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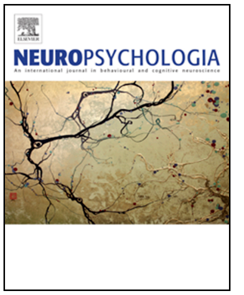

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Reflections on the Spoon Test

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Abstract

In this paper, we shall use Tulving's seminal empirical and theoretical research including the ‘Spoon Test’ to explore memory and mental time travel and its origins and role in planning for the future. We will review the comparative research on future planning and episodic foresight in pre-verbal children and non-verbal animals to explore how this may be manifest as wordless thoughts.

Keywords

Mental time travel, episodic memory, convergent evolution of cognition, corvids, child development, subjective experience of thinking

Introduction

Mental time travel refers to the ability to project the self in time to remember past experiences and anticipate future scenarios. It also allows us to imagine events that may never have actually occurred and to travel to places to which may never exist, other than in the mind's eye and therefore plays a critical role in story telling~ the thread that holds our lives and history together, both individually and collectively (Carruthers, 2009; Clayton & Wilkins, 2016; Wood & Byatt, 2009). It also provides an important role in developing and maintaining our identity by virtue of the fact that these thoughts about the past and the future are subjective. The memories we make shape who we are and how we choose to perceive and interpret them is informed by our identity (Clayton & Wilkins, 2017a). One can think of memory as the door to identity, and mental time travel as the journey we take as we pass through: it shapes who we are (Clayton & Wilkins, 2017b). Memory loss does not destroy the self, but it alters it (see Craver et al., 2014).

In a previous paper Clayton & Wilkins (2018) argued that these features of mental time travel explain a number of myths (or common assumptions) that are made about memory; for example that our episodic remembrances are objective, accurate, fixed repositories of information about what happened. Our memories are subjective and so malleable that they are not only capable of being reconstructed (Bartlett, 1932) but in some cases, misconstrued (Loftus et al., 1978), often due to imagination inflation (Garry et al., 1996). A case in point is the way in which magic effects work in the mind, successfully disorientating and obscuring our ability not only to see, but also to remember what happened, reflect on the experience and reason about it (Clayton & Wilkins, 2019; Kuhn, 2019; Tompkins, 2019; Wilkins & Clayton, 2019).

Perhaps that is why Proust argued that the "remembrance of things past is not necessarily the remembrance of things as they were" (Proust, 1913, pp. 13).

We, and others, have argued that these eccentricities of episodic memory arise because mental time travel evolved for the future not the past (e.g. Clayton & Wilkins, 2017b, 2018; Dudai & Caruthers, 2005; Schacter et al. 2007, 2008, 2012; Tulving, 2005). The Constructive Episodic Simulation hypothesis developed by Schacter and colleagues (Schacter et al., 2007, 2008, 2012) posits that a crucial function of the brain is to use information gleaned from past experience to simulate a series of future scenarios and in so doing allow us not only to juxtapose a number of alternatives, but crucially to predict and plan for those possible eventualities. Consequently it specializes in creating and re-creating alternative potential scenarios for how the future may unfold, as opposed to preserving an accurate record of what happened. This makes it both subjective and subject to change.

We swim in a subjective sea of time, which changes from moment to moment, surrounded by an ever-present awareness that what once was the future will soon become the past and that the real future will never be exactly the same as the one we imagined it to be. Without memory our thoughts have no anchor: they are just a series of unfolding events that float away into oblivion. We contextualize the present and the future by anchoring it in the past, but in doing so we sometimes change our experience of the past and this allows us to embody mental time travel as a primary resource for interpreting and making sense of our subjective experience. It also has consequences for episodic memory: why is it never exactly the same when we recall it at a later date, and which, if any, of the versions we choose to recall is real? The process involves the traveller (the self) moving backwards and forwards (in time) in the mind's eye because our personal memories of the past are inevitably entwined with our thoughts about the future as well as the present, at least in the healthy human brain, an issue to which we shall return later in this essay.

This subjective experience of remembering is only one way in which we capture the past, however. Tulving (1983) coined the term episodic memory to emphasize that the ability to remember the past is a psychologically distinct process from other forms of memory that do not involve mental time travel such as semantic memory (facts and knowledge about the world) and procedural memory (body memory skills and habits). Procedural memories are non-declarative whereas both semantic and episodic memories are declarative but Tulving made the important distinction between episodic cognition and semantic knowledge in terms of 'remember-know' (Tulving, 1983). In essence, episodic cognition is concerned with memories and pre-remembrances about the past and future respectively, which is necessarily subjective and involves the projection of the self in time and space. By contrast semantic, or factual, knowledge of the past and future does not necessarily require an awareness of either the projection of the self or time: for example, the semantic knowledge of one's birth date is not accompanied by any episodic remembrance of one's actual birth. Other examples abound: there is a vast array of semantic knowledge about the self but these terms refer to autobiographical facts such as the names of family members and their relationships to us as well as to self knowledge e.g. personality type; but these are all labels that do not require an episodic conjecture of the self in time (e.g. Grilli & Verfaellie, 2014; Renoult et al., 2012).

In addition to differentiating between factual knowledge and remembered experiences, Tulving (1972, 1983) also drew the distinction between familiarity and recall: I know I've seen you somewhere before [familiarity] as opposed to I recall who you are [remembering]. The dual process account argues that memory recognition for past events can be supported by two processes: episodic recollection of previous study events and/or a sense of familiarity for stimuli that have been experienced recently (Yonelinas, 1994). Signal detection analysis can be utilized to characterize features of the Receiver Operating Characteristics (ROC) functions of recognition memory performance that distinguish the contributions of episodic recollection and familiarity (e.g. Koen et al., 2016; Yonelinas, 1999; Yonelinas & Parks, 2007; Yonelinas & Jacoby, 2012). This is in acknowledgement of the fact that the semantic system contributes to experiential memory, for episodic memory does not operate in isolation. The semantic scaffolding hypothesis argues that semantic memory provides a crucial scaffold in which to embed the subjective experiences, a framework with which to evaluate and contextualise the episodic contribution to past and future (Irish et al 2012, Irish & Piquet 2013, Michaelian et al. 2016). Semantic memory plays a key role in allowing prior knowledge to be abstracted across many different experiences to structure and guide our current perceptions and future thoughts (e.g. Bubic & Abraham 2014, Irish & Piquet, 2013).

