

Mental time travel in animals?

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Are humans alone in their ability to reminisce about the past and imagine the future? Recent evidence suggests that food-storing birds (scrub jays) have access to information about what they have stored where and when. This has raised the possibility of mental time travel (MTT) in animals and sparked similar research with other species. Here we caution that such data do not provide convincing evidence for MTT. Examination of characteristics of human MTT (e.g. non-verbal declaration, generativity, developmental prerequisites) points to other avenues as to how a case for animal MTT could be made. In light of the current lack of evidence, however, we maintain that MTT is a uniquely human characteristic.

Do animals reminisce about the good old days and ponder what the future might hold for them? Humans frequently engage in such mental time travel (MTT), reliving past events and entertaining possible future scenarios [1,2] (Box 1). It has been argued that MTT is unique to humans [1,3,4], and that its emergence was a prime mover in hominid evolution [1]. Recently, a series of innovative studies on food-storing scrub jays has raised doubt about this claim. In recovering stored food, these birds appear to act in ways that depend on *what* they stored *where* and *when* in the past [5–8], and on what they might expect to happen in the future [9]. This has sparked interest in similar capacities in other species [10,11]. Although we applaud these efforts, we argue here that current evidence does not yet warrant crediting other species with MTT. By examining other characteristics of MTT we point to different ways in which evidence could be obtained if the competence were to exist in animals.

Episodic memory and the scrub jay challenge

Travelling mentally into one's past requires memory. Animals clearly have memory. But some memory researchers argue that there are distinct memory systems, raising the possibility that one of them is uniquely human. Tulving proposed that remembering an episode – what happened to me where and when – is processed in a different memory system from other types of information [4,12,13]. Episodic memory is thought to be part of the larger explicit system (i.e. comprising the memories that we can declare) [13,14] rather than the implicit system. Semantic memory – memory for facts about the world, not personal experiences – is the other explicit component. Episodic memory can be dissociated from semantic

memory in that each can be selectively impaired and each is associated with distinct cortical activity patterns [15,16]. Tulving claims that only humans have episodic memory [4,13].

Although the term is widely used, there has been some confusion about what episodic memory means, partly because Tulving modified his definition from the type of information stored (what, where and when) to an emphasis on what he terms 'autonoetic' (self-knowing) consciousness [17]. He did this because it became clear that one can *know* (semantic memory) something about what happened where and when, without *remembering* that past episode [4]. Autonoetic consciousness is the subjective (recollective) experience associated with travelling back to a point in time and re-experiencing a past event [2,17]. This requires concepts of self (the traveller) and subjective time (the dimension along which to travel) [4]. So whereas the earlier definition describes episodic memory in terms of the information encoded, the later emphasizes a specific type of recall; that is, MTT into the past.

We know that animals, from bees to monkeys, can learn from single events. But do they revisit the events that shaped their past? Innovative work by Clayton, Dickinson and their colleagues has produced perhaps the strongest case yet for episodic memory in animals [5–8,18]. Their studies on the caching and retrieval behaviour of scrub jays (Fig. 1) have shown that these animals can form integrated memories of what was cached where and when. Scrub jays appropriately adjust recovery attempts of differentially perishable food caches depending on how long ago they stored the food items. The authors concluded

Box 1. Time in the human mind

More than half of adult conversation refers to past or future events [42]. Who did what to whom and what happened next? What will happen, where and when? Many human actions are based on remote future goals. Although there is a growing literature on differences in future time orientation [43,44], the basic capacity to entertain events removed in time seems universal. Past events can be reconsidered, evaluated (e.g. regretted) and extrapolated to assess their consequences. Many aspects of human volition make sense only in the light of MTT [1], including apparent biological paradoxes such as suicide (when the future outlook is particularly bleak), celibacy and hunger strikes. Humans construct personal and community histories and plans. Strategies (for individuals or even entire countries) can be coordinated, progress reviewed and adjustments made if necessary. Temporal concepts, timekeepers and calendars have been developed to aid our orientation and plans. In short, it is safe to say that MTT is a significant human attribute, important to our dominance of the planet.

