*Power 3.1.9.2 (Faul, Erdfelder, Lang, & Buchner, 2007) to conduct a power analysis (binomial test, two-tailed). Based on Atance et al.'s (2015) finding that 4-year-olds succeeded in 79% of cases (effect size $g = .29$), we required 23 children per age group to achieve power of .80 with alpha set to .05.

Participants ($N = 94$) were 24 4-year-olds (13 females; $M_{age} = 52.17$ months, $SD = 3.54$), 23 5-year-olds (13 females; $M_{age} = 65.91$ months, $SD = 3.18$), 23 6-year-olds (11 females; $M_{age} = 77.83$ months, $SD = 3.61$), and 24 7-year-olds (15 females; $M_{age} = 89.54$ months, $SD = 3.82$). Children were predominantly White and middle class and were recruited from a large university city. Three additional participants were tested but not included in the analyses. Two were excluded due to experimenter error that resulted in substantial deviations from the procedure, and one was excluded for failure to complete the procedure. An additional eight participants experienced slight variations from the standard protocol (e.g., extra time in a room due to experimenter error, brief break to "check in" with parent, etc.) but were nonetheless included in the final analyses because the pattern of results was the same both with and without these eight participants included.

Procedure. The setup for this experiment involved two rooms—one with candy and one without (see Figure 1). To help children distinguish between the two rooms, one was called the Tree room, and the other was called the Cloud room. A picture of a Tree/Cloud was affixed to the Tree/Cloud room door and also to the plastic container that held the candy. Each room was furnished with a child-sized table and two child-sized chairs in addition to a blue plastic box that either contained the candy or not.

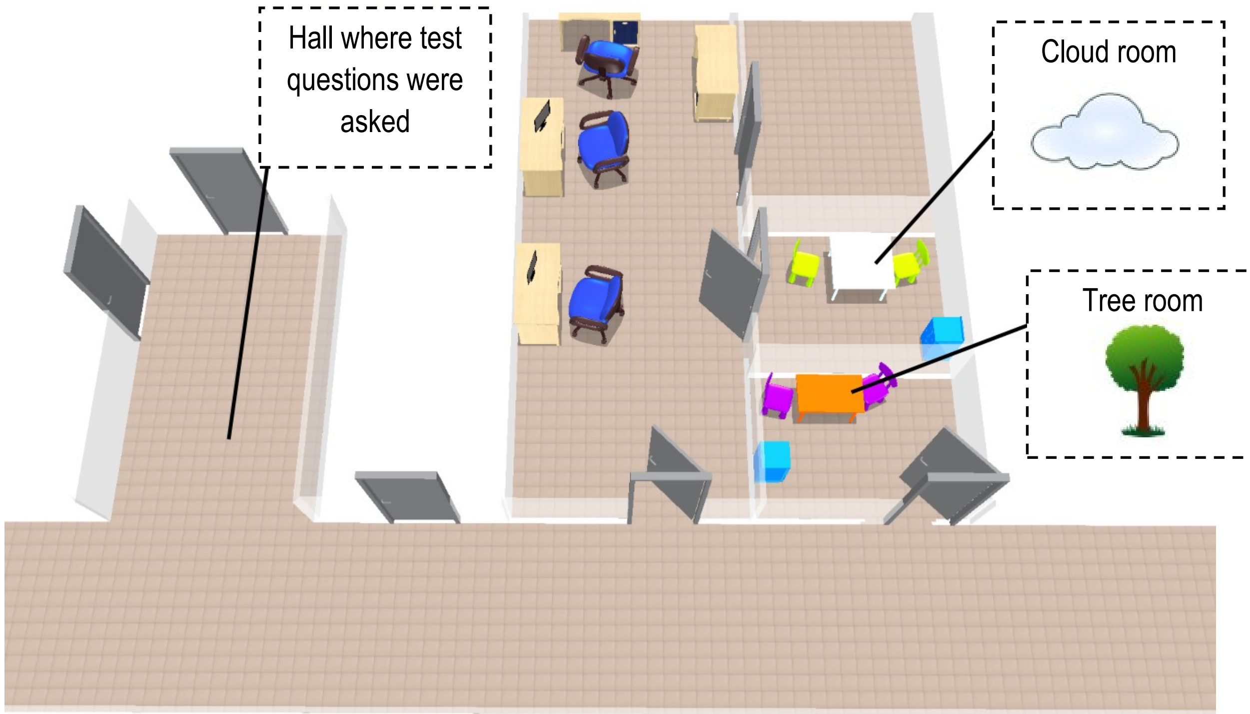

Figure 1. Schematic representation of the experimental setup.

The experimenter (E) showed the child both rooms and said, “We’re going to visit two different rooms today. This is the Tree room. Look! There’s a picture of a tree on the door. And this is the Cloud room. Look! There’s a picture of a cloud on the door.” The E then said, “Let’s start in the Tree room.” Upon entering the room, the E directed the child to check the plastic container for candy: “Let’s check the box to see if there is some candy for you to eat. Wow! There is candy for you to eat.” The E then used a spoon to transfer six candies from a ¾ full Tupperware container into a smaller bowl for the child. If there was no candy, the E said, “Let’s check the box to see if there is some candy for you to eat. Oh no! There isn’t anything for you to eat.” (50% of the children first entered a room with candy, whereas the other 50% first entered a room without candy.)

In either case, the E then told the child, “I have some work to do until this timer rings” (timer set to ring in 3 min). The E then put on headphones and pretended to work to reduce the likelihood that children would interact with him/her. In the room that contained candy (i.e., the "candy" room[1]), the child was free to eat the six candies for the 3 minutes. In the room that did not contain candy (i.e., the "no-candy" room), the child had to wait with nothing to do for the 3 minutes. If the child attempted to interact with the experimenter, the E reminded the child that he/she had a little work to do until the timer rang. Children visited each room (i.e., the candy and no-candy rooms) twice. This was done to allow children to learn that one room contained candy whereas the other room did not. After alternating between the two rooms twice, the child and E walked down the hall for the test questions, which were recorded on a digital audio recorder.

