

# Are Animals Stuck in Time or Are They Chronesthetic Creatures?

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## Abstract

Although psychologists study both the objective (behavior) and the subjective (phenomenology) components of cognition, we argue that an overemphasis on the subjective drives a wedge between psychology and other closely related scientific disciplines, such as comparative studies of cognition and artificial intelligence. This wedge is particularly apparent in contemporary studies of episodic recollection and future planning, two related abilities that many have assumed to be unique to humans. We shall challenge this doctrine. To do so, we shall adopt an ethological approach to comparative cognition and this necessitates two requirements. The first is that memory and planning need to be characterized in terms of objectively defined properties as opposed to purely phenomenological ones; the ability to remember what happened, where, and how long ago is a critical behavioral criterion for episodic memory. The second requirement is the identification of an ethological context in which these memories would confer a selective advantage. As a consequence, we turn this debate into an empirical evaluation in nonlinguistic animals and one embodied in synthetic creatures. Indeed, our behavioral conception of flexibly deployable information about “what, where, and when” has so far supported a comparative cognition in animals as diverse as corvids and primates. We argue that this approach may clarify and challenge ideas that have been based solely on research with human subjects, without the need to be constrained by phenomenological assumptions based on human-centric ways of thinking.

*Keywords:* Episodic memory; Future planning; Goal-directed actions; Animal models of human cognition

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## 1. Introduction

Psychology is unique in being the science of both the objective (behavior) and the subjective (phenomenology). An overemphasis on the subjective, however, drives a wedge between psychology and other closely related scientific disciplines, such as comparative studies of cognition and artificial intelligence. The wedge is no more in evidence than in the contemporary study of memory. Indeed, in his seminal studies of human memory, Endel Tulving introduced a fundamental distinction between our ability to remember specific personal happenings from the past, which he termed episodic memory, and our ability to acquire general factual knowledge about the world, which he referred to as semantic memory (Tulving, 1972, 1983). Ever since he made this remember-know distinction, most cognitive psychologists and neuroscientists have assumed that episodic memory is special because of the experiential nature of these memories; in other words that our episodic reminiscences are accompanied by a subjective awareness of re-experiencing now an event that happened in the past (e.g., Suddendorf & Corballis, 1997; Tulving, 1983; Wheeler, 2000). Indeed, adult humans can report on their experiences and judge whether they can recollect experiencing the event or whether they just know it happened (Tulving, 1985; Gardner 1988). Of course we also have many instances of knowledge acquisition in which we do not remember the episode in which we acquired that information. For example, although most of us know when and where we were born, we do not remember the birth itself or the episode in which we were told when our birthday is, and such memories are therefore classified as semantic as opposed to episodic.

Episodic and semantic memory, then, are thought to be two separate states of awareness; episodic remembering requires an awareness of reliving the past events in the mind's eye and of mentally traveling back in one's own mind's eye to do so, whereas semantic knowing only involves an awareness of the acquired information without any need to travel mentally back in time to personally re-experience the past event (Gardiner & Richardson-Klavehn 2000). It is for this reason that Tulving (2002) has argued that one of the cardinal features of episodic memory is that it operates in "subjective time," and therefore it differs from semantic memory not only in being oriented to the past but also specifically in the past of the owner of that memory. So while some semantic knowledge, such as the birth date example described above, does involve a datable occurrence, these memories are fundamentally different from episodic memories as they do not require any mental time travel. As William James so aptly wrote, "Memory requires more than the mere dating of a fact in the past. It must be dated in *my* past" (James, 1890, p. 6509). To do so, Tulving (2002) argues, requires a specific form of self-consciousness, *chronesthesia*, which enables us to address our own, personally experienced past.

