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The role of episodic and semantic memory in episodic foresight☆

Gema Martin-Ordas[a,b,*], Cristina M. Atance[a], Alyssa Louw[a]

[a] School of Psychology, University of Ottawa, Canada
[b] Center on Autobiographical Memory Research, Aarhus University, Denmark

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ABSTRACT

In this paper we describe a special form of future thinking, termed "episodic foresight" and its relation with episodic and semantic memory. We outline the methodologies that have largely been developed in the last five years to assess this capacity in young children and non-human animals. Drawing on Tulving's definition of episodic and semantic memory, we provide a critical analysis of the role that both types of memory might have on the episodic foresight tasks described in the literature. We conclude by highlighting some unanswered questions and suggesting future directions for research that could further our understanding of how memory is intimately connected to episodic foresight.

The most profound consequence of the conceptual revolution set in train by the introduction of the term episodic memory (Tulving, 1972, 1985) was that it established the idea of mental time travel through subjective time. Mental time travel allows one, as an "owner" of episodic memory ("self"), through the medium of autonoetic awareness, to remember one's own previous "thought about" experiences, as well as to "think about" one's own possible future experiences (Tulving, 2005, p. 9). The adaptive function of the episodic memory system has been suggested to lay not so much in the keeping of accurate records of the past, but in what it can offer to present and future fitness (Buckner & Carroll, 2007; Dudai & Carruthers, 2005; Schacter, Addis, & Buckner, 2007; Suddendorf & Corballis, 1997, 2007; Tulving, 2005).

While episodic memory has been the topic of intense research efforts (e.g., Tulving, 1984, 2005), mental construction of potential future episodes has only very recently begun to draw attention. Thinking about and imagining the future are highly adaptive capacities that allow us to act now to secure future benefits and avoid future difficulties. In fact, the ability to imagine future events seems to be an essential part of human cognition since much of our behaviors are guided by foresight (e.g., distant goals or plans) (Suddendorf, 2006). As a consequence, over the last few years, there has been an increasing multi-disciplinary effort to study future thinking and how it relates to episodic memory. Most of these studies come from the adult literature, where this link has typically been assessed by asking adults to think about a personal past event and to pre-experience a plausible future one (Addis, Wong, & Schacter, 2007; Okuda et al., 2003; Szpunar, Watson, & McDermott, 2007). Results have led to the idea of a "core brain network" that is activated when people remember their past, imagine their future, take the perspective of others (i.e., theory of mind), and also use some forms of spatial navigation (e.g., Buckner & Carroll, 2007; Spreng & Grady, 2010). Similarly, patients with impaired episodic memory have been found to have comparable problems with imagining future events (Hassabis, Kumaran, Vann, & Maguire, 2007; Klein, Loftus, & Kihlstrom, 2002; Tulving, 2005; Williams et al., 1996). In clinically normal participants, phenomenological characteristics of thinking about past and future events have also been reported to be similar (D'Argembeau et al., 2007; D'Argembeau &

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* Corresponding author at: Department of Psychology, Center on Autobiographical Memory Research, Aarhus University, Aarhus, Denmark.
E-mail address: ordas@psy.au.dk (G. Martin-Ordas).

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Van der Linden, 2004). Findings from social psychology (e.g., Gilbert & Wilson, 2007, 2011), developmental psychology (e.g., Busby & Suddendorf, 2005; Suddendorf, 2010a) and comparative psychology (e.g., Eacott & Easton, 2012; Raby & Clayton, 2009; Roberts, 2012; Roberts & Feeney, 2009; Suddendorf & Corballis, 2010) have also provided evidence for such a link.

The terminology that has been used to capture the notion of a "mental projection" of the self into the future tends to differ between researchers. While some refer to it as "episodic future thinking/thought" (Atance & O'Neill, 2001; Szpunar, 2010) or "episodic foresight" [the term that we will adopt here (Suddendorf, 2010a; Suddendorf & Moore, 2011)], others have used the terms "prospection" (e.g., Buckner & Carroll, 2007; Gilbert & Wilson, 2007; Suddendorf & Corballis, 2007) and "simulation" (e.g., Schacter & Addis, 2007). Nonetheless, most researchers would agree that the goal of all of these terms is to capture the ability to vividly pre-experience events in one's personal future.

Accordingly, this type of thought about one's personal future should be distinguished from thought about a more "general" future – or, what some have referred to as "semantic future thinking" (Atance & O'Neill, 2001) or "known future" (Klein et al., 2002). This "episodic/semantic" distinction echoes the one that Tulving drew with respect to memory and also appears to be useful with respect to the future. For example, Klein et al. (2002) describe an amnesic patient who could not provide a description of a personal future event but could respond to a question about a public (as opposed to personal) event (e.g., "Can you tell me what you think will be the most important medical breakthroughs likely to take place in the next ten years?").