Although Tulving's initial work on the defining features of episodic memory focused on the importance of spatiotemporal relations between events (Tulving 1972, 1983), later work emphasized the importance of episodic memory's function, namely mental time travel, and its relationship with the self and time, for there can be no time travel "without a traveller" (Tulving 2005, p. 15). Tulving coined the term 'autonoesis' to refer to a special kind of self-consciousness that allows us to reflect on our memories, questioning our experiences and their relevance for our identity. When we gaze at our reflection in the mirror, which one is real; and when we reflect upon our reminiscences, which aspects really happened and how does that affect the way we foresee the future to be ? (Figure 1).

Figure 1. Mirror Girl. Art work by Clive Wilkins (2008).

Tulving argued that it is our autonoetic awareness that allows us to do so, that it "characterizes conscious recollection of personal happenings. It refers to what William James (1890) probably had in mind when he talked about the 'warmth and intimacy' of remembering one's past experiences" (Tulving, 2005, p. 15).

'Chronesthesia' refers to another kind of consciousness that lies at the heart of memory, namely our awareness of the passage of time, of being able to travel backwards and forwards in the mind's eye to revisit the past in order to anticipate how we might position ourselves in the future. Unlike the passage of physical time, which, due to entropy, only ever goes forwards (e.g. there is no way of un-breaking an egg), mental time travel can operate in both directions. That said, retrospective mental time travel has a different pattern from prospective mental time travel for it is not a gradual unfolding of events over time: we jump back to a particular point in the past and then play our imaginings forwards again (Clayton & Wilkins, 2018; Corballis, 2014).

It has been argued that in terms of phenomenology, chronesthesia and autonoesis are the diagnostic features of episodic memory that make it distinct from other forms of memory. As William James remarked "Memory requires more than the mere dating of a fact in the past, it must be dated in my past. In other words I must think that I directly experienced its occurrence" (James, 1890, p. 6509).

Many psychologists and cognitive neuroscientists have argued that episodic memory is a uniquely human capacity (e.g. Suddendorf & Corbalis, 1997; Tulving, 1972, 1983, 2002, 2005; Wheeler, 2000; but see Corballis, 2013, 2014). Absence of evidence is not evidence of absence however. The problem is that these phenomenological features of episodic memory have been impossible to test in the absence of agreed behavioural markers of consciousness in non-linguistic creatures (Griffiths et al, 1999). To overcome this impasse, Clayton & Dickinson (1998) argued that we should therefore focus on behavioural features of episodic memory and mental time travel that Tulving originally referred to as the spatiotemporal relations between events (Tulving, 1972) in order to test for episodic memory and hippocampal function in animals (Suzuki & Clayton, 1990). Clayton and Dickinson (1998) suggested that the key behavioural criteria for episodic memory that could be tested in animals is the ability to form integrated memories of what happened where and when during unique episodes, and this would allow the subject to discriminate between similar episodes that occurred at different times and/ or locations (Griffiths et al., 1999).

The what, when and the where components are in fact inspired by Tulving's (1972) original definition of episodic memory, which emphasized the spatiotemporal relations between events, and the single past experience acknowledges the fact that episodic memories are encoded automatically (see Morris & Frey, 1997). Importantly, the content of the memory must be remembered, not simply known through relative familiarity, as explained earlier.

Subsequently, Clayton and colleagues argued that there were in fact three cardinal features: content (what, where and when memory), structure (an integrated what-where-when representation) and flexibility, namely that the information can be deployed flexibly not only for memories of the past but also to imagine and plan for future events (Clayton et al., 2003a). In acknowledging the lack of any tests for the accompanying phenomenological features concerning an awareness of self and subjective time this was termed 'episodic-like memory' (Clayton & Dickinson, 1998; Clayton et al., 2003a).

In the next section, we review the evidence that some non-human animals do have episodic-like memory and evaluate the extent to which they can also plan for the future. This is an important question because a key prediction based on the Constructive Episodic Simulation hypothesis is that if the processes involved in episodic-like memory do engage the mental time travel system then it necessarily follows that any subject that uses episodic-like memory to recall the past should also be able to imagine future scenarios and plan for them accordingly. Cognitive neuroscience supports this claim about the relationship between episodic memory and future planning in two ways. The first is by demonstrating that patients such as KC and DB who are unable to remember the past are also impaired in their ability to imagine the future, even when they have access to semantic knowledge of past and future (e.g. Rosenbaum et al., 2005; Klein et al., 2002), and that these hippocampal amnesiacs are impaired in their ability to imagine and construct future scenes (e.g. Hassabis et al., 2007). The second is that fMRI studies of healthy subjects show that the same patterns of brain activation are found when people are asked to remember the past and when requested to imagine the future (e.g. Addis et al., 2007; Buckner & Carroll, 2007; Schacter et al., 2007, 2008, 2012).

Episodic-like memory and future planning in animals

Over the past twenty years, a number of studies on episodic-like memory have been conducted on a range of animals including corvids, rodents and apes. The results of these experiments show that a number of non-human species can remember the what, where and when of individual past events (for recent reviews see Clayton, 2014; Clayton, 2017) and that, like humans, hippocampal activity plays a key role (for recent reviews see Moser et al, 2015; Thom & Clayton, 2016).

It may be worthy of note that some of the best evidence comes from studies of corvids, whose cognitive abilities have earned them the title 'Feathered Apes' (Emery & Clayton, 2004, 2005). These birds hide food caches for future consumption and have excellent memories of specific past caching episodes. Figure 2 illustrates the procedure that we used to establish that the jays can remember which foods they cached where and when (Clayton & Dickinson, 1998). Figure 2a shows the training procedure; Figure 2b illustrates the test procedure.