Language-based reports of episodic recall suggest that the retrieved experiences are not only explicitly located in the past but also that they are accompanied by the conscious experience of one's recollections (e.g., Wheeler, 2000), of feeling that one is the author of the memory, or of travelling back not in any mind's eye but in *my* mind's eye, what Tulving

(1985) called *autonoetic consciousness*. It is this feature of episodic recollection that William James referred to when describing what he called the “warmth and intimacy” of one’s personally experienced episodic memories (James, 1890), or in the words of Endel Tulving “...makes possible mental time-travel through subjective time—past, present and future. This mental time travel allows the ‘owner’ of the episodic memory (‘self’), through the medium of autonoetic awareness, to remember one’s own previous ‘thought about’ experiences...” (Tulving, 2005, p. 15).

From a biological perspective, however, a critical question is why the two separate memory systems would have evolved in the first place. It is easy to appreciate the selective advantage of semantic memory, for it allows the subject to acquire generic information about the world, which can be retrieved at a later date, and to update that generic repository of knowledge should the environment change. In doing so, for example, the subject can memorize where reliable resources are without having to search afresh each time and know how to find one’s way home afterwards. What is, at least at first sight, less clear is why an individual would need an episodic memory system in addition to the semantic one. What possible benefit does the owner of the memory accrue from being able to re-experience the event as opposed to just knowing what happened?

Wheeler (2000) suggested that these episodic recollections might be important for maintaining the integrity of the self, given that this form of memory is accompanied by the subjective self-conscious experiences of chronesthesia and autonoesis. However, while it certainly appears to be the case that amnesics such as KC and DB are unable to episodically recall the past even though their semantic knowledge is spared, they show no detectable impairment in self-awareness (Klein, 2002; Rosenbaum et al., 2005).

An alternative theory, and one that has gained increasing popularity of late, is that the function of episodic memory lies not with the benefits of remembering per se, but that its function is to support future planning, the ability to travel forwards in the mind’s eye to imagine future events and scenarios (Dudai & Carruthers, 2005; Schacter & Addis, 2007). By this argument episodic memory and episodic future planning are two sides of the same coin; one allows one to travel mentally back in time to re-experience the past and the other allows one to travel forward in time to pre-experience the future (Suddendorf & Corballis, 1997). According to the *prospective brain hypothesis* of Schacter, Addis, and Buckner (2007), the brain’s crucial function is to use past experience that has been acquired by the episodic memory system in order to ponder, plan, and predict future possibilities, and it is for this reason that our episodic memories are surprisingly inaccurate compared to our semantic ones, and certainly more fragile and more labile (see Schacter, Addis, & Buckner, 2008 for an excellent recent review).

Evidence to support this line of argument comes from two sources. The first is that there appears to be a specific core network of regions in the brain of healthy human adults that supports both episodic recollection and future planning (Addis, Wong, & Schacter, 2007; Buckner & Carroll, 2007; Schacter et al., 2007). The second is that neuropsychological cases studies of patients such as DB and KC, mentioned above, who show specific impairments in episodic but not semantic memory, have similar deficits in episodic but not semantic forethought (e.g., Klein et al., 2002; Rosenbaum et al., 2005).

If this hypothesis is correct, then the function of episodic memory lies primarily in its constructive rather than reconstructive ability: its purpose is to mentally simulate multiple future scenarios by flexibly recombining details from past events without having to physically engage in the actual behavior. Inevitably there is a trade-off between flexibility and stability, and therefore the cost is that the episodic memory system is much more vulnerable than the semantic knowledge system to memory errors such as misattribution and false recognition (Schacter & Addis, 2007).

From a biological perspective, the characterization of memory in terms of the phenomenological properties of consciousness presents major problems because positing a subjective state of awareness is difficult to integrate with evolutionary processes of natural and sexual selection, which operate on behavioral attributes such as reproductive success and survival rather than on mental states. Adopting an ethological approach to comparative cognition necessitates two requirements. The first is that the memory needs to be characterized in terms of objectively defined properties as opposed to purely phenomenological ones, such as the types of information encoded. Indeed, we shall argue that the ability to remember what happened, where, and how long ago is a critical behavioral criterion for episodic memory. The second requirement is the identification of an ethological context in which these memories would confer a selective advantage. Note that by doing so we turn this debate into an empirical evaluation in nonlinguistic animals and one embodied in synthetic creatures; and adopting this approach may clarify and challenge ideas that have been based solely on research with human subjects, without the need to be constrained by phenomenological assumptions based on human-centric ways of thinking.