For clarity's sake, the test questions we describe next correspond to a version of the protocol in which there was candy in the Tree room and no candy in the Cloud room. The E said, "You got to visit the Tree room and the Cloud room today (drawings of a tree and a cloud were placed side-by-side on the ground in front of the child). You're going to visit the Tree room and the Cloud room again tomorrow. Look what I have: candies (the child was shown a Tupperware ½-full of novel candies, including a chocolate bar, gummy worms, gummy bears, jelly beans, and starbursts). These are for when you visit tomorrow." The E then told the children about John the Garbage Man: "Look! This is a picture of John the Garbage Man. Every night, John goes into the Cloud room and throws away any candy he finds. John only cleans the Cloud room, he never cleans the Tree room, and he only cleans at night." Children were reminded, "You're going to visit the Tree room and the Cloud room again tomorrow," and then asked the *future thinking question*, "Which room do you want to put this candy in for tomorrow?" The correct response (i.e., the room that contained candy, "Tree" in this case) was coded as 1; all other responses were coded as 0.

After selecting a room, children were asked, "Why do you want to put these in the

[Tree/Cloud] room?" We developed a coding scheme to classify children's explanations into three, mutually exclusive categories (see Table 1). Children in the first category referenced the intervening event (the Garbage Man's visit) in their explanations and therefore may have been representing important temporal information required for task success (temporal reasoning system) (Hoerl & McCormack, 2018). Children in the second category referenced the room lacking candy and therefore might have been reasoning based on a representation of the present (temporal updating system). All other explanations were coded as "Other": The extent to which these children were or were not representing the present or future is ambiguous. All participants' explanations were transcribed by the experimenters and then later verified by a research assistant. All participant transcriptions were coded by the first author, who was blind to the age and performance of the child on the other test questions. For inter-rater reliability, a research assistant independently coded all participants. Inter-rater reliability was calculated using Cohen's (1960) kappa (κ), and indicated excellent agreement, $\kappa = .91$.

Table 1

Coding Scheme for Children's Explanations

Explanation Category	1. Mentions Intervening Event (Future-Oriented Explanation)	2. Mentions Lacking Candy in Empty Room (Present-Oriented Explanation)[a]	3. Other[ab]
Coding Criteria	A reference to Garbage Man/John/He/Him and/or that candy will be thrown out/cleaned/taken/eaten /consumed/wasted	A reference to not having candy in the empty room	All other responses
Examples	"So that I saved it from John." "Because he never, never, never cleans the tree room." "So the Garbage Man doesn't steal the candy and put it in the garbage."	"Because it's got no candy in the tree room." "Because there's no candy." "Because today there was no candy in the cloud room."	"I kind of don't know." "Because it's so fun." "Because we go to the cloud room first." "So I can have some candy tomorrow."

[a]Children in these categories never referenced the Garbage Man or throwing away candy (i.e., the intervening event).

[b]Children in this category never referenced the empty room.

Children were then asked the following *memory questions*: (1) "Was there any candy in the Cloud room?" and (2) "Was there any candy in the Tree room?" If children provided the response to one of the memory questions in their explanation of their room choice, the corresponding memory question was not asked if it directly followed the explanation in the counterbalanced order. For example, if the child said he put the candy in the Cloud room "because it doesn't have any candy," the experimenter did not then ask, "Was there any candy in the Cloud room?" but, rather, the child was credited with having answered that memory question correctly. Children were asked three additional memory questions: (3) "When does John the Garbage Man clean?" (4) "Which room does John the Garbage Man clean?" (5) "What does John do every night?" (See Table 2 for correct responses.) The future thinking question was always asked before the memory questions to rule out the possibility that answering the memory questions first would prompt the correct response to the future thinking question. We counterbalanced whether children started in the room with candy or the room with no candy, whether the Tree or Cloud room contained candy, and whether the Tree or Cloud room was mentioned first in the test questions.

Results

Memory Check Questions. A one-way ANOVA revealed no effect of age (4, 5, 6, 7) on children's total score (range = 0-5) on the memory questions, $F(3, 90) = 2.10$, $p = .106$, $\eta_p^2 = .065$. A series of Friedman's tests for each age group showed that children's performance also did not differ between the five questions, all *p*s > .100 (see Table 2).

Table 2

Memory Question Performance by Study

Memory Question	Correct	Incorrect	Percentage Correct
Study 1a (*n* = 94)			
Was there any candy in the Tree room? (Yes/No)	89	5	95
Was there any candy in the Cloud room? (Yes/No)	88	6	94
When does John the Garbage Man clean? (Night)	89	5	95
Which room does John the Garbage Man clean? (Tree/Cloud)	92	2	98
What does John do every night? (Clean; throw out candy)	92	2	98
Total Score (Mean and Standard Deviation)	4.79/5 (.53)		96
Study 1b (Control) (*n* = 23)			
Was there any candy in the Tree room? (Yes/No)	23	0	100
Was there any candy in the Cloud room? (Yes/No)	22	1	96
Total Score (Mean and Standard Deviation)	1.96/2 (.21)		98

Note. Correct responses in parentheses. For "yes/no" questions, the correct response differs as a function of counterbalancing order.

Future Thinking Question.

Preliminary analyses. A series of Mann-Whitney U tests revealed that children's responses to the future thinking question did not vary significantly as a function of whether the first or second room contained the candy, $U = 1039.00$, $p = .638$, $\eta^2 = .002$, or whether the candy or no-candy room was mentioned first in the test question, $U = 963.50$, $p = .213$, $\eta^2 = .016$. There was also no effect of gender, $U = 1004.00$, $p = .435$, $\eta^2 = .006$.