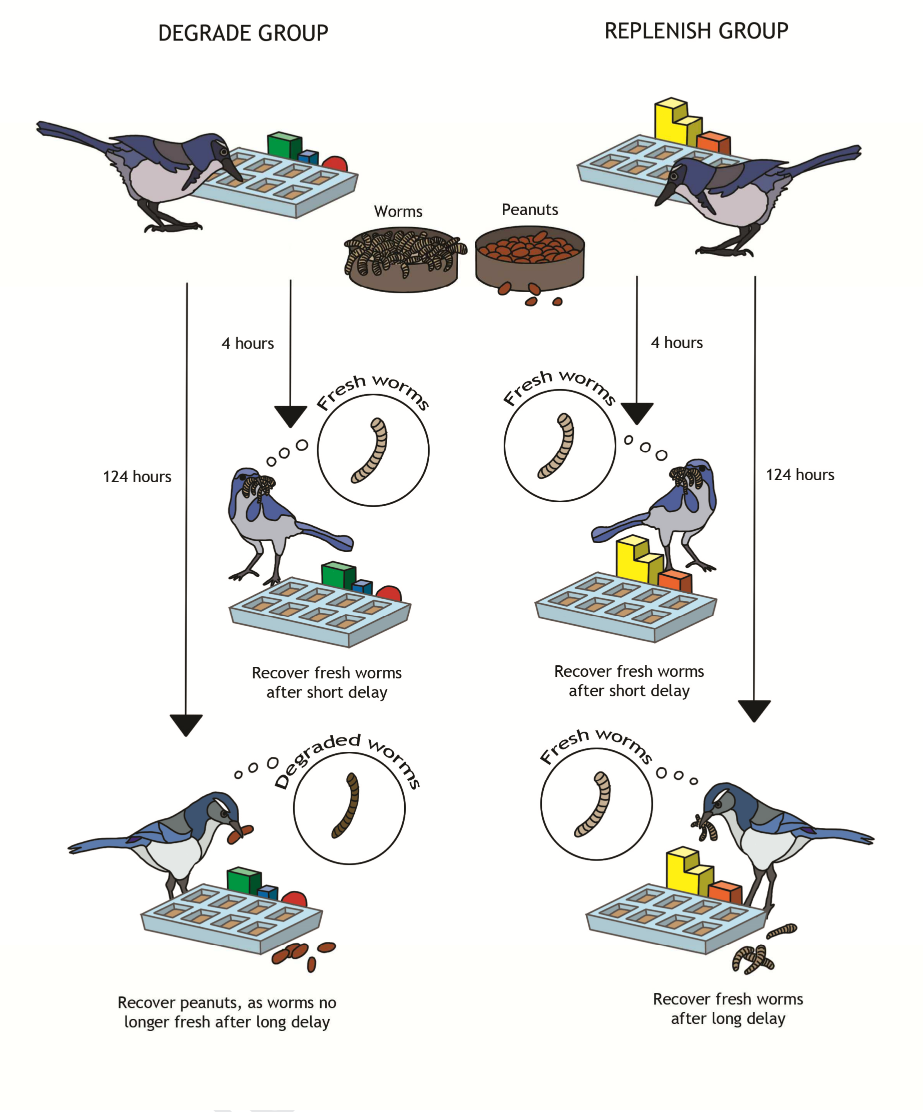

Figure 2a. What, Where, When Training. Art work by Nathan Emery.

The Degrade Group had the opportunity to cache worms, which were fresh after the short delay and rotten after the long delay. They could also cache non-perishable peanuts. The procedure capitalising on the fact that the birds' preferred food type perished over time and was therefore only edible after the short delay. Over a series of 4 training trials, the birds learned to recover worms after the short delay when they were still fresh, and peanuts after the long delay when the worms had perished. By contrast, for the Replenish group, the worms were replaced by fresh worms prior to cache recovery so that they never had the opportunity to learn that worms naturally perish, and therefore they continued to search preferentially for worms after both the short and the long delay.

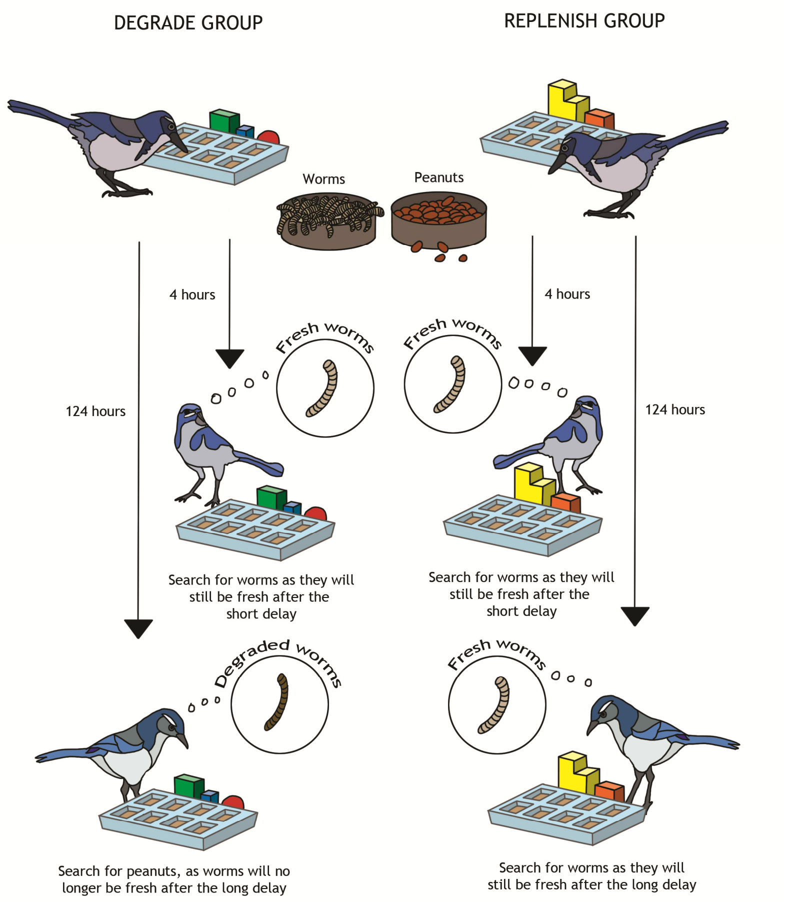

Figure 2.What, Where, When Test. Art work by Nathan Emery.

On test, the birds cached as usual but the procedure differed from training in that they could only search and not recover any of the caches they had made. This was because all of the cues emanating from the food caches were removed by the experimenter prior to cache recovery in order to investigate whether the birds relied on memory to search for what had been cached where and when as opposed to visual and olfactory cues associated with the food.

At issue, however, is whether the corvids can recall their memory of what happened where and when or whether there is a simpler memory-related mechanism that would allow them to achieve the same ends behaviourally; in this instance through the salience of the recognition of what has been seen before namely 'familiarity', as opposed to mental recall (Figure 3).