So the question then becomes one of asking where in the natural world these two processes might intersect, in which species, and under what conditions. One classic candidate is the food-caching behavior of corvids, members of the crow family that include jays, magpies, and ravens as well as crows. These large-brained, long-lived, and highly social birds hide food caches for future consumption and rely on memory to recover their caches of hidden food at a later date, typically weeks if not months into the future. So clearly food-caching is a behavior that is oriented toward future needs. Indeed, the act of hiding food is without obvious immediate benefit and yields its return only when the bird comes to recover the caches it made. Given that these birds are dependent on finding a significant number of these caches for survival in the wild, it seems likely that the selection pressure for memory would have been particularly strong (Griffiths, Dickinson, & Clayton, 1999), particularly since they cache year round (Curry, Peterson, & Langen, 2002). These birds also cache reliably in the laboratory, providing both ethological validity and experimental control (Clayton, 1999). At issue, however, is whether these birds episodically remember the past and plan for the future or whether such behavior can be explained by simpler mechanisms, such as knowing rather than remembering where they hid their food caches. For these reasons, we shall now turn our attention to assessing the evidence as to whether these food-caching corvids can remember the past and plan for the future.

## 2. Episodic memory

As we stated earlier, language-based reports of episodic recall in humans suggest that the retrieved experiences are not only explicitly located in the past but also that they are accompanied by the conscious experience of one's recollections (e.g., Wheeler, 2000). From a comparative perspective, the problem with this definition, however, is that in the absence of agreed nonlinguistic markers of consciousness, it is not clear how one could ever test whether animals are capable of episodic recollection. For how would one assess whether an animal can experience an awareness of the passing of time and of re-experiencing one's own memories while retrieving information about a specific past event.

### 2.1. Behavioral criteria for episodic memory

This dilemma can be resolved to some degree, however, by using Tulving's original definition of episodic memory (Tulving, 1972), in which he identified episodic recall as the retrieval of information about "where" a unique event occurred, "what" happened during the episode, and "when" it took place. The advantage of using this definition is that the simultaneous retrieval and integration of information about these three features of a single, unique experience may be demonstrated behaviorally in animals. We termed this ability "episodic-like memory" (Clayton & Dickinson, 1998) rather than episodic memory because we have no way of knowing whether this form of remembering is accompanied by the auto-noetic and chronesthetic consciousness that accompanies human episodic recollections. Indeed, we have argued that the ability to remember the "what-where-and-when" of unique past episodes is the hallmark of episodic memory that can be tested in animals (Clayton, Griffiths, Emery, & Dickinson, 2001a; Clayton, Bussey, & Dickinson, 2003a; Sal-wiczek, Dickinson, & Clayton, 2008) as well as in preverbal children (see Clayton & Russell, in press for a recent review).

### 2.2. Empirical tests of episodic-like memory

We focus our analysis on one particular species of food-caching corvid, the western scrub-jay, capitalizing on one feature of their ecology, namely, the fact that these birds cache perishable foods, such as worms, as well as nondegradable nuts, and as they do not eat rotten items, recovering perishable food is only valuable as long as the food is still fresh. At issue here is whether the jays could remember the "what, where, and when" of specific caching events.