The main goal of this paper is to analyze the relation between memory – both semantic and episodic – and episodic foresight, focusing on research that has been conducted in the areas of developmental and comparative psychology. To do so, we begin by providing a brief overview of the research on episodic foresight in young children and non-human animals. We then draw on Tulving's definition of episodic and semantic memory to analyze how these two types of memory contribute to episodic foresight behaviors. We conclude by highlighting some unanswered questions and suggesting future lines of research.

Episodic Foresight in Young Children

Young children's episodic foresight has been assessed using both "verbal" and "non-verbal" approaches. We briefly outline studies in both of these areas next while noting those instances in which children's task performance was related to their episodic memory.

Verbal Measures

Children begin to talk about the future by 2 years of age (Eisenberg, 1985; Nelson, 1989; Sachs, 1983). At first, such utterances may refer only to events occurring later in the day (e.g., "We gotta drive pretty soon" or "Gotta put a bandaid on a little later") (Sachs, 1983, p. 15), but later in the third year of life, references to events happening in the more remote future also begin to emerge (Sachs, 1983).

Children's talk about the future has been explored more systematically in the past 5–10 years and has largely focused on the 3–5 year age range (e.g., Atance & O'Neill, 2005; Busby & Suddendorf, 2005; Hayne, Gross, McNamee, Fitzgibbon, & Tustin, 2011; Quon & Atance, 2010). For example, Busby and Suddendorf (2005) asked 3-, 4-, and 5-year-olds to report an activity that they would do tomorrow. They found that a majority of the 4- and 5-year olds were able to answer this question correctly (as measured by parental reports), with significantly fewer 3-year-olds able to do so. Moreover, in one of their two experiments, children's capacity to predict a future event was significantly correlated with their capacity to accurately report a past event (i.e., "Can you tell me something that you did yesterday?") (a finding that has also been replicated by Suddendorf, 2010a) suggesting that episodic foresight and episodic memory are related.

Several more recent studies have expanded on Busby and Suddendorf's (2005) paradigm by asking children more specific questions about the future. In Quon and Atance (2010), children were asked about the next time they would partake in a specific event (e.g., breakfast or going to the park). Five-year-olds' responses were rated as significantly more likely by parents than those of 3- and 4-year-olds and were thus consistent with those of Busby and Suddendorf's findings but differed in that children's performance levels were, overall, higher. Whereas 3-year-olds' accuracy in reporting a future event in Busby and Suddendorf's study was approximately 30%, the corresponding percentage in Quon and Atance was approximately 60.

Higher accuracy rates were also found by Hayne et al. (2011). In their study, parents, rather than children themselves, were asked to provide the experimenter with future events corresponding to two time points: "later today" and "tomorrow." The experimenter then asked children, for example, "Your mum told me that tomorrow, you will go visit your grandpa. What can you tell me about this?" Ninety-two percent of 3-year-olds provided accurate additional information about the future event in question. Children were also asked about events occurring "earlier today" and "yesterday" with the results revealing a significant correlation (after controlling for age and language scores) between the number of clauses that children provided for the past and future events, providing further evidence for a link between episodic foresight and episodic memory. What remains unclear from these studies, however, is the extent to which episodic foresight draws on episodic (or semantic) memory.

Non-Verbal Tasks

Another means that researchers have used to measure children's episodic foresight is to assess their tendency to select/save an item for future use (e.g., Atance & Meltzoff, 2005; Metcalf & Atance, 2011; Russell, Alexis, & Clayton, 2010; Suddendorf & Busby, 2005; Suddendorf, Nielsen, & von Gehlen, 2011). The work of Suddendorf and colleagues (and as we will see shortly that of non-human animal research also) was partly inspired by their argument that a key feature of episodic foresight is the ability to plan for a future need that is not currently experienced. This is best illustrated by Tulving's (2005) proposed "spoon test" which he argues is feasible for both young children and non-human animals. This test is based on the following scenario: A young girl dreams she is at a party where all the guests are being served a delicious chocolate pudding. However, to eat the pudding, guests must have their own spoon and the young girl does not. That night, she falls asleep again while holding a spoon in her hand because she wants to avoid making the same mistake again. Tulving argues that children younger than age 4 and non-human animals should have difficulty passing any task that draws on the logic of this scenario. We will focus now on the research carried out in children, and, in the section entitled "Episodic foresight in non-human animals", we will discuss the research in non-human animals.

In one study, Suddendorf and Busby (2005) tested the developmental aspect of this prediction by exposing 3-, 4-, and 5-year-olds to a room that contained only a puzzle board (but no puzzle pieces). Next, children were taken into another room where they played games for 5 min. They were then told that they would return to the first room and were shown four items (including the missing puzzle pieces) and asked to choose one to bring with them. Only the 4- and 5-year-olds were more likely than a control group (who were not presented with the puzzle board in the empty room) to select the puzzle pieces.