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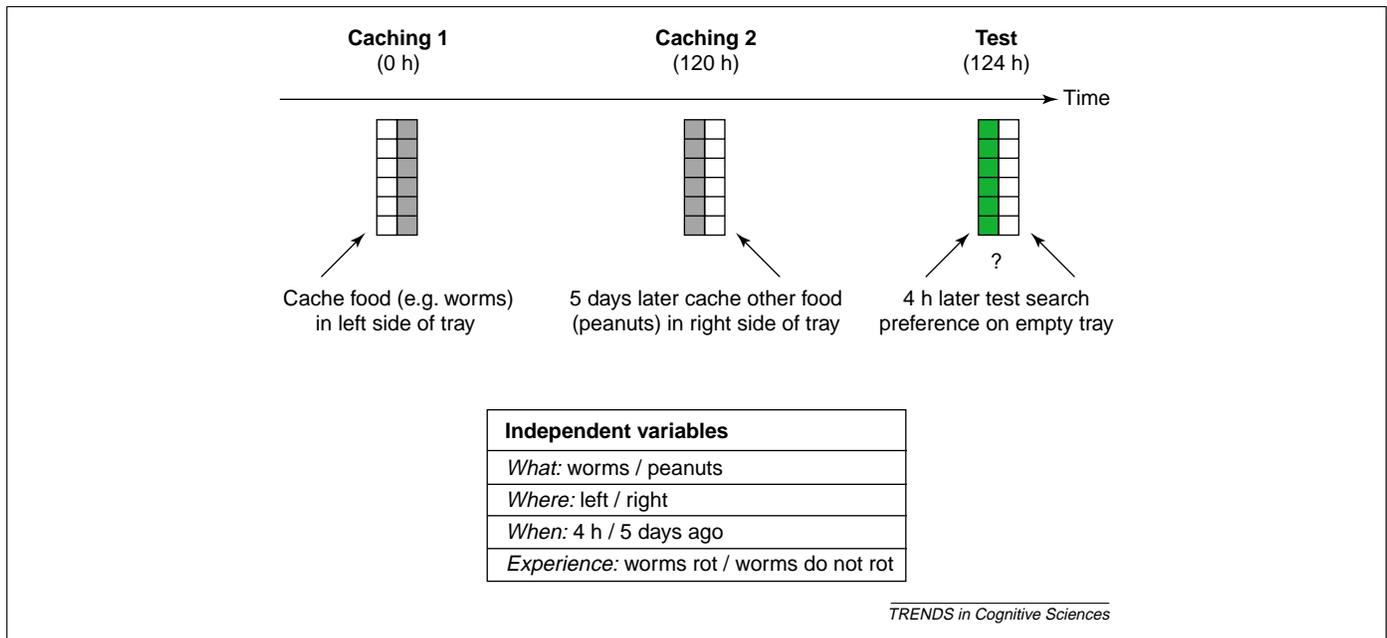


Fig. 1. Experimental design that showed memory for ‘what’, ‘where’ and ‘when’ in scrub jays [5]. Individually caged jays are given the opportunity to cache food, in sand, on one side of an ice-cube tray. In the example shown, on day 1 the birds cache worms in the left side of the tray (the other side is covered), and 5 days later they cache peanuts in the right side of the same tray (with left side covered). In the test phase, 4 hours after this, the birds are given the tray (with the food removed) and allowed to search. They show more searches on the left side than the right – revealing an apparent preference for the worms. Regardless of which food was cached first, jays generally prefer worms over nuts and search accordingly. But worms rot after a few days, whereas peanuts do not. When some of the jays were given an opportunity to learn that 124-hour-old worms are inedible, in the test phase they continued to prefer the worm side of the tray when the worms were cached second, but changed preference to the side where the peanuts were cached when the worms were cached first (and were therefore likely to be rotten). This suggests that the birds have access to information about *what* (peanuts/worms) was cached, *where* (left/right), and *when* (4 h/124 h). Various control conditions have been used to ascertain that this information is indeed what is responsible for the search behaviour at recovery [6].

that the birds show all the behavioural criteria of episodic memory [18]. But Clayton and colleagues cautiously refer to ‘episodic-like’ memory because the phenomenological experience defined by Tulving – auto-noetic consciousness – could not readily be shown to exist.

Is episodic-like memory anything like episodic memory? Clayton, Griffiths and Dickinson [18] offer the following choice:

Option 1: Insist that auto-noetic consciousness is crucial to episodic memory, which, they submit, probably makes it impossible to refute the claim of human uniqueness (because in the absence of language in animals there are no obvious behavioural manifestations).

Option 2: Characterize episodic memory in terms of the information encoded (i.e. Tulving’s earlier definition) and accept that scrub jays have it because they have been shown to encode the what, where and when information into an integrated memory.

At first sight these seem to be the only options and, as scientists, it would seem clear which option we should adopt. Hypotheses need to be falsifiable. But let us be clear what is and what is not implied if we take Option 2 and say that jays (and possibly other species) have episodic memory. It is implied that jays use what, where, when information; it is not implied that their memory retrieval is anything like remembering past episodes. In fact, the cognitive processes involved need not be *about* the past at all. As Dretske noted [19]: event A might cause cognitive change B that effects behaviour C at a later point in time, but this need not imply that B carries any information

about A itself – the mediator B might be causal rather than informational. Thus, although jays perform actions C (recovery) that make sense only in the light of A (caching what, where and when) it need not imply that B represents the past event A. B might instead be a separate system (some implicit feed-forward algorithm) that causes certain caching and recovery behaviour. In fact, even if one can show that an animal has explicit access to the information, this need not imply MTT. There is a double dissociation here [1]. One can know what happened where and when without being able to remember the event [4] (e.g. your birth) and, conversely, one can travel back in time without access to accurate when and where information. I (TS) can vividly re-experience meeting a fascinating character once in the Philippines (or was that Indonesia?) sometime in the early nineties (or was that the late eighties?). Jays might know what food is hidden where and whether it is still good to eat, without knowing how or why they know it. If we take Option 2, then, there should be no implication (although it remains a possibility) that jays recollect the past episode and reason about the present state from there. Perhaps *what–where–when* or ‘www-memory’ would be a more neutral, descriptive term than episodic memory.

Although it is interesting that jays can encode, store and use such information, we suspect that many people are fascinated by this line of work largely because it raises the possibility of human-like episodic recall (Tulving’s later definition) in animals. According to Option 1, however, this might be impossible to show, in which case the human uniqueness claim would merely be a presumption. We

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