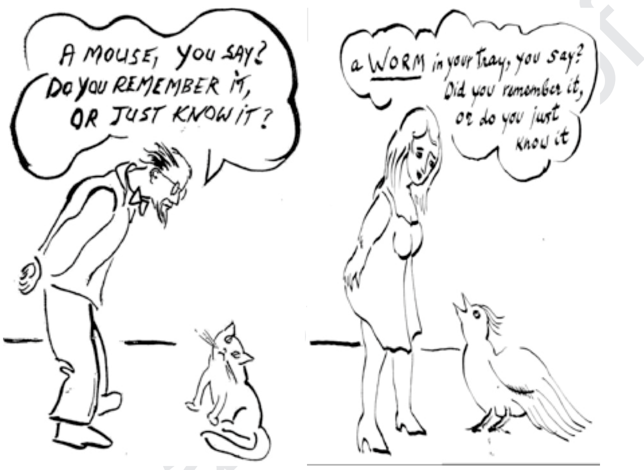

Figure 3. The issue with relative familiarity. Art work by Ruth Tulving.

In order to test for this, we ran an additional control in which we contrasted memory based on familiarity and memory based on recall. To do so we covered one side of the caching tray during each of two caching events, allowing them to cache worms in one side of the tray and peanuts in the other. The jays therefore had to remember which side of a particular tray they had cached in during each caching event, and what they had cached there, and as opposed to simply keeping track of which tray they had seen most recently and therefore was the most familiar in their perception. The findings were clear: the corvids, in this case Californian scrub-jays[1],

[1] When we first began our investigations this species was known as the Florida scrub-jay but the American Ornithology Union subsequently reclassified the birds as Western scrub-jays and more recently California scrub-jays.

remembered what they had cached where and when, as opposed to relying on the relative familiarity of the trays (i.e. which one have I seen most recently). This is important empirical evidence that shows that their ability to recover their caches is controlled by memory recall not relative familiarity (Clayton & Dickinson, 1998, 1999).

In subsequent experiments we explored the subjective experience in time in the mind of the jay by also investigating the 'ripening' of food as opposed to 'perishability', namely where preferred items are only palatable with long delays after caching as opposed to short time periods (de Kort el al., 2005). The birds were also able to remember what had been cached where an when, suggesting this was achieved through episodic-like memory as opposed to selective forgetting over long delays.

Further studies show that the birds keep track of which individuals were present and therefore could watch what they were caching at a particular time and place (Dally et al., 2006), and also of the threat they pose given differences in dominance status (Dally et al., 2005). Scrub-jays can also update information after the time of caching and generalize across situations, thereby demonstrating that these episodic-like memories can be flexibly deployed (Clayton et al., 2003b). Evidence for an integrated representation of what happened where and when was also found in a series of experiments demonstrating that the birds could recall where they were when they cached X, when and where they last cached X, and what they cached when they where in a particular place (Clayton et al., 2001).

A number of other laboratories have subsequently investigated whether or not other animals have episodic-like memory using paradigms analogous to those employed with the jays. There is now good evidence that a diverse range of animals can remember the what-where-and-when of past events, from cuttlefish to great apes (see Clayton, 2017 for a recent review). It remains to be seen, however, whether such behavioural criteria are sufficient to ascribe episodic memory, as opposed to episodic-like memory, to these animals. For example, Tulving (2005 p. 47) remarks "Nicola Clayton's scrub-jays would have been certified as full-fledged episodic creatures back in 1972. But whether we like or do not like the changes in our ideas about nature, there is no other way in science. Science lives and survives only as long as there is progress in its understanding of nature, and change is a necessary condition of progress". Although Tulving's opinion that episodic memory and mental time travel are uniquely human has remained unchanged over the years, his focus on what he considered to be the key characteristics have changed. Initially episodic memory was defined in terms of the recall of spatio-temporal relations between events (Tulving, 1972, 1983), but the discovery that some patients could remember the what, where and when of an event without personally experiencing it through the projection of self and time led to a reconceptualization that focussed on the phenomenological features, namely autonoesis (Tulving, 1985) and chronesthesia (Tulving, 2002, 2005).

There is, however, some support for the notion that episodic-like memory engages the same processes as episodic memory, which comes from three sources. The first is that converging evidence from the cognitive development literature suggests that children pass tests of episodic-like memory (remembering what happened where and when) at around the same time as other tests of mental time travel (episodic memory and future planning) and show the same typical trajectory: they fail the tests at three years of age, begin to pass the tests of the age of four, and by five or six years of age they show competence in these abilities (see Clayton, 2014 for a recent review). Importantly for the argument about converging evidence, when the tests have been directly inspired by the comparative research on animals such as the what, where, when caching paradigm (Clayton & Dickinson, 1998) and future planning caching paradigms (Raby et al., 2009) this same developmental trajectory is found in young children aged 3-5 years of age (Russell et al., 2011; Atance et al., 2014 respectively). Futhermore, Hayne et al. (2011) found a strong correlation between the amount of information reported by children about past and future events and although 5-year-olds provided more details in their descriptions than 3-year-olds there was a similar proportion of first-person reference for 3-year olds and 5-year-olds.

Aside from behavioural tests of episodic-like memory in animals and young children, there are two additional sources of evidence that episodic-like memory engages the same psychological processes that control episodic memory in humans. The first comes from neurophysiological recordings of hippocampal activity. In humans, it is well known that the hippocampus is activated when subjects consciously engage in remembering the past and imagining the future. Analogous explorations of 'replay recordings" of hippocampal activity in rodent models may be taken to suggest that rats may also engage in such mental time travel[2] (see Moser et al., 2015 for a recent review).

[2] There are inevitably other explanations such as the replay of spatial relationships or the replay of non-spatial information related to rest- or sleep-dependent processes involved in motor learning and/or procedural memory.

The second comes from behavioural and cognitive neuroscience. For this we need to return to the Receiver Operating Characteristic (ROC) curves we alluded to earlier. Eichenbaum and colleagues' seminal work on the use of signal detection analyses to characterize recognition memory performance in rats. First they found that it is indeed possible to distinguish independent components of recognition in animals that are associated with features of recollection and familiarity in humans, and second, that hippocampal damage induced by lesions results in a selective deficit in recollection and not familiarity in the rats (Eichenbaum et al., 2010; Fortin et al., 2004).