A subsequent study by Suddendorf et al. (2011) built on this general design by showing 3- and 4-year-olds a locked box with a triangular keyhole that could be opened by a red triangle key to retrieve a sticker. Children were given experience with the key after which the experimenter pretended to have broken it so that children would perceive a future need for a similar one. Children were then told that they would get to play with the box later. After 15 min in another room, children were presented with four keys (only one of which could open the box) and asked to select one to take back to the first room. Choice of the correct key by 4-year-olds (65%) was above chance, whereas choice by the 3-year-olds (29%) was not. When asked to solve the problem in the present, however, even 3-year-olds succeeded. One limitation of this paradigm (that the authors, themselves, acknowledge) is that it may not assess children's ability to anticipate a future need that differs from a current one (which, as we will see in the next section, is a key criticism aimed at some of the research with non-human animals). To date, we are aware of no "spoon test" used with children that does.

Several other studies, though not explicitly designed to mirror the "spoon test," have also explored children's ability to save an item (or items) for future use. Russell et al. (2010) engaged 3-, 4-, and 5-year olds in a game that entailed a child and an experimenter standing on either side of a table and each using a drinking-straw to blow a ping-pong ball into a goal. A key feature of the task was that to play the game from the experimenter's (but not the child's) side of the table, children needed a box to stand on (so that they could reach the table). Children played the game from their side of the table and were then told that they would come back the next day to play from the experimenter's side, and that they needed to set aside two items to do so. The two essential items were the drinking straw and the box to stand on. Only the performance of the 5-year-olds exceeded what would be expected based on chance (though all age groups succeeded in a present-oriented version of the task).

More recently, Metcalf and Atance (2011) assessed the extent to which 3-, 4-, and 5-year-olds saved marbles to use in a large, desirable marble game in favor of using them in a smaller, less desirable marble game that they always accessed first. Saving rates were low overall and, surprisingly, did not differ as a function of age. This lack of an age effect may be due to the substantial variability that is inherent in saving behavior (at least in adults, e.g., Bernheim, Skinner, & Weinberg, 2001) or to the fact that children's saving was measured in a more "spontaneous" way (e.g., children were not presented with forced-choice options about whether to save or not). However, children did save more on a second trial in which they were presumably able to draw on their past experience of not having saved the first time around.

As with the verbal tasks described earlier, none of the studies that have used variants of the "spoon test" has explicitly measured the extent to which task performance may rely on children's memory for the past – an issue to which we return in the section entitled "Function of episodic and semantic systems in foresight behaviors." However, it is clear from most studies that children's episodic foresight develops substantially between the ages of 3 and 5 years, thus mirroring the developmental trajectory reported for children's episodic memory (e.g., Nelson & Fivush, 2004; Perner & Ruffman, 1995).

Episodic Foresight in Non-Human Animals

Thus far, we have discussed verbal and non-verbal methods that have been used to examine the emergence of episodic foresight in children. Part of the reason for the use of non-verbal tasks in children has been to eliminate language as a confound variable (Suddendorf & Busby, 2003a, 2003b). In addition, such methods are also more amenable to capturing the criteria that have recently been argued to be evidence of episodic foresight (e.g., Suddendorf & Busby, 2003a, 2003b, 2005; Tulving, 2005): (a) the use of single trials (to avoid associative learning); (b) the use of novel problems; (c) the use of different temporal/spatial contexts to assess the future-oriented action; and (d) the use of problems from different domains (Suddendorf et al., 2011).

In addition (as alluded to earlier), some researchers have argued for the importance of the organism planning for a need that it is not currently experiencing (e.g., Bischof, 1985; Bischof-Köhler, 1985; Suddendorf & Corballis, 1997, 2007). The so-called *Bischof-Köhler hypothesis* thus argues that ". . . animals other than humans cannot anticipate future needs and drive states and are therefore bound to a present that is defined by their current motivational state" (Suddendorf & Corballis, 1997, p. 150). The Bischof-Köhler hypothesis has become a cornerstone in contemporary comparative episodic foresight studies (Crystal, 2012; Suddendorf & Busby, 2003a, 2003b; Suddendorf & Corballis, 2007, 2008; Suddendorf, Corballis, & Collier-Baker, 2009) and had also influenced developmental research (e.g., Suddendorf et al., 2011).

Both the criteria set out by Suddendorf and colleagues and by Tulving, along with the capacity to plan for a need that is not currently experienced, are nicely demonstrated in the previously described spoon test (Tulving, 2005). Not surprisingly, most of the comparative research on future thinking is based on this non-verbal task. For example, Mulcahy and Call (2006) carried out a tool-use study with two species of great apes, orangutans and bonobos. In this experiment, subjects were presented with an out-of-reach reward and with a set of useful and useless tools, which they could take into a waiting room. To obtain the reward, subjects had to return to the room where the out-of reach reward was placed, carrying the useful tool, either 1 or 24 h after having seen the reward. Mulcahy and Call showed that great apes were capable of saving tools needed in a distant future. However, Suddendorf and colleagues (Suddendorf, 2006; Suddendorf & Corballis, 2007) argued that the subjects could have potentially experienced a desire for the reward throughout and thus the experiment did not directly address the Bischof-Köhler hypothesis.