Focal analyses. A series of binomial tests revealed that the performance of 4-, 5-, and 6-year-olds was no different from chance (0.5/1). In contrast, the performance of the 7-year-olds was significantly above chance (see Figure 2 and Table 3). Children's age in months was significantly correlated with their performance on the task, $r_{pb} = .328$, $n = 94$, $p = .001$, suggesting that there was developmental improvement.

In sum, although children of all ages were able to remember critical task information, only 7-year-olds took the intervening event into account by selecting the correct room in which to store candy for "tomorrow."

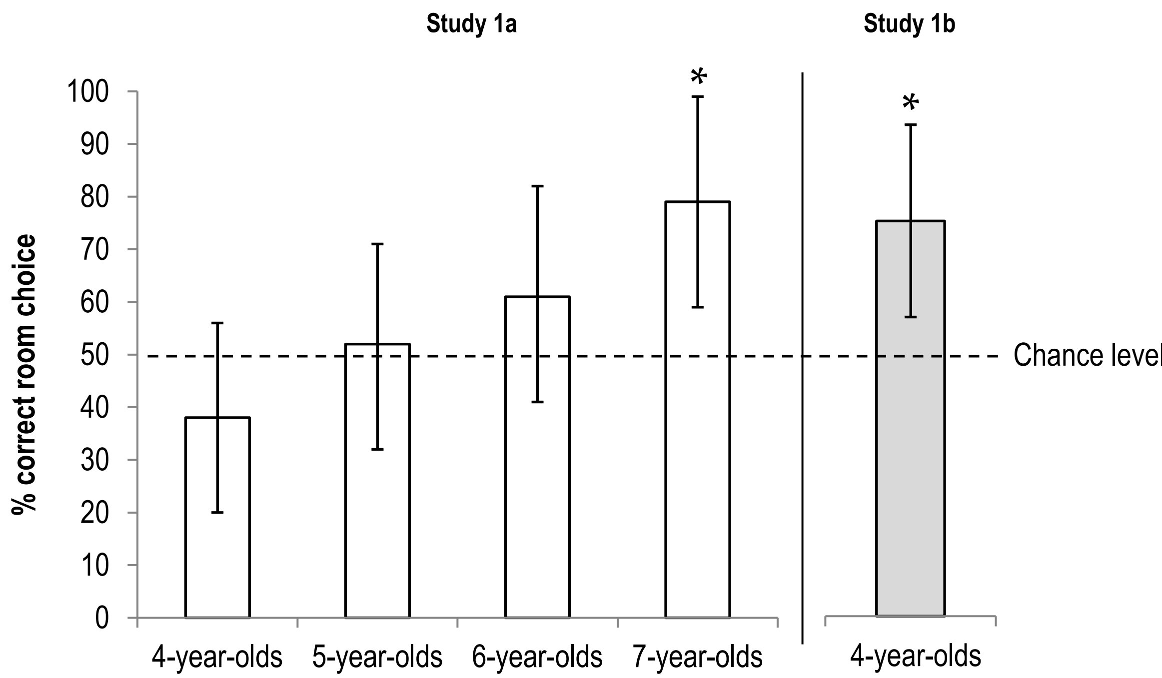

Figure 2. Percentage of children who placed novel candy in the correct room. Error bars represent 95% confidence intervals.

* = significantly above chance (0.5/1) according to binomial tests, all ps < .036

Table 3

Future Thinking Question Performance by Age and Study

Age (Years)	Correct	Incorrect	Percentage Correct	Binomial Test
Study 1a				
4 (n = 24)	9	15	38	p = .307
5 (n = 23)	12	11	52	p = 1.000
6 (n = 23)	14	9	61	p = .405
7 (n = 24)	19	5	79*	p = .007
Study 1b				
4 (n = 23)	17	6	74*	p = .035

* = significantly **above** chance according to binomial test (test proportion = 0.50)

Children's Explanations.

A binomial test revealed that children who referenced the intervening event (i.e., the Garbage Man's visit) placed the novel candy in the correct room above chance, consistent with these children successfully reasoning based on the future (see Table 4). Children whose explanations referenced lacking candy in the empty room placed the novel candy in the correct room significantly *below* chance. These children's explanations were consistent with the current state of the world but did not take into account the future intervening event. Children's performance in the "Other" explanation category was no different from chance. See also Table 5 for the percentage of children offering each explanation type by age in years.

Table 4

Future Thinking Question Performance by Children's Explanations (Study 1a)

Explanation Category	Correct	Incorrect	Percentage Correct	Binomial Test
1. Mentions Intervening Event (Future-Oriented Explanation) (n = 47)	42	5	89	$p < .001$*
2. Mentions Lacking Candy in Empty Room (Present-Oriented Explanation) (n = 27)	1	26	4	$p < .001$†
3. Other (n = 20)	11	9	55	$p = .824$

* = significantly **above** chance according to binomial test (test proportion = 0.50)

† = significantly **below** chance according to binomial test (test proportion = 0.50)

Table 5

Children's Explanations By Age

Age (Years)	1. Mentions Intervening Event (Future-Oriented Explanation) (%)	2. Mentions Lacking Candy in Empty Room (Present-Oriented Explanation) (%)	3. Other (%)
4 (n = 24)	17	50	33
5 (n = 23)	52	26	22
6 (n = 23)	48	30	22
7 (n = 24)	83	8	8

Study 1b

Although previous research (Atance et al., 2015; Caza & Atance, 2019) has shown that 4-year-olds pass our task when there is no mention of "John the Garbage Man," due to other small task variations, we thought it prudent to re-run the task from Study 1a with a new group of 4-year-olds (and removing mention of John the Garbage Man). In this case, the correct response was to place the candy in the room where there was none. Participants were 23 4-year-olds (12 females; M_{age} = 53.48 months, *SD* = 3.58). Three participants had slight variations from the standard protocol but were included in the analyses because the pattern of results was the same both with and without these participants.