If animals show episodic-like memory and this episodic-*like* memory is genuinely *like* episodic memory, then we can make a further prediction. According to The Constructive Episodic Simulation hypothesis, animals that pass tests of episodic-like memory should also be capable of imagining the future and planning for it. In support of this, studies on corvids have shown that the birds use information about previous caching episodes to learn where and when not to cache in the future (Clayton et al., 2005). Furthermore, they can also plan for the future, for example knowing when to protect their caches from potential thieves in order to maximise the chance they will be able to recover their caches at a later date, a decision that depends on previous experience of being a thief as opposed to a hard-wired automatic response (Emery & Clayton, 2001) and one mediated by their ability to remember which individuals were present when they cached and the likelihood they might pilfer the caches in the future (Dally et al., 2006). They can also take into account the current desires of potential pilferers and adjust their caching tactics accordingly (Ostojić et al., 2017). In addition, the jays can ignore their current needs at the time of caching in order to choose to cache those items they have learned they will want in the future when they come to recover and eat their caches (Cheke & Clayton, 2012; Correia et al., 2007). This is an important issue because in their seminal paper "Mental time travel and the evolution of the human mind", Suddendorf and Corballis (1997) proposed the Bischof-Köhler hypothesis that non-human animals are unable to dissociate current needs from future ones and therefore cannot plan for a temporally distant future motivational state that differs from a current state. So the jay findings contradict this hypothesis by showing that the birds are able to cache a food they do not want to eat now in order to be able to eat it when they come to recover it several hours or even days later (Correia et al., 2007) and can adjust their caching to take into account two different future motivational states (Cheke & Clayton, 2012). Given the ill-informed dietary choices humans often make when hungry (e.g. Cheke et al., 2106) this seems no small feat.

One potential counter argument is that the ability to cache is innate and given the only benefit to the individual cacher is to recover the food at a later date then caching might necessarily be prospective in nature, without any need for cognitive control of future decisions. This is why the experiments demonstrating flexibility in their use information about previous caching episodes to learn where and when not to cache in the future (Clayton et al., 2005) and how to protect their caches from being stolen by other birds (Emery & Clayton, 2001; Dally et al., 2006) are important because they counter the suggestion that these caching decisions are simply instinctual/hard-wired .

One possible simpler mechanism, however, is that the act of recovering a particular food might trigger the memory of the time the bird cached that food. If the bird is hungry for that particular food then recovering that food type will be rewarding, thereby directly reinforcing the act of caching that particular food type through the memory of doing so (Clayton et al., 2009). Such memory-mediated reinforcement does not require the jay to project its self in time to imagine what its future motivational state will be. Indeed, it may be for this very reason why the jays are so adept at dissociating current and future motivational states, namely because they do not need to use their mental time travel system to do so. Perhaps the reason the jays are able to dissociate current and future needs is precisely because they are not relying on episodic cognition, that subjective experience of thinking, which all too easily constrains our perception and our memories (Cheke et al., 2011).

At issue, then, is whether such studies of future planning in corvids, and in other animals such as squirrel monkeys and rats that have been tested on analogous tasks (e.g. Naqshibandi & Roberts, 2006), engage the same cognitive process as those involved in episodic-*like* memory. In other words is there evidence that the future planning experiments in animals rely explicitly on episodic-*like* future thinking?

Perhaps it might be helpful to consider the application to our own species, after all humans are certainly able to anticipate future needs and cache food accordingly. Trips to the supermarket for the weekly shop are a case in point. If we know that family will be visiting for several days then we will buy more food than usual: clearly an example of decisions done *with the future in mind*. However, it is not necessarily the case that we dissociate completely from the context of our present motivational state when we engage in such decision making for it is well established that shopping for food is influenced by our current levels of hunger (Nisbett & Kanouse, 1969), even though we know that the hunger we are experiencing is a temporary state, which will be unlikely to affect our needs for the rest of the week. It may be precisely because we are relying intuitively on our mental time travel system that we make such mistakes (e.g. Gilbert, 2006; Cheke et al., 2011). If the ability to plan for the future need not necessarily involve episodic foresight then there may be a need to rethink the behavioral criteria for future planning and their relationship to mental time travel. Tulving argues there is a way forward, which he refers to as the Spoon Test "a future-based test of autonoetic consciousness that does not rely on and need not be expressed through language… In an Estonian children's story with a moral, a young girl dreams about going to a friend's birthday party where all the guests are served delicious chocolate pudding, her favourite" (Tulving 2005, p. 43).

Tulving's Spoon Test

As the story unfolds it becomes clear that all the little girl can do is to passively observe the sequence of events. She cannot eat any of the dessert because she does not have a spoon, and the rules of the party game are that no one is allowed to eat the dessert unless they have brought their own spoon. What a disappointment! "So the next evening, determined not to have the same disappointing experience again, she goes to bed clutching a spoon in her hand" (Tulving, 2005, p. 44), which she caches under her pillow in order to have the right tool to hand in the future should a similar scenario unfold.

To pass the Spoon Test the subject must act analogously to the little girl, using a specific previous past experience (an episodic memory, or an episodic-like memory) to take action now for an event that might happen in the future, namely caching a spoon so that it is ready to take to a new party, at some point in the future. Such decisions specifically involve episodic cognition, in terms of both the subjective experience of remembering and future thinking~ recalling a specific episode in the past, imagining similar future scenarios, and taking a specific action in the present in order to prepare for future events. Tulving (2005, p. 45) suggests that "the future intention should be directed at something that happens in a place other than one in which the present preparatory action is carried out. The spoon has to be picked up here and now, with a deliberate intention of putting it to use at a future time. The major reason for the insistence on a different place has to do with the minimization of the influence of the present situational cues on the spoon carrying behaviour". In other words, to satisfy the Spoon Test the prospective action must be conducted as a distinctly separate event in space and time, not just a continuation of the current episode. Furthermore, the act needs to be performed with the future in mind, and clearly dissociable from any current need. Tulving (2005, p. 44) states that "the behaviour in question must not be instigated by, and must not satisfy, a present need or be governed by current physiological states". At issue then is whether there is any evidence that some animals can pass this Spoon Test?

Mulcahy & Call (2006) were the first to devise a Spoon Test for non-human animals. They trained bonobos and orangutans to use a tool to obtain an out-of-reach food reward, and then gave the apes the opportunity to choose a tool that they could carry into their sleeping quarters (i.e. a different place) to be used the following morning. The results were mixed: most of the apes sometimes chose the correct tool, but the individual pattern of success for each subject was not consistent across trials, as one would expect if the apes had a genuine understanding of the task. Simpler explanations are invariably possible: in this case, that the observed behavior can be attributed to long-delay instrumental conditioning (Cheke & Clayton, 2010; Raby et al., 2007; Shettleworth 2007; Suddendorf, 2006). Subsequent experiments by Osvath & Osvath (2008) for apes, and Raby et al. (2007) for scrub-jays, provided more persuasive evidence of future planning in animals. With regard to the latter, namely the jays' ability to plan for breakfast the following morning Shettleworth summarised "two requirements for genuine future planning are that the behaviour involved should be a novel action or combination of actions….and that it should be appropriate to a motivational state other than the one the animal is in at that moment….Raby et al. describe the first observations that unambiguously fulfil both requirements" (Shettleworth, 2007, p. 825). Most recently Kabadayi and Osvath (2017) showed that another species of corvid, the raven, can anticipate the nature, time, and location of a future event based on previous experiences using anticipating future states and do so using bartering and tool trading, not just caching and therefore that these birds can flexibly apply future planning in behaviours that are not part of their natural repertoire, i.e. not seen in the wild (Boeckle & Clayton, 2017).