In a more recent study, however, also based on a tool-use task, Osvath and Osvath (2008) addressed some of the criticisms aimed at Mulcahy and Call's (2006) study. Osvath and Osvath (2008) demonstrated that chimpanzees and orangutans: (a) were able to select a useful tool to obtain a reward (e.g., juice) 1 h later; (b) were able to override an immediate desire for a favorite food in favor of future needs; (c) when first presented with a tray containing a useful tool and 3 useless tools and immediately after with a second tray including a second copy of the useful tool and a favorite fruit (a grape), subjects chose the useful tool from the first tray – presumably because it could be used to obtain a reward (in this case, juice) later, but ignored the identical tool on the second tray and chose the grape instead; and (d) when given a choice of four new tools to obtain a future reward, were able to choose the tool that was functionally equivalent to the old one, despite not having used it previously to obtain the future reward. Associative learning cannot account for these results because only once during the study did subjects obtain the tool with an immediately accessible reward present, and this was on the first occasion they used the tool. Likewise, semantic future thinking is ruled out by the fact that subjects were able to select the correct tool even when they did not have previous experience with it. Therefore, Osvath and Osvath (2008) concluded that the results from their four experiments suggest that great apes were engaging in planning behaviors for the future by outcompeting current drives and mentally pre-experiencing an upcoming event (see Suddendorf et al., 2009 for a critical review; see Osvath, 2010 for a response). As such, this study would seem to argue against the Bischof-Köhler hypothesis; or, the idea that only humans can anticipate future needs that differ from current ones (for a study with monkeys that might also argue against the Bischof-Köhler hypothesis, see Naqshbandi & Roberts, 2006).

Interestingly, the strongest evidence to date for future planning comes from research with scrub-jays (Correia, Dickinson, & Clayton, 2007; Raby, Alexis, Dickinson, & Clayton, 2007). For example, in Raby et al., scrub-jays were given the experience of two compartments on alternate mornings. In one of the compartments, subjects were given food (e.g., breakfast compartment), whereas in the other one they were not (e.g., "no breakfast" compartment). On the test day, scrub-jays were unexpectedly given the chance to store food in one of the compartments. Raby et al. found that scrub-jays cached more food in the compartment in which they might experience hunger the following morning, relative to the compartment where they never experienced hunger in the morning. In a second experiment, when given one food type in one compartment and another food type in the other, subjects cached each food in the compartment where it had not been found. Raby et al. concluded that scrub-jays' caching behavior can only be explained in terms of future planning because not only did it involve a novel action (therefore, associative learning cannot account for performance) but it also challenges the Bischof-Köhler hypothesis since, at the time of caching, scrub-jays were not hungry. However, some have viewed this study with skepticism (Premack, 2007; Roberts, 2012; Roberts & Feeney, 2009; Suddendorf & Corballis, 2008). For example, it has been argued that scrub-jays might have a predisposition to cache a food type in locations where they had not previously encountered that food type (a "balance food sources" heuristic). However, using such a heuristic does not necessarily exclude the possibility that the birds were using some type of episodic foresight to carry out the storing behavior (Clayton et al., 2008; Raby & Clayton, 2009).

Correia et al. (2007) provided further evidence for scrub jays being able to anticipate future specific hunger in the absence of a current immediate need. In this experiment, scrub jays that were prefed one type of food (i.e., food A) preferentially cached a different type of food (i.e., food B) 3 h later. However, between caching and recovery, one group of scrub jays was prefed with the alternative food (e.g., B) before being allowed to recover what they had cached. The next day, after they were prefed food A, instead of caching food B, they preferentially cached food A that they were prefed, in anticipation of being prefed food B after caching and prior to recovery. Thus, Correia et al. (2007) concluded that in the absence of a specific hunger for a type of food (A), scrub-jays preferentially cached that type of food (A), in anticipation of being prefed food B prior to recovery (for a study with another corvid species also showing evidence for planning, see Cheke & Clayton, 2011).

Even though the study of episodic foresight and future planning in non-human animals is limited, the evidence we have described indicates mostly positive results. Therefore, most would agree that some kind of future thinking ability is present in animals other than humans. However whether non-human animals need to mentally re-experience the past in order to project themselves into the future is still under debate. Part of the interpretive problem lies in the fact that there is no consensus on the behavioral markers that might indicate phenomenological and subjective experiences in non-verbal animals. In the absence of language, there is no clear way to disentangle which type of future thinking is at play in non-human animals. Agreeing upon what these markers may be is an ongoing challenge for comparative (and developmental) researchers.

In the next section we critically review the episodic foresight tasks we have outlined in children and non-human animals by trying to disentangle the role that memory in general, and episodic and semantic memory specifically, may play in task performance. But, first, we take a step back to briefly review the concepts of episodic and semantic memory.