Although the birds had no cue predicting whether the worms had perished other than the passage of time that had elapsed between the time of caching and the time at which the birds could recover the caches they had hidden previously, the birds rapidly learned that highly preferred worms were fresh and still delicious when recovered 4 hr after caching, whereas after 124 hr, the worms had decayed and tasted unpleasant. Consequently, the birds avoided the worm caches and instead they recovered only the caches of nuts, which never perish. Following experience with caching and recovering worms and nuts after the short and long

intervals, probe tests, in which the food was removed prior to recovery, showed that they relied on memory to do so rather than cues emanating directly from the food (Clayton & Dickinson, 1998, 1999). Subsequent tests revealed that the jays could remember which perishable foods they have hidden where and how long ago, and irrespective of whether the foods decayed or ripened (Clayton, Yu, & Dickinson, 2001b; de Kort, Dickinson, & Clayton, 2005).

Since the initial studies, a number of other laboratories have also turned their attention to the question of whether animals have episodic-like memory. Using paradigms analogous to those employed with the jays, there is now good evidence that rats (Babb & Crystal, 2006a,b), mice (Dere, Huston, & De Souza Silva, 2005), and magpies (Zinkivskay, Nazir, & Smulders, *in press*) can remember the what-where-and-when of past events. Other groups have used different behavioral paradigms to assess animal episodic-like memory. For example, Norman and Eacott (2005) argued that an important feature of episodic memory is the retrieval of information about the context of the episode and have demonstrated that rats can remember in the context in which they encountered a particular object. Fortin, Wright, and Eichenbaum (2004) took a very different approach to the analysis of animal episodic-like memory. Rather than focusing on the content of the memory, they used a signal detection analysis of odor recognition to demonstrate that rats generate asymmetrical receiver-operator curves that are characteristic of the conjoint control of episodic recollection and simple recognition memory in humans (Yonelinas, 2001).

### 2.3. *Flexibility*

We have argued that this representation of the time since caching is essential for the efficient recovery of perishable food items, and that Western scrub-jays use a flexible, declarative memory system to do so (Clayton et al., 2001b; Clayton, Yu, & Dickinson, 2003b). Perhaps the most impressive demonstration of flexibility comes from a study in which the jays were allowed to cache perishable and nonperishable items but then discovered, in the interval between caching and recovery, that the perishable food type degraded more quickly than originally thought (Clayton et al., 2003b). We reasoned that, if the birds do use a flexible declarative memory system, they should be able to update their knowledge about the rate of perishability of the food and change their search behavior at recovery accordingly, even though the episodic information about what they cached where and when was encoded prior to the acquisition of the new knowledge about the decay rates.

The jays were able to do just that: If they cached perishable and nonperishable items in different locations in one tray and then subsequently discovered that the perishable items from another tray had degraded more quickly than they expected, then when given the original tray back the birds switched their search preference in favor of the nonperishable nuts. The birds continued to search for the perishable food if it had been cached recently, thus showing that they had not simply developed a general aversion to searching for food that might perish. To our knowledge, this is the only published demonstration of the declarative flexibility with which animals can update their information after the time of encoding (Clayton et al., 2003b).

### 3. Forethought

If forethought, at least in the form of episodic future thinking, falls under the general umbrella of mental time travel and is the reason for why episodic memory evolved in the first place as we suggested in the Introduction, then we should expect to find a concomitant development of episodic memory and episodic future thinking. So if one accepts the evidence that the scrub-jays can episodically recall the past, at least in terms of the behavioral criteria, then these birds should also be capable of planning for the future. The topic is of course a controversial one, and indeed there is much debate about whether nonhuman animals are capable of forethought (e.g., Suddendorf & Corballis, 2007; and responses by Clayton et al., 2008; Raby, Alexis, Dickinson, & Clayton, 2007a, b). For how does one test whether the jays' caching decisions are controlled by future planning?

#### 3.1. Behavioral criteria for future planning

The first distinction that one must draw is between prospectively oriented behavior and future planning. Several anticipatory activities, including migration, hibernation, nest building, and food-caching, are clearly conducted for a future benefit as opposed to a current one, but they would not constitute a case of future planning unless one could demonstrate the flexibility underlying cognitive control, and thereby rule out simpler accounts in terms of behavior triggered by seasonal cues or previous reinforcement of the anticipatory act.