There will always be skeptics (e.g. Hampton, 2018). The argument boils down to two things. Firstly, is there a simpler associative account to explain the purported studies of future planning? (e.g. Redshaw et al., 2017; Suddendorf, 2006; Suddendorf et al., 2009). Secondly, do these Spoon Test tasks really require the use of *episodic-like future-thinking* or could they be achieved in the absence of mental time travel, i.e. without any requirement to project the self in time (e.g. Clayton, 2017)? The problem is that there is no way of knowing whether the jays' ability to plan for future breakfasts and the ravens' tool use and bartering abilities are based on the projection of the self in time, which is what would be required to satisfy an episodic future-thinking account. The same reasoning applies to the apes' ability to choose tools. It is entirely possible that the jays and apes rely on a 'semantic' knowledge-based sense of the future, in which they take prospective action but without any personal mental time travel into the future (Raby et al., 2007). To solve the Spoon Test, all the subject has to do is to decide what has to be done to ensure the implement will be at hand, be it a spoon, another tool, or a food-cache, without the need to imagine one's self in possible future episodes or scenarios (Raby & Clayton, 2009).

Is there any converging evidence to bear on these issues, within the realm of child development for example? As aluded to earlier in this essay, developmental studies of mental time travel provide an important comparison for assessing whether, and to what extent, non-human animals show such capacities in the absence of verbal report. As Scarf and colleagues argue "Those working with non-human animals have been set an ever growing number of criteria that their spoon tests must adhere to … however, one could argue that these criteria are only relevant in so far as they have been upheld in developmental studies that have concluded young children are capable of mental time travel" (Scarf et al., 2014, p. 2).

A number of studies have shown that children show the same typical age trajectory for passing the Spoon Test as they do for other tests of episodic memory and future planning (e.g. Atance & Somerville, 2014; Payne et al., 2015; Scarf et al., 2013; Suddendorf & Busby, 2005; Suddendorf et al., 20011). In other words they fail the tests at three years of age, begin to pass the tests of the age of four, and in some of the more complex versions of the task then it is not until children reach the age of five or six that they show competence in these abilities (see Atance 2015; Scarf et al. 2014 for recent reviews). For example, Suddendorf et al. (2011) tested 3- and 4-year old children on a novel problem that involved the use of a specially shaped key to unlock a box. In the first room, children were shown a box that contained a keyhole that was either in the shape of a triangle or a cross and the experimenter demonstrated how to use the key that matched the shape of the keyhole to open the box containing a number of highly preferred stickers. Children were allowed to try it out for themselves twice and obtain a sticker each time they did so. They were then distracted and the key they had previously used to open the box was replaced by a broken key and shown that the broken key failed to open the box. The experimenter then ushered the child into another room where they were distracted by playing games for 15 minutes. After the 15-minute delay, they were given the choice of four differently shaped keys, one of which matched the key they had previously used to open the box, which they could take with them when they went back into the first room. The majority of 4-year-olds chose the correct key whereas 3-year-olds performed at chance.

One could argue that this study and similar ones (e.g. Scarf et al., 2013; Atance & Somerville, 2014) only tested children's foresight for the very next event (Redshaw & Suddendorf, 2013) because the experimenters did not include a delay between the choice phase and the next phase, when the opportunity to use the item they selected. Subsequent experiments by Redshaw & Suddendorf (2013) included a 5-minute delay between the two phases and found that the performance of 4-year-old children on the spoon test was just as good. Although these authors argued that the mechanism used to plan for the very next event may be the same mechanism used to plan for more distant events, it will be important for future studies to use substantially longer delays in order to investigate whether, and to what extent, longer time delays impacts upon these 'spoon' selection choices.

In common with comparative cognition, research on developmental cognition is not without its skeptics. To illustrate this, we shall provide two examples of how these skepticisms have moved the field forward. The first concerns a recent study by Martin-Ordas (2017) who argued traditional one-step Spoon tests are inadequate for assessing future planning and therefore tested 3-, 4-, and 5-years olds on a two-step version of the Spoon test in which the children were invited to play a marble run game. To do so, the children had to obtain a key in order to access the marbles before being able to actually play the game. Although the 4-year olds were able to choose the correct key, it was only the 5-year olds that were able to reason about the temporal sequence of the two future events *and* select the key. These results highlight the role of temporal reasoning (i.e. decisions about the order in which the steps should be taken) and therefore that tool choice measures alone need not rely on future thinking.

The second example concerns the potential role of associative learning in solving these Spoon tests in children. In the earlier discussion on the comparative evidence, it was argued that corvids and apes, may simply choose the item that has been assigned salience or value, without necessarily imagining the future event. This same criticism could be applied to the children too and therefore Dickerson et al. (2018) developed a new test in which two of the items offered to children were associated with positive outcomes, but only one was still useful. They found that although 5-, 6-, and 7-year-olds were able to select the correct item at above chance levels, the 3- and 4-year-olds did not. This was not a memory problem: in further tests, the 4-year-olds showed an accurate memory for the encoding event. Consequently it can be argued that positive association substantially impacts performance on the tool selection test in 4-year-olds. Dickerson et al. (2018) have therefore argued that future planning may have a more protracted developmental trajectory than episodic memory, although we would argue that an alternative account is that Spoon tasks rely both on future planning and causal reasoning in a way that the tests of episodic memory do not. Indeed other studies we have conducted on tool selection tasks in children also suggest that the development of causal reasoning is key (Loissel et al., 2018).

Studies on cognitive development in young children also suggest that it may be less cognitively complex to think about the future from another person's point of view rather than from one's own personal perspective, perhaps because in so doing there is no need to dissociate current self desires from future self desires. Consider the 'Blow Football' experiment investigating such issues in young children aged from three to five years of age (Russell et al., 2010), which required them to deploy a straw to blow a ball across a table-top. The table was curiously designed to be taller on one side than the other. On the initial test the child could easily reach because they played from the short side of the table, but in the future, when required to play from the other side of the table, a stool would be needed to reach the required height. The children were given a choice of six items and asked which two they would like to save, or cache, in order to play the game again tomorrow. The critical items were the stool and the straw. Distractor items included a paper copy of a referee, a team badge, a pair of football boots and a soft cuddly toy.