Results

In contrast to 4-year-olds in Study 1**,** 4-year-olds in this control study (who were not told about John the Garbage Man's visit) performed significantly above chance (see Figure 2 and Table 3), and outperformed 4-year-olds in Study 1a, $U = 175.50$, $p = .013$, $\eta^2 = .131$.

Discussion

We modified Atance et al.'s (2015) future thinking task so that children's success rested on their capacity to represent and reason about a future that differed from the present. Although performance improved with age, only the 7-year-olds were significantly above chance. This is in stark contrast to previous spoon tests and their variants in which the majority of 4-year-olds (and sometimes 3-year-olds) succeed (e.g., Atance et al., 2015; Caza & Atance, 2019; Redshaw & Suddendorf, 2013; Suddendorf et al., 2011). However, as we have argued, these tasks may overestimate children's future thinking capacity because they do not involve contexts in which there is an intervening event that makes the correct answer different between the present and future. Consistent with this argument, 4-year-olds in Study 1b performed above chance when the intervening event (i.e., "John the Garbage Man") was removed.

Our modified task likely required the use of the more advanced “temporal reasoning” system (Hoerl & McCormack, 2018), as children had to reason about temporal order and represent a future that differed from the present. Our task could not be solved with a representation of the present alone (i.e., the “temporal updating” system). But what evidence is there that some children in our study may have failed because they based their room choice on a representation of the present (i.e., temporal updating system) while others may have succeeded because they represented/reasoned about time itself (i.e., temporal reasoning system)? To clarify this point, we examined children’s explanations for their room choices: We found that children who referenced the intervening event (offering a future-oriented explanation, consistent with temporal reasoning) chose to place the novel candy in the correct room above chance (89%). Children who referenced lacking candy in the empty room (offering a present-oriented explanation, consistent with temporal updating) chose to place the novel candy in the incorrect room (96%). The descriptive results in Table 5 are consistent with a developmental progression in children’s explanations.

The chance analysis of children’s room choice revealed that 4-, 5-, and 6-year-olds all placed the novel candy in the correct room no more than would be expected by chance. This raises the question of whether these children simply guessed/selected the correct room at random or whether this chance performance reflects that some children in these age groups reasoned successfully and others did not (i.e., individual differences within age groups obscured by the dichotomous outcome variable, i.e., room choice). Approximately half of 5- and 6-year-olds mentioned the intervening event in their explanation for their room choice (52 and 48%, respectively), which suggests that perhaps up to half of children in these ages are actually reasoning based on the future and are not guessing. Only 17 percent of 4-year-olds mentioned the intervening event in their explanations, however, and 50 percent gave a present-oriented explanation, suggesting that the chance performance of 4-year-olds may represent a true deficit in this age group's capacity to reason based on the future in our task. These conclusions are tentative, however, as children's verbal explanations are an imperfect proxy for their reasoning and also do not correlate perfectly with their room choice.

A study by Dickerson, Ainge, and Seed (2018) provides additional converging evidence that children's success on spoon tasks may not rely on their capacity to think ahead. Using a task similar to Suddendorf et al.'s (2011), these researchers showed that 4-year-olds were just as likely to incorrectly select an item that had previously been paired/associated with a reward, but that would *not* be useful in the future, as they were to select the correct item that had future utility. Together with our study, these findings challenge the claim that spoon tests and their variants, which have become the "litmus test" of episodic foresight, require this very capacity.

Why was it not until age 7 that children consistently passed our task? We can rule out the possibility that younger children failed because they could not remember *what* the Garbage Man does every night, *where* he does it, and *when* he does it. Indeed, each age group remembered this information. However, critical to task success may have been the capacity to *recombine* this information to construct the required future scenario (Martin-Ordas, Atance, & Caza, 2014; Schacter & Addis, 2007; Suddendorf & Corballis, 1997), a "binding" process that improves between ages 4 and 7 (Yim, Dennis, & Sloutsky, 2013). The "when" component is especially relevant to solving our task because the timing of the Garbage Man's visit determines the correct response. Indeed, previous work suggests binding for "when" emerges later than binding for "what" and "where" (Cuevas, Rajan, Morasch, & Bell, 2015; Hayne & Imuta, 2011; Martin-Ordas, Atance, & Caza, 2017; Scarf, Boden, Labuschagne, Gross, & Hayne, 2017).

Although age 7 may appear to be late in development to solve the kind of task we designed, it is consistent with recent work conducted in the realm of children's counterfactual reasoning—or, the capacity to reason about how events could have turned out differently (e.g., “Had I brought my umbrella, I would not have gotten soaked on my walk home”; Byrne, 2016; De Brigard & Parikh, 2019; Roese, 1997). Developmental researchers use the term “nearest possible world” constraint to refer to “the manipulation of one aspect of an event while holding all other features constant” (Nyhout, Henke, & Ganea, 2017, p. 2). Although children solve simple counterfactual reasoning tasks by age 4, it is not until ages 6 to 8 that they solve more complex counterfactual tasks that require them to consider the nearest possible world constraint (Nyhout et al., 2017; see Nyhout & Ganea, 2019, however, for a recent example of nearest possible world constraint reasoning in 4- and 5-year-olds using a structurally simpler non-narrative based task). Our task may comprise a future-oriented analogue of this constraint because solving our task requires that children simulate a future that is the same as the present, save for one key difference (i.e., the impact of the Garbage Man’s visit).