Episodic and Semantic Memory

Even though students from the developmental (Campbell, 1994, 1997, 2002; Clayton & Russell, 2009; Hoerl, 2008; Perner, 2001) and comparative arena (Clayton, Bussey, & Dickinson, 2003; Clayton, Bussey, Emery, & Dickinson, 2003; Eacott & Easton, 2010; Easton & Eacott, 2008; Zentall, Clement, Bhatt, & Allen, 2001) have dealt with the issue of how to distinguish between episodic recollection and semantic remembering in a number of ways, all of these theoretical frameworks have used Tulving's proposal as a starting point. Therefore in what follows we will focus on Tulving's influential theory of the declarative memory system (1972, 1983, 2001, 2005). In his earlier conceptualization, Tulving (1972) defined semantic memory as our database of knowledge about the world, including words, objects, places, and people, and their inter-relationships. In contrast, episodic memory was defined as memory for "temporally dated episodes or events, and the temporal-spatial relations" among them (Tulving, 1972, p. 385). Thus, when we state that the capital of Canada is Ottawa, we are drawing on semantic memory; however, when we remember ice-skating along the Rideau Canal in Ottawa last year, we are drawing on episodic memory. This distinction, as outlined by Tulving (1983), focused originally on the different types of information processed by the two systems, unique spatial–temporal contexts for episodic memory, and facts and concepts for semantic memory.

More recently, Tulving (2002, 2005) has emphasized that the critical distinction is not so much the type of information being processed, but instead the type of phenomenological experience that seems to play a crucial role in such a distinction. Tulving (1983) suggested that autonoetic consciousness is a defining property of episodic memory and is expressed in experiences of mental time travel, as in the mental reinstatement of personal experiences of previous events at which one was present. Of course, this ability still presupposes that the individual can retrieve the spatial–temporal context in which the to-be-remembered event occurred. Thus, spatial–temporal context remains a critical component of episodic memory. In contrast, noetic consciousness is considered the defining property of semantic memory and is expressed without any such self-recollection but simply in awareness of familiarity or knowing. In a clear departure from previous usage, Tulving used the term "remembering" to refer to expressions of autonoetic consciousness and the term "knowing" to refer to expressions of noetic awareness.

Thus both the phenomenological experience together with the spatial–temporal component seem to be crucial factors to distinguish episodic from semantic memory (though evidence for a clear-cut division between these two types of memories is somewhat contentious, e.g., see Squire, Stark, & Clark, 2004 for a review). Both episodic and semantic memory are thought to depend on the medial temporal lobe (MTL) and diencephalic structures (i.e., thalamic nuclei) of the brain (Shimamura & Squire, 1987; Squire, Knowlton, & Musen, 1993). However, there is disagreement about the contributions of specific brain areas within these structures to episodic and semantic memory, based on evidence from case studies on human amnesics with varying brain pathologies. Researchers have suggested that the anterograde amnesia observed in patients with MTL damage is a result of the disruption of declarative memory as a whole, with semantic and episodic memory being equally impaired (for a similar perspective, see Eichenbaum, 1997; Eichenbaum, Otto, & Cohen, 1994; Eichenbaum, Schoenbaum, Young, & Bunsey, 1996).

In contrast, Tulving and Markowitsch (1998) developed a different framework for the declarative memory system. They consider that episodic and semantic memory are two subsystems of declarative memory that exist not as parallel subsystems but as one system embedded in the other. Semantic knowledge can be acquired with an impairment of episodic memory capabilities, but episodic memory cannot exist without semantic knowledge. Episodic memory is thus an extension of semantic knowledge: the context of when and where the information was acquired is combined with the semantic knowledge that was gained on that occasion. Damage to the semantic system would therefore impair both semantic and episodic memory, whereas damage to the episodic system would result in impairments of episodic memory acquisition but not necessarily of the semantic system.

In the next section, we propose a critical review of the previous work on episodic foresight by trying to disentangle the role that memory in general, and episodic and semantic memory specifically (as defined by Tulving), may play in the episodic foresight tasks.

Function of Episodic and Semantic Systems in Foresight Behaviors

As we mentioned in the introductory section, there has been increased interest in addressing the link between episodic foresight and episodic memory (Addis et al., 2007; Okuda et al., 2003; Suddendorf, 2010b; Szpunar et al., 2007; the relevant developmental studies were discussed in the section entitled "Episodic foresight in young children"). However, what has not yet been theoretically well articulated or empirically investigated is the contribution of different knowledge structures (e.g., semantic knowledge) to the construction of episodic future thoughts (though it has been acknowledged by several authors including Anderson & Dewhurst, 2009; D'Argembeau, Ortoleva, Jumentier, & Van der Linden, 2010; Suddendorf, 2010b; Suddendorf & Corballis, 2007; Szpunar, 2010).