There was a clear developmental difference between the children: the three-year olds chose items that they wanted right now such as the team badge, whereas the five year olds were able to resist their current desires in favour of what would be needed to play the game. The performance of four year olds was particularly interesting, as they were only able to pass the test when asked to make their choice based on what another child 'just like them' would need but not when asked what they themselves would need. In other words, four year old children could pass the task in the 'future-other' condition but failed the task in the 'future-self condition. One explanation for these results is that four year old children can solve the task of 'future other' in the absence of mental time travel, i.e. without the need to imagine one's self in possible future episodes or scenarios. Furthermore it should be noted that there is no requirement to dissociate between the needs of the present-self and future-self given the task only requires an understanding of what another person will want in the future. Perhaps this is what makes the 'future other' condition easier than the 'future self' condition.

Cognitive roadblocks in human episodic cognition

Young children are not the only ones to dissociate present and future needs. Adult humans also have a tendency to think that the future will be more like the present than it actually will be. Gilbert (2006) describes this temporal myopia, or short sightedness, when it comes to envisioning futures, in his wonderfully entertaining book *Stumbling on Happiness*: for example he convincingly demonstrates that peoples' choices of what they think they will want to eat tomorrow will be heavily influenced by their current motivational state, irrespective of whether or not those states will be experienced tomorrow (see also Cheke et al., 2016). We make ill-informed dietary choices when we go supermarket shopping when hungry because of our inability to dissociate current needs from possible future ones.

Such temporal myopia constrains our memories of what happened. It could be argued we fail to remember events because we are too busy reconstructing memories to fit into our existing schema of how the world works, and in so doing override what was actually perceived. Visual illusions and magic effects capitalize on these aspects of perception too, as does art, literature, music and dance (Laland et al., 2015). The errors that illusions and other visual effects induce in our perceptions are systematic, revealing fundamental features of our perception. As Gilbert (2006, p. 46) so eloquently states "they are not silly mistakes but clever mistakes, ones that allow those of us who understand them to glimpse the elegant design and inner workings of the mind". The mistakes we make when we try to imagine our personal futures and reflect upon our treasured memories are also systematic and they too have a pattern that tells us about the powers and limitations of using our creative navigator's compass to explore the world. We use our eyes to look into space, and our creative compass to circumnavigate space and time~ just as our eyes sometimes lead us into seeing things as they are not, our episodic cognition can lead us to remember things falsely and foresee things as they will not be (Clayton & Wilkins, 2017a). 'Boundary extension' is a classic case in point. This is the phenomenon whereby people consistently perceive and imagine a greater expanse of a scene than the one they were actually shown (Intraub & Richardson, 1989). In essence, it is an error of commission in which people think they remember seeing a surrounding region of a scene that was not visible in the original view. Interestingly, it does not occur in response to all pictures, only those that convey scene structure, and furthermore it does not occur for all boundaries within a scene, but only those boundaries that form the exterior to the view (Gottesman & Intraub, 2002, 2003).

This is phenomenon long known to painters and photographers who work within a picture plane that has a defined edge and limit. The art of composition and knowing where to finish an image is crucial to the communication of an idea. In order to make sense of an image the viewer most frequently will infer what went on moments before and will conjecture what is coming next. In addition they infer what is beyond the boundary. In so doing they invent more of the world and the story of that world than they were originally shown. Indeed, in a similar vein the theatrical proscenium arch allows the audience to suspend disbelief in the imaginative or artificial worlds that they experience. In this instance the arch although it describes the edge of the stage does not describe the edge of our imagination.

Not all human minds are subject to boundary extension, however. Although amnesiacs are impaired in their ability to remember the past and cannot imagine or reconstruct complex spatial scenes (Hassabis & Maguire, 2007, Hassabis et al., 2007) they do not show the boundary extension phenomenon (Mulally et al., 2012), presumably because they do not have access to the mental time travel system to perceive and remember. This raises interesting questions about how mental time travel, or the lack thereof, might affect cognitive processes and what insights such findings might provide in our quest to better understand the cognitive roadblocks in our thinking processes.

Can we gain any insights from humans without episodic memory or with obsessive episodic memory?

Perhaps most revealing are the seminal studies of patients such as Kent Cochrane (K.C.; Rosenbaum et al., 2005, Craver et al., 2014) and D.B. (Klein et al, 2002) who suffered specific impairments in episodic cognition, both in terms of remembering the past and imagining the future. KC and DB know facts about the past and can conjecture information about the future, but they cannot directly experience it: when asked to do so they report that their minds go blank and that they feel the same kind of blankness when asked to remember the past or imagine the future. The striking thing here is that KC and DB cannot conjure up a single event into their conscious awareness. They have no subjective experiences about themselves, and cannot imagine what such experiences would be like. It is as though they were not present when the events they are asked to describe actually happened, but were merely told the facts afterwards as a series of timeless selfless labels about the occurrence, constrained to the objective, devoid of the subjective.

Tulving (2005, pp. 24) sums this up as follows: "K.C.'s major problem is that he cannot remember anything that has happened to him. However hard he tries, and however powerfully he is prompted, he cannot bring into his conscious awareness a single event, happening, or situation that he witnessed or participated in. The global episodic amnesia covers the spam of his whole life. The period from his birth to the present day: he cannot recollect anything from his life either before or after the accident…He does not remember a single visit to the family cottage, and not a single happening there in which he participated. Nor is he capable of remembering anything that ever having happened in the house where he has now lived for over 40 years. He knows that he owned a black Honda, but does not remember a single trip he ever took in it".

At the other end of the spectrum are people with a condition called Highly Superior Autiobiographical Memory (HSAM) or hyperthymesia (e.g. Parker et al., 2006; Le Port et al., 2012, 2017). These individuals have highly accurate and extremely long lasting memories of autobiographical events. They are seemingly able to recall every event that has happened to them and spend an obsessive amount of time reliving their past.

It is important to note that the information is acquired and retained without the explicit use of mnemonic techniques such as memory palaces (e.g. Luria, 1968), in other words HSAM individuals claim that they do not rehearse their experiences or use mnemonic techniques with the *explicit intent* of creating and rehearsing strong memories, so unlike many memory experts the effect is specific to autobiographical episodic memories, not semantic memory (Ericson & Moxley, 2014). Indeed, although they have exceptional autobiographical memories, they are no better than control subjects at laboratory memorization tasks. Subsequent research suggests that HSAM may well be the result of the more efficient consolidation and retrieval of these detailed memories, perhaps rooted in obsessively driven, habitual rehearsal of autobiographical material (Le Port et al., 2017).