An even later development is the capacity to represent a mismatch between the present and future in the realm of physiological states (Atance & Meltzoff, 2006; Mahy, Grass, Wagner, & Kliegel, 2014). For example, Mahy et al. (2014) found that 7-year-olds incorrectly predicted that they would prefer a glass of water to some tasty pretzels when induced to feel thirst in the present. Even more striking is that this difficulty persists into adulthood (Kramer, Goldfarb, Tashjian, & Lagattuta, 2017) thus highlighting important variations in performance as a function of the kind of state that people are asked to predict.

One could argue that our task has high verbal and memory demands which may have contributed to younger children’s failure. However, it was for this reason that we asked children a series of memory check questions. Although it may be possible to develop a task with fewer such demands, it is necessary to do so in a way that preserves the present-future mismatch. We were unable to come up with an alternate means of doing so that did not rely on verbally informing children about the intervening event that creates the present-future mismatch. Perhaps in a subsequent task version using a shorter timescale (i.e., not over the span of one night), children could be given the opportunity to personally experience the effects of the intervening event and then be called upon to make a choice for the future. As it stands, however, our data highlight that it is not until age 7 that children can make an adaptive choice for the future when an intervening event creates a present-future mismatch. Developmental and comparative researchers should continue to develop and refine behavioral methods for children and non-human animals that can only be solved by simulating a future that differs from the present.

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Footnotes

[1]The labels “candy” and “no-candy” were never spoken to the child. We use them here to clarify the explanation of the task.

Chapter 4: General Discussion

My dissertation included several new contributions to the developmental literature on future thinking. In the first article (Chapter 2), we directly compared 3- to 5-year-olds' future thinking across two conceptually distinct domains. This was an important contribution because existing tasks have generally used tools/toys even though humans' capacity for future thought is domain general.

Also in Chapter 2, we examined children's spontaneous utterances to address the fact that very little is known about children's spontaneous episodic thinking despite the ubiquity of involuntary episodic thinking in everyday life. To our knowledge, this is the first investigation of spontaneous future thinking in young children.

In the second article (Chapter 3), we addressed a key limitation of existing future thinking tasks; that is, that children could potentially solve behavioural future thinking tasks without having to represent the future. We modified Atance et al.'s (2015) two-rooms task so that correct answer for right now and tomorrow was different.

In the following sections, I review the major findings of this research program as well as some limitations and future directions. I pay special attention to topics not covered in the chapter-specific Discussion sections or the General Introduction.

Future Thinking Across Domains and Spontaneous Talk

Children's future thinking across domains

In the first article (i.e., Caza & Atance, 2019), we employed a modified version of Atance et al.'s (2015) two-rooms task. A main goal of the first study was to examine whether 3- to 5-year-olds can think about the future across domains, as most existing future thinking tasks focus on tools and toys but neglect other important domains, such as food. In the food condition, children had to think ahead about satisfying a future physiological need (desire for food), whereas in the toy condition, children had to think ahead about a more psychological need (avoiding boredom). We found that 4- and 5-year-olds placed extra resource in the correct room more often than 3-year-olds. Overall, children were more successful in the food condition than the toy condition. In the food condition, 3-, 4-, and 5-year-olds all placed extra resources in the correct room above chance. In the toy condition, only 4- and 5-year-olds performed above chance.

The toy condition also served as a replication of Atance et al. (2015) with some of the peripheral task features, such as unnecessary social and pretense components, removed: Many existing future thinking tasks include some unnecessary pretense, including plastic food (e.g., Suddendorf et al., 2011), puppets (e.g., Atance et al., 2015; Redshaw & Suddendorf, 2013), and pirates (e.g., Payne et al., 2015; Scarf et al., 2013). We also asked the memory questions after the future thinking question to decrease the likelihood that children's memory responses prompted future thinking and generally met more of Suddendorf et al.'s (2011) criteria for future thinking tasks. Despite these minor changes, our results in the toy condition are consistent with Atance et al.'s (2015).

Limitations and future directions. Although our findings suggest that domain does impact performance, more research is required to clarify why this is the case. As discussed in Chapter 2, it is possible that food is a "privileged domain" of reasoning given its relevance to survival (Cassidy et al., 2005). Our results could also be explained by a difference in desirability between the two stimulus types. One way to clarify this point would be to run the task with multiple conditions of toys and foods, ranging in desirability. If performance differed consistently between these toy and food conditions, then I would be more confident that conceptual domain is an especially important contributor to children's performance. Children could also directly rate the desirability of particular toys or foods. If children continue to perform better in food conditions even when these foods are rated as less desirable than toys, this would also increase confidence in the domain argument. Irrespective of whether children's differential performance is caused by desirability and/or precocity in the domain of food/hunger reasoning, our findings highlight that choice of stimuli has the potential to impact children's performance. Accordingly, researchers should be cautious about drawing general conclusions about children's future thinking from one particular task in a specific domain.

Although we characterize this task as "behavioural," it does require that children provide a verbal response (i.e., selecting a room). An alternative version of this task could instead require children to physically place candy in their room of choice. However, this task modification would violate one of Suddendorf and Corballis' (2010) criteria for future thinking tasks discussed in the General Introduction, namely the spatial separation between the problem and the test question to avoid cuing based on seeing the test materials (in this case, the rooms).

As reviewed in the General Introduction, an important limitation of this study and behavioural future thinking tasks more generally is that children could potentially solve the task without actually representing the future or reasoning about time. That is, the correct answer (i.e., put the resource in the room where there is none) is correct whether children are representing the present or the future. This limitation was addressed in Chapter 3, which is discussed further below in the section "Thinking About a Future That Differs from the Present."