D'Argembeau and Mathy (2011) addressed this issue by examining the content of people's thoughts when they were attempting to think about a possible personal future event. Their results showed that general personal knowledge plays a crucial role in the construction of episodic future thoughts. In fact, D'Argembeau and Mathy found that when participants attempted to construct specific future events in response to cue words, they most frequently activated personal semantic information and/or general events before producing the specific future event. This finding clearly indicates that episodic future thinking is not solely based on episodic memory. There is also evidence that a substantial amount of people's future-oriented thoughts consists of abstract representations that do not refer to specific events (D'Argembeau, Renaud, & Van der Linden, 2011). For example, when adults are asked to complete sentence stems with reference to their personal future (e.g., "Next year I . . ."), they spontaneously report general information (i.e., future thoughts relating to extended future life periods or personal semantic information) more frequently than specific events (Anderson & Dewhurst, 2009). Overall, these studies seem to suggest that general knowledge or semantic memory plays a crucial role in constructing and thinking about future personal events.

It is unknown, however, whether children and non-human animals explicitly recall past experiences to construct episodic future thoughts or whether episodic details are retrieved without being explicitly linked to past events. We will first re-examine some of the verbal tasks used with young children with an eye to how semantic and episodic memory may contribute. We then conclude by taking a closer look at one task that has been used to test episodic foresight in both children and non-human primates: the non-verbal "spoon task."

Recall that several of the verbal tasks used with children found a significant correlation between episodic foresight and episodic memory. However, as we noted, the extent to which episodic foresight may *rely* on episodic memory was not addressed. Nonetheless, it is conceivable that children's talk about the future relies at least partly on their memory for the past. A particularly impressive narrative from a 2-year-old child, Emily, as reported by Nelson (1989), is pertinent to this issue:

We are gonna . . .
at the ocean.
Ocean is a little far away.
baw, baw, buh (etc.)
far away . . .
I think it's . . .
couple blocks . . . away.
Maybe it's down,
downtown, and across the ocean,
and down the river,
and maybe it's in,
the hot dogs will be in a fridge,
and the fridge (would) be in the water over by a shore,
and then we could go in,
and get a hot dog and bring it out to the river,
and then sharks go in the river and bite me,
in the ocean . . . (Nelson, 1989, p. 66).

This narrative clearly draws on Emily's semantic memory because Nelson (1989) notes that it includes details told to Emily by her father, as well as her own knowledge about how the world works (e.g., "hot dogs will be in a fridge"). Nonetheless, some details that Emily provided also comprised novel predictions about the future (e.g., "and then sharks go in the river and bite me") which suggests that they are not solely the function of episodic and semantic memory. But, as we saw in the study reported by Busby and Suddendorf (2005), for example, neither are young preschoolers' predictions always accurate (at least as assessed by parents). An interesting hypothesis is that drawing on semantic and episodic memory contributes to the accuracy of our future projections.

Drawing on Tulving's claim that episodic memory/foresight entails autonoetic consciousness, Tustin and Hayne (2010) argue that the frequency with which a person uses the first-person perspective to describe his/her experience (e.g., using pronouns like "I" or "we") is potentially important. Thus, the fact that Hayne et al. (2011) found that almost half of the future event clauses that children provided in their study included a first-person pronoun, with very few including impersonal pronouns such as "you" and "they," is notable. More specifically, they argue that this signals that the episodic system was involved in children's accounts. However, the way in which the questions about a particular event were worded (e.g., "Your mum told me that tomorrow, you will go visit your grandpa. What can you tell me about this?") would seem to encourage a response from the child that includes the pronoun "I" or "we" as opposed to "you" or "they." Another difficulty in determining whether children actually drew on episodic memory to help formulate their talk about future events is that children, themselves, did not generate the event in question but, rather, their parents did. We raise this methodological issue because an important feature of the episodic memory system is the ability to spontaneously remember/generate an event that has happened/will happen to the self. As a result, an interesting question is the extent to which the episodic and/or semantic systems are involved when the memory is "cued" versus spontaneously generated.

How might children's and non-human animals' performance on the "spoon test" rely on episodic and/or semantic memory? In Suddendorf and Busby (2005), it has been argued that children may have succeeded in choosing the puzzle pieces by making an association between these and the puzzle board (e.g., Russell et al., 2010). As such, it is unclear whether children needed to mentally re-experience the past (i.e., draw on episodic memory) to succeed. Such an "associative" argument does not as readily apply to the study by Suddendorf et al. (2011). Because there were multiple keys, for example, children could not merely have succeeded by making an association between "key" and "box." As such, it seems more plausible that children needed to remember specific information about which key was needed. However, recovering information about the key would not necessarily require remembering an episodic event. Similarly, in Russell et al. (2010), it is unlikely that children succeeded in choosing the straw and box due to pre-existing associative knowledge. But, again, whether success on these tasks entailed mentally traveling back in time to retrieve the actual episode in which the need for the item was experienced is unclear.