A.J., who later became known as Jill Price, is the most well known example of people with HSAM, but over 50 case studies have now been identified[3]. One might suspect that this would be to the detriment of their thoughts about the past and the future but there is no good evidence in support of this. Although Jill Price does complain of negative effects as a result of being flooded by her detailed autobiographical memories, the majority of other HSAM cases report that their superior memory provides an enhanced access to the past, which may positively influence both current decision making and future planning.

Although routine ruminations/perseverations of autobiographical information may serve to preserve HSAM participants' memories, the available evidence does not support the hypothesis that HSAM relies on explicit rehearsal. When they ruminate and obsess about the past, they remember vast details about what happened on specific days from long ago, and can do so across a series of years: they can remember for example what they had for breakfast, what they wore, who they saw and where they went on June 25 2000, and 2001, 2002 and so on and so forth.

If this ability were due entirely to explicit rehearsal, achieving HSAM would require as much devotion to recalling life events as a world memory champion devotes to memorizing decks of cards, for example, but it does not (Foer, 2011). The routines and pressures of daily life demands seem to prevent the typical HSAM individual from this level of commitment to the maintenance of their memories. Consequently Le Port and colleagues have argued that HSAM participants may be *incidentally* strengthening their memories, by means of an obsessive habit, which

[3] https://cnlm.uci.edu/hsam/

allows them to acquire and habitually use an implicit ability to embed autobiographical information within a larger memory network, and this may be the reason they differ from obsessive compulsive disorder (OCD) (Le Port et al, 2012, 2017). Differences in the functional connectivity of the Default Mode Network, previously shown to be important for self-referential thought, self-projection and autobiographical remembering (Buckner et al., 2008) would point to neurobiological processes contributing to HSAM that are distinct from OCD; for example the role of the praecuneus in the autobiographical retrieval network (Mazzoni et al., 2019; Santangelo et al., 2018).

So far we have contrasted individuals with HSAM and amnesiacs but there is an even more pure disorder of autonoetic consciousness than medial lobe amnesia, namely Severely Deficient Autobiographical Memory (SDAM), which refers to a lifelong inability to re-experience personal past events from a first-person perspective. These individuals cannot mentally travel back in time to re-experience the subjective event in the first person, though they can learn and remember from a third person perspective, which is why they cannot hold grudges! Unlike amnesiacs these individuals do not exhibit any dense anterograde memory deficits just an inability to vividly recollect their autobiographical experiences. And like HSAM the condition does not arise through brain trauma, but seems to be an ability manifest from early development (e.g. Palombo et al., 2015; Palombo et al., 2018; Zeman et al., 2015).

In the analysis of amnesiacs we see the debilitating effects of life and consciousness in the absence of a normally functioning mental time travel system. Primarily this results in the inability to contextualize the present. Examples abound: how can I know how I am feeling today or wonder how I will feel tomorrow without conscious access to a memory of how I was feeling before, be it yesterday or a decade ago? Interestingly there is no evidence of such a deficit in SDAM subjects. Perhaps this is because SDAM is a developmental condition and consequently these individuals learn methods of compensating, possibly through enhanced implicational reasoning abilities (see Palomba et al., 2018). Perhaps a similar case can be made for HSAM subjects: having lived with their condition for many years (for HSAM often becomes apparent in the early teens), they develop ways of managing the flood of memories that they experience.

So how do these abilities influence autonoetic and chronesthetic awareness? For the reasons stated above it would seem that for HSAM and SDAM subjects these subjective experiences of the projection of self and time are relatively normal. Amnesia, however, anchors time to the past, and thus results in a failure to contextualise the present within the framework of past, present and future, through a lack of conscious access to the memory of what happened and therefore a failure to appreciate a sense of pastness, a sense of swimming through a subjective sea of time. Mental time travel is disrupted, and the projection of self in time fails to function normally and therefore amnesiacs lack the kind of self-awareness most of us take for granted. K.C., for example remembers nothing of what has happened to him. As Tulving (2005, pp. 26) states “It is difficult to imagine that these missing features have no bearing in his awareness of himself. This awareness is not ‘normal.’ What is missing is what I have referred to as autonoetic consciousness…” Yet despite the claim that memory is the door to identity (Clayton & Wilkins, 2017a) neither memory loss nor episodic memory obsession leave the individual without personality or individual character traits. Perhaps aspects of identity are carried in the way we use language and accessed by other non-episodic forms of memory (Clayton & Wilkins, 2017b).

As we alluded to in the introduction, a number of psychologists have argued that episodic memory and future planning go hand in hand (e.g. the Prospective Episodic Simulation hypothesis, Schacter et al., 2007). However, we can trace these ideas back long before psychology was founded. One of the most eloquent accounts can be found in the lament 'To A Mouse' by Robbie Burns, in which he makes reference to the notion that we cast our mind's eye backwards to 'prospects drear' and forwards 'to guess and fear', and suggests that this ability is something that distinguishes men from mice (Burns, 1785).

Spoons are featured prominently in this paper, but perhaps our concentration on the Spoon Test (Tulving, 2005) may have detracted from another feature of spoons, namely their reflectance (Figure 4).

Figure 4. Enigmatic Spoon. Art work by Clive Wilkins (Wilkins, 2008).

The little girl who cached the spoon under her pillow in the famous Estonian folk story would have been fascinated by the way in which her reflection altered depending on which side of the spoon she used to see herself. She may have wondered which was the true reflection, concave or convex, and quickly come to the conclusion that neither was more important than the other, simply two sides of the same self. That is the nature of perspective taking. The self is retained through time yet it also changes with time, just as our memories do. We only ever see memories from where we now stand, for the very same reason that we can never stand in the same river twice. The present will change in the blink of an eye. In spite of mental time travel, we cannot go back in time to see memories as they were, nor can we project the self forwards to see them as they will be: we can only imagine such scenarios and wonder what these metacognitive reflections reveal about the subjective experience of thinking. Perhaps we should take Jean Cocteau to heart when he says "Mirrors should think longer before they reflect"[4].

[4] Jean Cocteau

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NC and CW contributed equally to the content of this paper, and they wrote the manuscript together.

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We explore memory and mental time travel and its origins and role in planning for the future.

We review the work on comparative cognition and cognitive development.

This allows us to explore non-verbal and pre-verbal mental time travel.