Children's spontaneous future thinking

We also investigated children's spontaneous talk as they participated in the study. Researchers have identified involuntary/spontaneous mental time travel as an important avenue for study given the ubiquity of unprompted mental time travel in daily life (Atance & Mahy, 2016; Berntsen, 2010). Children of all ages spontaneously spoke about future and past events related to the task. Although we found that 4-year-olds produced significantly more past utterances than 3-year-olds, the frequency of children's future talk in our task was not statistically different across ages and conditions. The absence of a clear developmental difference in future utterances over the ages we examined contrasts with the developmental difference obtained in children's performance on our explicit future thinking question (i.e., 4- and 5-year-olds performed significantly better than 3-year-olds). This pattern of findings is consistent with the argument that fewer executive control demands are required in spontaneous mental time travel due to the lack of deliberate retrieval or generation of future possibilities (Krøjgaard et al., 2014; Krøjgaard, Kingo, Jensen, & Berntsen, 2017). We found that children who solved the task (explicitly) spoke more about the future and past than children who failed. This research makes a novel contribution to the expanding literature examining spontaneous thought across various psychological subfields (see Cole & Kvavilashvili, 2019, for a recent editorial).

Limitations and future directions. Our design does not allow us to draw a causal relationship between number of temporal utterances and task success. Given the post-hoc decision to examine spontaneous utterances, we were not able to employ an experimental manipulation as in previous investigations of spontaneous episodic memories in children (i.e., Krøjgaard et al., 2014, 2017). Designs with an experimental manipulation to induce spontaneous future utterances are required to further explore any causal role of spontaneous talk/thinking to explicit task success.

Spontaneous cognition likely serves an important adaptive function for humans, and our results are consistent with the theory that spontaneous thought may somehow aid more explicit decision-making. However, there is a dark side to involuntary episodic thinking: Spontaneous cognition appears to play a role in many psychopathologies (Berntsen, 2019). For instance, individuals with post-traumatic stress symptoms sometimes experience distressing spontaneous episodic memories of traumatic events ("flashbacks"), which share many similarities with positive spontaneous episodic memories (Berntsen, 2001; Berntsen & Rubin, 2014; Malaktaris & Lynn, 2019). In social anxiety disorder, people engage in post-event processing (i.e., recounting distressing social experiences) as well as pre-event simulations, which are likely in part explicitly prompted as well as spontaneous (Clark, 2001). So-called "intrusive thoughts" (i.e., spontaneous thoughts experienced as distressing or unwanted) are common in the general population and can be especially distressing in obsessive-compulsive disorder (Bream, Challacombe, Palmer, & Salkovskis, 2017; Seli, Risko, Purdon, & Smilek, 2017). These thoughts often involve very upsetting future episodes (e.g., seeing one's family die in a car accident; stepping into traffic). In a recent study, both past and future involuntary autobiographical thought predicted proneness to experiencing hallucinations (Allé, Berna, & Berntsen, 2018). Our research and that of others suggests that the foundational cognitive abilities required for spontaneous episodic thought appear to be in place early in development (earlier than explicitly prompted episodic thinking). Further research into the relationship between adaptive and pathological variants of spontaneous episodic thought to the past and future in both childhood and adulthood may aid in identifying the cognitive mechanisms that maintain various psychopathologies.

Thinking About a Future That Differs from the Present

A central limitation of future thinking tasks used with children is that they could be solved without representing the future. This possibility is introduced because the current state of the world and the future do not differ in these tasks. We set out to address this limitation by modifying the two-rooms task so that children could only solve it by representing a future that differed from the present. Four- to 7-year-olds remembered the information required to solve the modified task, but only 7-year-olds made a future-oriented decision more often than chance. With the task modification removed (i.e., no present-future mismatch), even 4-year-olds were above chance, consistent with the existing research in this area. Our work challenges the notion that, starting at age 4, children solve behavioural tasks of future thinking by acting on their representations of the future.

In order to succeed on our task, children could not simply rely on memory of their visits to the two rooms as they could in Atance et al. (2015) and Caza and Atance (2019). In order to succeed, children had to mentally construct/represent a novel future event, which would presumably be more difficult than simply recalling a past event and may partially account for the increased difficulty of the task. This is consistent with McCormack and Hanley's (2011) finding that children have more difficulty reasoning about future events that they have not observed than past events they have.

Hoerl and McCormack (2018) recently argued that temporal cognition may involve two systems: the *temporal updating* system and the *temporal reasoning* system. The former is said to be more primitive than the latter, but both are present in adult human cognition. The more primitive temporal updating system operates by updating representations of the present as opposed to representing and reasoning about time itself: In other words, it operates by "*changing representations*, rather than by *representing change*" (Hoerl & McCormack, 2018, p. 6). Our modified task likely required the use of the more advanced "temporal reasoning" system (Hoerl & McCormack, 2018), as children had to reason about temporal order and represent a future that differed from the present. Our task could not be solved with a representation of the present alone (i.e., the "temporal updating" system). Consistent with this claim, we found that children who referenced the intervening event (offering a future-oriented explanation, consistent with temporal reasoning) chose to put the novel candy in the correct room above chance (89%). Children who referenced lacking candy in the empty room (offering a present-oriented explanation, consistent with temporal updating) chose to put the novel candy in the incorrect room (96%).

Limitations and future directions

Ideally, we would also develop a control condition in which children are told they will be returning *before* the intervening event (i.e., John the Garbage Man's visit). This would allow us to directly assess whether children can reason about the temporal sequence of future events. The correct answer in this case would be to put the extra resource in the room that contains none to satisfy a desire for food in that room. We attempted to do just this; however, we found that the resulting task was pragmatically awkward: Children might be left thinking, "Why is the Experimenter talking about John the Garbage Man if it is not relevant?" Or put another way, it is odd to tell someone irrelevant information. Tasks that violate conventions of communication are used at researchers' peril (Grice, 1975; Siegal, 1995). Perhaps novel tasks with a different structure would lend themselves better to this sort of control. We were limited by our attempt to adapt an existing task (i.e., Atance et al., 2015) so that the correct answer for present and future differed.