So the first issue to address is whether the caching behavior of the jays is sensitive to its consequences. To do so, once again we capitalized on the fact that the jays love to eat and cache fresh worms but that they do not eat them once they have degraded. We used a variant of the Clayton & Dickinson, 1998 caching paradigm in which the jays were given fresh worms and nuts to cache and recover 2 days later. Rather than varying the interval between caching and recovery to investigate the birds' preference to search for worms when they should still be fresh and to switch to searching for nuts when the worms should have degraded, as we had done in the original experiments on episodic-like memory, in the current experiment, the worms were always degraded at recovery. The issue was to investigate their choice of what to cache, as opposed to where to search at recovery. The objective of this experiment was to assess whether the birds could learn that even though the worms were fresh at the time of caching there was no point in caching them because they would always be degraded and therefore unpalatable at the time of recovery. The jays rapidly learned to stop caching the worms, even though they continued to eat the fresh worms at the time of caching, and compensated by caching the less preferred nuts. This result demonstrates that caching is indeed selective to its consequences in the sense that the jays could learn what not to cache (Clayton et al., 2005).

Subsequent experiments demonstrated that the jays could also learn where and when not to cache (de Kort et al., 2005). For example, when the jays were given two opportunities to cache, one immediately after the other, but any caches made during the first caching opportunity were stolen by the experimenters, the jays rapidly learned to only cache during the

second caching event. Furthermore, they would remove a beak full of worms just before the end of the first caching event and stash in the throat pouch, so that they had additional worms to cache in the second caching event to those provided by the experimenters. De Kort et al. (2007) have argued that this behavior suggests not only a sensitivity to the consequences of caching but also to planning, as it suggests the jays are caching for a future motivational state, namely at the time of recovery, independent of the jay's current state at the time of caching.

### 3.2. *The Bischof-Köhler hypothesis*

Suddendorf and Corballis (1997) have also argued that a critical feature of future planning is that the subject can take action in the present for a future motivational need, independent of the current motivation. Indeed, they argued that mental time travel provided a profound challenge to the motivational system in requiring the subject to suppress thoughts about one's current motivational state in order to allow one to imagine future needs and to dissociate them from current desires.

To illustrate this distinction between current and future motivational states, consider the following example. A current desire for a croissant at breakfast may lead to an early morning trip to the local baker. Of course it will take some time to reach the market, and therefore the croissant will not be eaten now but in a few minutes time. But although the croissant will be eaten at a future time as opposed to the present, this behavior would not fulfill the Bischof-Köhler criterion because the action is governed by one's current motivational state. By contrast, going to the baker's shop in order to ensure that there are croissants for tomorrow's Sunday brunch would be an example of the future planning envisaged by the Bischof-Köhler hypothesis because this action would be performed for a future motivational need, independent of one's current needs.

This hypothesis was inspired by a comparative perspective, from reviewing the evidence for human and nonhuman primate cognition, and indeed it has led to a number of tests of whether animals can dissociate current from future motivational needs. In one study to address this issue, Naqshbandi and Roberts (2006) gave squirrel monkeys the opportunity to choose between eating 4 dates and eating just 1 date. Eating dates makes monkeys thirsty, but rather than asking the monkeys to choose between water and the dates, the experimenters manipulated the delay between the choice (1 vs. 4 dates) and receiving water such that the monkeys received water after a shorter delay if they had chosen the 1 date rather than the 4 dates. The monkeys gradually reversed their natural preference for 4 dates, suggesting that they were anticipating their future thirst. However, because the monkeys received repeated trials in which they learned the consequences of their choices, one can give a simple associative explanation in terms of reinforcement of the anticipatory act by avoidance of the induction of thirst.