One final developmental task that is worth mentioning in this context is the one by Metcalf and Atance (2011). Recall that children were given two trials of the same task and on the second trial children saved significantly more marbles to use in the large marble run than they had on the first. As such, memory for their experience on the first trial appears to have played a role in their performance on the next. Although it is tempting to argue that children may have re-experienced the disappointment that accompanied failure to save the first time around (episodic memory), it is also possible that because the task involved more than one trial, children may have learned after the first trial that saving is a good strategy – such a rule being a function of memory that is more semantic in nature.

Some form of memory clearly plays a role in a number of the developmental tasks that have been used to assess episodic foresight. However, these tasks were not structured to explicitly examine the roles of episodic and semantic memory in task performance. While we have strived to provide some insight into this issue, an obvious direction for future research on the development of episodic foresight is to move beyond assessing potential correlations between past and future versions of the same task and to carefully examine the extent to which episodic and semantic memory contribute to task success.

We now turn to the research conducted with non-human animals. Interestingly, it is in this area of research that we may be able to provide the clearest analysis of what type of memory is involved in task success. This is partly because this issue has received more attention than in the developmental sphere – especially with respect to the factors that may be driving animals' behavior on tasks of episodic foresight.

We have mentioned that great apes and scrub-jays pass the spoon test proposed by Tulving (2005). However, what we do not know from these studies is whether this type of future planning depends on episodic foresight or on semantic future thinking (see Eacott & Easton, 2012, for an interesting take on this issue). Regarding the work with jays, Cheke and Clayton (2010) suggest that the ability to learn that "a food item or tool will gain value later that it does not currently possess" (p. 13) does not require pre-experiencing a future event but, rather, a concept of change over time, and this could be achieved with non-episodic foresight. Recently Cheke and Clayton (2011) have taken their theoretical framework a step further and suggested that the 'mnemonic associative theory' could be used to explain jays' behavior in the planning tasks. Fundamentally, this account suggests the possibility that when an episodic memory of an event is retrieved at the time of another event, an association can be formed between the two events, and that this may be a mechanism for long-delay associative learning. Thus, Cheke and Clayton suggest that both associative learning processes and future-oriented cognition might be at work in future planning behaviors.

Remarkable, though, is the fact that research on non-human primates has mainly been criticized not only because it does not necessarily reflect self-projection but also because of the type of memory required to solve the episodic foresight tasks. In fact, Suddendorf (2006; Suddendorf & Corballis, 2008) suggested that in ape planning studies it is not clear whether they anticipated a specific future situation or whether their behavior could be explained in terms of more general learning principles because the apes had to select the same tool on all trials. It is true that we cannot assess the subjective experience of apes' behavior, but even if learning accounts for apes' knowledge about the suitability of the tools, it does not necessarily rule out the possibility that subjects are thinking about the future situation in order to take the appropriate tool. We assume that human semantic prospection requires knowledge that there is a future (Raby & Clayton, 2009); what then is going on in the ape's mind when it chooses the correct tool in the Mulcahy and Call (2006) or the Osvath and Osvath (2008) studies?

Tulving (2005) suggested that, with the single exception of episodic memory, all forms of memory are oriented towards the future. It would follow, then, that having a sense of the future would seem to be much more important, at least for non-human animals, than having a sense of the past. Additionally, using past experience does not necessarily require knowing that the information was learned in the past. Taking this into account, we would like to question not only whether future planning is based on future foresight but also whether future foresight exclusively requires episodic memory. It is assumed that humans can combine both episodic and semantic future thinking; thinking about our next holidays might combine semantic knowledge of the weather with episodic future thinking about details of our trip. But can we plan our trip by projecting ourselves into the future event without the episodic details of previous trips?

Thus far, we have provided some insights on how developmental research has addressed the role of memory in the episodic foresight task. This together with our analysis of the research with non-human animals has opened up the possibility that episodic foresight might take place without episodic memory. Next we provide some insights on how future research could address this issue.

Future Research Avenues

We have mentioned in a previous section that the distinction between episodic memory and semantic memory is somewhat blurred. In fact, according to Tulving's early definition (1972), while an episodic memory can be identified as a single isolated event and not a concatenation of prior experiences, semantic memory almost always concerns information acquired long ago, via multiple exposures and usually lacking contextual information (Brewer, 1986; Greenberg & Verfaellie, 2010). What is more interesting is the fact that many of our everyday memories seem to fall somewhere between episodic and semantic (Greenberg, Keane, Ryan, & Verfaellie, 2009). For example, imagine you are asked to generate what you would need to pack for your next trip by thinking about what you usually packed for your previous trips. What type of memory is this? On the one hand, this memory has no specific temporal component and is not an event; thus it is not necessarily drawn from episodic memory. On the other hand, the specific spatial contexts suggest that it has not been decontextualized and, therefore, it might not be drawn from semantic memory. Likewise, you might not seem to be conscious of a particular prior experience, but instead you seem to be conscious of a group of several previous experiences. Memories like these are not explicitly addressed in the classic episodic–semantic model, but they appear to fit Neisser's (1981) concept of "repisodic memory" (e.g., merging of memories of events into one representative event), Barsalou's (1988) idea of summarized or extended events, or Conway's (2001) "general events" level of autobiographical knowledge. They are also fairly common; in a study of autobiographical memory in college students, over 30% of elicited memories were of this type (Rubin, Schrauf, & Greenberg, 2003). Therefore, it is possible that episodic foresight based on semantic memory or "repisodic" memory (also general events) is a simpler mechanism that could have appeared earlier in evolution and is present in our ancestors.