Another way of running this task could also involve three rooms instead of two. In this version, children would visit the Cloud room (containing candy), the Tree room (empty), and a third room, perhaps the Flower room (also empty). Children would then be told that John the Garbage Man only cleans the Tree room. In this scenario, the most adaptive choice would be to put extra candy in the Flower room for tomorrow. If children are only thinking about today, however, they might be expected to place the novel candy equally in the Tree and Flower rooms. This three-room design might address the oddness of placing extra candy in a room that already contains some.

Finally, our task involved an agent (i.e., Garbage Man) as the intervening event. Another approach would be to rely on an entity without a mind as the intervening event to further simplify the task and remove an unnecessary social element. For instance, perhaps children could be told that the door to the Tree room has an automatic lock which will make any candy placed in it inaccessible by morning.

Conclusion

There are many theoretical and methodological challenges to studying the emergence of future thinking in childhood. The studies in this dissertation addressed three new avenues within this literature. Firstly, existing tasks have not systematically examined children's capacity to think about the future across different domains despite the fact that future thinking is domain general in humans. Our findings in Chapter 2 suggest that, although future thinking is domain general, it may emerge unevenly in different domains and cross-domain studies are essential to establish generalizable timelines of the emergence of future thought. Secondly, existing tasks rely on explicitly prompting children's forethought as opposed to examining spontaneous future thinking. We were able to capture spontaneous talk about the past and future (as a proxy for spontaneous thought) in the context of the study in Chapter 2. We found that children of all ages frequently spoke about the past and future and even spontaneously solved the task without explicit prompting in some cases. Further, talk of the future and past was related to performance on the explicit test question. This preliminary attempt to capture spontaneous future thinking in children is the first of its kind. Thirdly, existing tasks might be solvable by relying on representations of the present alone. We addressed this important shortcoming by modifying an existing future thinking task (i.e., Atance et al., 2015) so that the correct answer for the present differed from the future. Therefore, it could not be solved based solely on a representation of the present. We found that children succeeded at this more complex version of the task only by age 7, much later than age 3 or 4 (which is when children solve existing tasks). This investigation raises important questions for researchers as they endeavor to develop tasks that best capture future thinking in young children and non-human animals.

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"This is real life." – Matthew Clyde

Appendices

Appendix A: Sample Protocols from Chapter 2

Food Condition

E: We're going to visit two different rooms today. This is the **Tree room**. Look! There's a picture of a tree on the door. And this is the **Sun room**. Look! There's a picture of the sun on the door.

E: Let's start in the **Tree room**!

(E and child start in the Tree room; *E starts stopwatch and times for 3 minutes*)

[CANDY] E: Let's check the box to see if there's some candy for you to eat. Wow! There is candy for you to eat *(E opens tupperware and puts 6 candies in a bowl).*

(E directs child to seat at table)

E: Okay. I have some work to do until this timer rings.

E: Now it's time to go to the **Sun room**.

(E and child move to the Sun room; *E starts stopwatch and times for 3 minutes*)

[NO-CANDY] E: Let's check the box to see if there's some candy for you to eat. Oh no! There isn't anything for you to eat *(E looks in box with child and shows that it's empty).*

(E directs child to seat at table)

E: Okay. I have some work to do until this timer rings.

E: Now it's time to go back to the **Tree room**!

(E and child move to the Tree room; *E starts stopwatch and times for 3 minutes*)

[CANDY] E: Let's get some more candy for you to eat *(E opens tupperware and puts 6 candies in a bowl).*

(E directs child to seat at table)

E: Now it's time to go back to the **Sun room**.

(E and child move to the Sun room; *E starts stopwatch and times for 3 minutes*)

[NO-CANDY] E: Let's check the box to see if there's some candy for you to eat. Oh no! There still isn't anything for you to eat *(E looks in box with child and shows that it's empty).*

(E directs child to seat at table)

E: Okay. I have some work to do until this timer rings.

E: Now I just have a few questions for you, and I'm just going to ask them down the hall.

(E and Child walk down hallway to quiet area.)

<u>Foresight Question:</u>

You got to visit the **Sun room** and the **Tree room** today.

You're going to visit the **Sun room** and the **Tree room** again *tomorrow*. Look what I have: candies *(E shows child tupperware ¾-full of candy)*. These are for when you visit the **Sun room** and the **Tree room** again *tomorrow*.

Which room do you want to put these in?

Child's choice: ____ (if child responds, move to "**For all children")**

> **- If child doesn't respond:** Which room do you want to put these in? ____ (if child responds, move to "**For all children")**

For all children: "Why do you want to put these in the X room?"

Child's explanation: ____

(If child explains answer with something like "Because there's no candy in the X room," do not ask the child the corresponding memory question.)

<u>Memory Questions:</u>

Was there any candy in the Sun Room? ________________________

Was there any candy in the Tree Room? ________________________

Prompt if child doesn't start eating candies: ***"You can eat those if you want!"***

Toy Condition

E: We're going to visit two different rooms today. This is the **Sun room**. Look! There's a picture of a sun on the door. And this is the **Tree room**. Look! There's a picture of the tree on the door.

E: Let's start in the **Sun room**!

(E and child start in the Sun room; *E starts stopwatch and times for 3 minutes*)

[TOYS] E: Let's check the box to see if there are some toys for you to play with. Wow! There are toys to play with *(E gives C toys).*

(E directs child to seat at table)

E: Okay. I have some work to do until this timer rings.

E: Now it's time to go to the **Tree room**.

(E and child move to the Tree room; *E starts stopwatch and times for 3 minutes*)

[NO-TOYS] E: Let's check the box to see if there are some toys for you to play with. Oh no! There isn't anything for you to play with *(E looks in box with child and shows that it's empty).*

(E directs child to seat at table)

E: Okay. I have some work to do until this timer rings.