More convincing evidence for a dissociation of current and future motivational states comes from a study by Correia, Dickinson, and Clayton (2007) on the food-caching scrub-jays. Like many other animals, when sated of one type of food, these birds prefer to eat and cache another type of food. Correia and colleagues capitalized on this specific satiety effect



to test whether the birds would choose to cache the food they want now or the food they think they will want when they come to recover their caches in the future. At the start of the experiment the birds cached the food they desired at the time, but then rapidly switched to storing preferentially the food that was valuable at the time of recovery rather than the one they wanted to eat at the time of caching, suggesting that the jays can plan future actions based on what they anticipate they will desire in the future as opposed to what they need now. So this study supports the notion that jays can dissociate future from current motivational needs, and therefore provides direct evidence to challenge the Bischof-Köhler hypothesis (for further discussion see Clayton et al., 2008).

For the skeptic, however, this kind of task need not require prospective mental time travel because the scrub-jay does not need to imagine a future situation. Suppose that the act of recovering a particular food recalls the episode of caching that food. If the bird is hungry for that particular food, then recovering it will be rewarding and therefore this could directly reinforce the act of caching the food through the memory of doing so. The point is that such memory-mediated reinforcement does not require the bird to envisage future motivational states.

### 3.3. *Tulving's spoon test*

Tulving has argued that it is possible to test whether animals are capable of such episodic future thinking, and he devised the “spoon test,” which he argues is a “future-based test of auto-noetic consciousness that does not rely on and need not be expressed through language” (Tulving, 2005, p. 43). The test is based on an Estonian children’s story, in which a young girl dreams about going to a birthday party. In the dream, all of her friends are eating a delicious chocolate mousse, which is her favorite pudding, but alas she cannot because she does not have a spoon with her, and no one is allowed to eat the pudding without a spoon. As soon as she gets home she finds a spoon in the kitchen, carries it up to her bedroom, and hides—or caches—it under her pillow, in preparation for future birthday parties, she and even dreams of future birthday parties for that matter.

The point, then, is to use past experience to take action now for an imagined future event. To pass the “spoon test” our subject must act analogously to the little girl carrying her own spoon to a new party, a spoon that has been obtained in another place and at another time. Is there any evidence that animals and young children can pass this “spoon test”? Although some animals, notably primates and corvids (namely the scrub-jays we discussed earlier), have been shown to take actions now based on their future consequences, most of these studies have not been shown to be selected with reference to future motivational states independent of current needs as discussed in Section 3.2. (Suddendorf, 2006), or without dissociating the place and time (Tulving, 2005).

Mulcahy and Call (2006) were the first to devise a “spoon test” for animals. In their study a variety of species of nonhuman apes were taught to use a tool to obtain a food reward that would otherwise have been out of reach, and then the apes were given the opportunity to select a tool from the experimental room, which they could carry into the sleeping room for use the following morning. Although most of the subjects did chose

the correct tool on some trials, the individual patterns of success for each subject were not consistent across subsequent trials, as one would expect if they had a true understanding of the task. Furthermore, the apes received a number of training trials, so reinforcement of the anticipatory act cannot be ruled out (Raby et al., 2007a; Shettleworth, 2007; Suddendorf, 2006). A more convincing case of planning was provided by Osvath and Osvath (2008). In a series of experiments, these authors demonstrated that when selecting a tool for use in the future, chimpanzees and orangutans can override immediate drives in favor of future needs.

One of the most convincing examples of the “spoon test” in animals comes from recent studies on the food-caching scrub-jays. In the laboratory, our jays have been shown to spontaneously plan for tomorrow’s breakfast without reference to their current motivational state (Raby et al., 2007a). The birds were given the opportunity to learn that they received either no food, or a particular type of food, for breakfast in one compartment, while receiving a different type of food for breakfast in an alternative compartment. Having been confined to each compartment at breakfast time for an equal number of times, the birds were unexpectedly given the opportunity to cache food in both compartments one evening, at a time when there was plenty of food for them to eat and therefore no reason for them to be hungry. Given that the birds did not know which compartment they would find themselves in at breakfast tomorrow, we predicted that if they could plan for the future then they should cache a particular food in the compartment in which they had not previously had it for breakfast.