If this is true and we are potentially able to draw on episodic foresight without using episodic memory, we still have to address some fundamental questions. First, is it possible to distinguish the contribution of episodic, semantic or repisodic memories – or general events – to episodic foresight in non-verbal subjects? We believe that to some extent it is possible to recall events for which we do not have general knowledge. If there is a semantic element in the memory, this could suggest the existence of conceptual abilities; but this will not always necessarily be the case. As Kant stated (cited by Clayton & Russell, 2009), "[H]e who sees his first tree does not know what he sees" (Kant, 1992). That is, semantic content can be experienced without being conceptually grasped (Clayton & Russell, 2009).

In fact, it might be possible that most future-oriented behaviors could be achieved using semantic prospection by extracting the autonoetic and phenomenological elements (Raby & Clayton, 2009). If the episodic and semantic – or repisodic – systems produce similar outcomes and the only difference between them is the sense of autonoetic awareness, is it possible to rely on behavioral markers to approach this issue? Kwan et al. (in press) showed that K.C., a person with episodic amnesia and an inability to imagine future experiences, nonetheless systematically discounted the value of future rewards, and his discounting was within the range of controls in terms of both rate and consistency. This study demonstrated that in the absence of episodic memory, decision-making about future events could be based on semantic memory. Such findings open up the possibility that semantic memory – or repisodic memories – could suffice to behave in a future-oriented manner without the need of projecting oneself (e.g., phenomenological experience) in the future event.

Second, if memories that are neither truly episodic nor semantic (i.e., repisodic or general events) exist, is it also possible that a similar system oriented towards the future exists? If so, this type of future thinking should differ from what Atance and O'Neill (2001) coined as "semantic" and "episodic" future thinking. Can we think about the future without self-projection or exclusively relying on semantic knowledge? Imagine your next job interview based on your previous job interviews. In doing this, you are including episodic details such as the location where the interview could potentially take place. However, you could also be including semantic information because you know which questions you could potentially be asked. This exercise of thinking about the future job interview is neither truly episodic nor truly semantic since it is based on repeated experiences but it lacks self-projection. Is this type of future thinking frequent in our everyday life?

Third, when does the use of episodic memory become necessary for episodic foresight? We agree with Suddendorf and Corballis (2007) that a self-knowing awareness of what has happened may help dramatically in preparation for what is going to happen. For example, one might prepare for a forthcoming vacation based on past experiences of previous holidays. However, lacking the self-knowing awareness of a past event might still allow us episodic foresight. Although we might have a less accurate image of the future scene, be less flexible in the way we imagine possible future scenarios, or plan less effectively than when we use episodic memory, we may still be able to project ourselves into the future scenario by using semantic knowledge. This hypothesis should be tested.

Finally, why did the episodic and semantic systems evolve in the first place? Do they serve different functions? We echo Raby and Clayton's (2009) proposal that episodic memory could have a more crucial social function than semantic memory and that it may not be essential for episodic foresight, although it can be used for that function. This is not a new idea; in fact authors such as Nelson (1992), Dessalles (2007) and Boyer (2008) have already attributed a social function to episodic memory (e.g., to tell stories, to share specific information, or as a way to assess people's reliability as coalition partners). However, Raby and Clayton further hypothesize that perhaps the development of the two cognitive systems was driven by different evolutionary pressures. They speculate that semantic memory could have evolved as a mechanism for learning from previous experience, and that episodic memory could have evolved as a social tool to promote a sense of self and understanding of others, in conjunction with theory of mind.

Conclusions

We have described various methodological approaches that have been used to study young children's and non-human animals' episodic foresight. Developmental findings suggest that the capacity to mentally project the self into the future develops substantially between the ages of 3 and 5 years. Interestingly, non-human animals, including some great apes and scrub jays, seem to perform similarly to older preschoolers in contexts in which they must modify their current behavior in anticipation of a future need (though similar interpretive difficulties apply). We have pointed out that even though episodic memory seems to be intimately related to episodic foresight, the role that both, semantic and episodic memory, play in episodic foresight has not been precisely addressed. We also suggest that episodic foresight might be possible without the need of recalling episodic memories. We propose new avenues of research based on the idea that projecting ourselves into future events does not necessarily require mentally traveling back in time. We believe that this research could provide us with important insights on the ontogeny and phylogeny of episodic foresight.

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