E: Now it's time to go back to the **Sun room**!

(E and child move to the Sun room; *E starts stopwatch and times for 3 minutes*)

[TOYS] E: Let's get some more toys for you to play with *(E gives C toys).*

(E directs child to seat at table)

E: Now it's time to go back to the **Tree room**.

(E and child move to the Tree room; *E starts stopwatch and times for 3 minutes*)

[NO-TOYS] E: Let's check the box to see if there are some toys for you to play with. Oh no! There still aren't any for you to play with *(E looks in box with child and shows that it's empty).*

(E directs child to seat at table)

E: Okay. I have some work to do until this timer rings.

E: Now I just have a few questions for you, and I'm just going to ask them down the hall.

(E and Child walk down hallway to quiet area.)

<u>Foresight Question:</u>

You got to visit the **Sun room** and the **Tree room** today.

You're going to visit the **Sun room** and the **Tree room** again *tomorrow*. Look what I have: toys *(E shows child box of toys)*. These are for when you visit the **Sun room** and the **Tree room** again *tomorrow*.

Which room do you want to put these in?

Child's choice: ____ (if child responds, move to "**For all children")**

> **- If child doesn't respond:** Which room do you want to put these in? ____ (if child responds, move to "**For all children")**

For all children: "Why do you want to put these in the X room?"

Child's explanation: ____

(If child explains answer with something like "Because there are no toys in the X room," do not ask the child the corresponding memory question.)

<u>Memory Questions:</u>

Were there any toys in the Sun Room? _________________________

Were there any toys in the Tree Room? _________________________

Prompt if child doesn't start eating candies: ***"You can eat those if you want!"***

Appendix B: Sample Protocol from Chapter 3

E: We're going to visit two different rooms today. This is the **Cloud room**. Look! There's a picture of a Cloud on the door. And this is the **Tree room**. Look! There's a picture of a tree on the door.

E: Let's start in the **Cloud room**!

(E and child start in the Cloud room; *E starts stopwatch and times for 3 minutes*)

[NO-CANDY] E: Let's check the box to see if there is some candy for you to eat. Oh no! There isn't anything for you to eat *(E looks in box with child and shows that it's empty).*

(E directs child to seat at table)

E: Okay. I have some work to do until this timer rings.

E: Now it's time to go to the **Tree room**.

(E and child move to the Tree room; *E starts stopwatch and times for 3 minutes*)

[CANDY] E: Let's check the box to see if there is some candy for you to eat. Wow! There is candy to eat *(E gives C candy).*

(E directs child to seat at table)

E: Okay. I have some work to do until this timer rings.

E: Now it's time to go back to the **Cloud room**!

(E and child move to the Cloud room; *E starts stopwatch and times for 3 minutes*)

[NO-CANDY] E: Let's check the box to see if there is some candy for you to eat. Oh no! There isn't anything for you to eat *(E looks in box with child and shows that it's empty).*

(E directs child to seat at table)

E: Now it's time to go back to the **Tree room**.

(E and child move to the Tree room; *E starts stopwatch and times for 3 minutes*)

[CANDY] E: Let's get some more candy for you to eat *(E gives C candy).*

(E directs child to seat at table)

E: Okay. I have some work to do until this timer rings.

E: Now I just have a few questions for you, and I'm just going to ask them down the hall.**(E and Child walk down hallway to quiet area.)**

Test Question

You got to visit the **Cloud room** and the **Tree room** today.

You're going to visit the **Cloud room** and the **Tree room** again tomorrow [show pictures]. Look what I have: candies (E shows child tupperware 1/2-full of candy). These are for when you visit tomorrow.

Look! This is a picture of John the garbage man [show picture]. Every night, John goes into the **Cloud room** and throws away any candy he finds. John only cleans the **Cloud room**—he never cleans the **Tree room**—and he only cleans at night.

You're going to visit the **Cloud room** and the **Tree room** again tomorrow.

Which room do you want to put this candy in for tomorrow?

Child's choice: ____ (if child responds, move to "**For all children") (T)**

For all children: "Why do you want to put the candy in the X room?"

Child's explanation: ____
(If child explains answer with something like "Because there's no candy in the X room," do not ask the child the corresponding memory question.)

Prompt: If child's explanation suggests uncertainty about where John cleans or if he really cleans, then say, "John only cleans the **Cloud room**—he never cleans the **Tree room**—and he only cleans at night."

Memory Questions:

Was there any candy in the Cloud Room? ________________________

Was there any candy in the Tree Room? ________________________

When does John the garbage man clean? ________________________

Which room does John the garbage man clean? ________________________

What does John do every night? ____________________

Appendix C: Non-Parametric Analysis Approach to Memory Questions in Chapter 2

Table 3A

Memory Question Scores for Room Containing the Resource by Age and Condition

Age (Years)	Correct	Incorrect	Percentage Correct	Binomial Test
Toy Condition				
3 (n = 23)	20	3	87	$p < .001$
4 (n = 23)	21	2	91	$p < .001$
5 (n = 14)	14	0	100	$p < .001$
Food Condition				
3 (n = 23)	21	2	91	$p < .001$
4 (n = 23)	21	2	91	$p < .001$
5 (n = 14)	14	0	100	$p < .001$

Table 3B

*Memory Question Scores for Room **Not** Containing the Resource by Age and Condition*

Age (Years)	Correct	Incorrect	Percentage Correct	Binomial Test
Toy Condition				
3 (n = 23)	19	4	83	p = .003
4 (n = 23)	21	2	91	p < .001
5 (n = 14)	14	0	100	p < .001
Food Condition				
3 (n = 23)	22	1	96	p < .001
4 (n = 23)	20	3	87	p < .001
5 (n = 14)	14	0	100	p < .001