This the birds did, suggesting that they could anticipate their future need for breakfast tomorrow, at a time when they would be hungry. Importantly, because the birds had not been given the opportunity to cache during training, we can in this experiment rule out an explanation in terms of mediated reinforcement of the anticipatory act. These findings led Shettleworth to argue that “two requirements for genuine future planning are that the behavior 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 fulfill both requirements” (Shettleworth, 2007, p. 825).

Although it seems clear that the scrub-jays and chimpanzees do pass the “spoon test,” at issue, however, is whether these tasks truly tap episodic future thinking. Indeed, we (Raby et al., 2007a; Raby, Alexis, Dickinson, & Clayton, 2007b) have argued that in the absence of language there is no way of knowing whether the jays’ ability to plan for future breakfasts reflects episodic future thinking, in which the jay projects itself into tomorrow morning’s situation, or semantic future thinking, in which the jays act prospectively but without personal mental time travel into the future. In the latter case, all the subject has to do is to work out what has to be done to ensure the implement is at hand, be it a spoon, some other tool, or a food-cache. In no sense does this task require the subject to imagine or project one’s self into possible future episodes or scenarios. As Raby et al. (2007a) have argued, however, what these studies do demonstrate is the capacity of animals to plan for a future motivational state that stretches over a timescale of at least tomorrow, thereby challenging the

assumption that this ability to anticipate and act for future needs evolved only in the hominid lineage.

#### **4. Concluding remarks**

In this review, we have argued that at least some animals, notably a few primates and corvids, are capable of recollecting the past and planning for the future. In the case of the scrub-jays the functional account of caching appears to be reflected in the psychological processes underlying this behavior; by fulfilling the behavioral criteria we have outlined they therefore show at least some elements of episodic memory and forethought.

At first sight this conclusion seems surprising and contrary to the view of many psychologists and cognitive neuroscientists who argue that these abilities are uniquely human. Indeed, in an influential paper, Suddendorf and Corballis (1997) developed an idea originally offered by Tulving (1983), namely that only humans can reminisce about the past and plan for the future. Indeed, in the formulation of their “mental time travel hypothesis,” Suddendorf and Corballis (1997) claimed that nonhuman animals cannot recall past experiences (episodic memory) or anticipate future states (future planning) because they cannot dissociate themselves from the more or less immediate present; in essence, they are “stuck in time” because they are incapable of temporal perspective taking (Roberts, 2002). The results presented here challenge this view.

So this comparative influence has inspired human researchers to reconsider two aspects of cognition that were for many years assumed to be uniquely human, namely the ability to recall the past and plan for the future. The question of whether animals can mentally travel in time remains controversial, but few would deny that this comparative program of work has generated a refinement in the conception of forethought and episodic memory, and an increased awareness of the sophistication of thought without language.

We would argue that maintaining an objective characterization of psychological functions is a prerequisite for integrating these behavioral conceptions into other disciplines, from comparative cognition to artificial intelligence. Furthermore establishing an empirical foundation permits a comparison between natural and artificial creatures whose minds are so different from ours. Without a behavioral conception of the psychological function of episodic memory and future planning there was no way of addressing variations in the different kinds of minds to assess the question of whether these differences are qualitative or quantitative.

Our behavioral conception of flexibly deployable information about “what, where, and when” has so far supported a comparative cognition in animals as diverse as corvids and primates, which in turn, raises questions about whether these abilities have evolved through homology (shared ancestry) or whether they evolved independently as a result of adaptation to similar socioecological selection pressures. Additional comparisons across a wide range of animals will need to be conducted to address this issue. Clearly, this comparative research paradigm would have been impossible if it had relied on a phenomenological characterization of psychology.

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