



FORUM

New evidence for animal foresight?

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Mental time travel, the ability to project oneself forwards or backwards in time, has recently become a focus of work in comparative psychology (Suddendorf & Busby 2003; Clayton et al. 2003a), neuropsychology (Addis et al. 2007; Szpunar et al. 2007), cognitive psychology (Buckner & Carroll 2007; Hassabis & Maquire 2007; Suddendorf & Corballis 2007a), social psychology (Gilbert & Wilson 2007) and developmental psychology (Atance & O'Neill 2001; Suddendorf & Busby 2005). A controversial aspect of this work is the claim that mental time travel is uniquely human (Suddendorf & Corballis 1997; Suddendorf & Busby 2003; Tulving 2005). A particular suggestion as to what might limit non-human animals' mental time travel into the future is the so-called Bischof-Köhler hypothesis, which states that only humans can flexibly anticipate their own future mental states of need and act now to secure them (Bischof 1978; Bischof-Köhler 1985; Suddendorf & Corballis 1997). Correia et al. (2007) claimed to have refuted, for the first time, the Bischof-Köhler hypothesis in western scrub-jays, *Aphelocoma californica*. In an accompanying article, Roberts (2007), once sceptical of evidence for mental time travel in animals (Roberts 2002), concluded that these results, together with other recent findings (Babb & Crystal 2006; Mulcahy & Call 2006; Naqshbandi & Roberts 2006; Raby et al. 2007), show that some animals can travel mentally in time. Here we warn that each of these studies has attracted critiques identifying methodological and interpretational flaws, and that this new study fares no better.

Correia et al. (2007) fed scrub-jays with one type of food for 3 h and then allowed them to cache this and an alternative food. The birds were subsequently prefed with the

alternative food before being allowed to recover what they had cached. The data from the second and third of such trials led the authors to conclude that the jays made 'the appropriate caching decisions that maximize the satisfaction of their future motivational state over the current one' (Correia et al. 2007, page 859). Thus, the authors argued, these results challenge the Bischof-Köhler hypothesis. But did the data really show that the birds had stored more of the food that will become more desirable only in the future, as this interpretation suggests? No. Although the birds cached a greater proportion of this food (as shown in their Figure 3), the absolute number of items stored for this future situation did not change in any meaningful way. The birds in the crucial 'different' group cached a mean of 0.7 items of the prefed food on the first trial, and means of 1.2 items and 0.8 items on the second and third trials, respectively. Thus, they did not increasingly store the food that was more desirable in the future.

The apparently stark increase over the three trials evident in Figure 3 in Correia et al. (2007) actually reflects the decrease in caches made of the other food item, down to zero. The birds therefore only stopped caching items that turned out to be plentiful at recovery, rather than storing more items of food that would be desirable at recovery. These data are hardly sufficient to show that the birds acted to secure a future need, but suggest rather that they quickly learned not to cache items that turned out to be of little value. While this might (but need not) entail some time-delayed feedback system and one-trial learning (see discussion below), it is certainly not proof that the birds anticipated a future need, as Correia et al. (2007) argued.

Indeed, there are two further problems with the study that were pointed out to us by Sarah Shettleworth. First, to calculate these rather misleading proportions, Correia et al. (2007) dropped all data from birds that did not cache either food, leading to an even smaller, uneven sample

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size in the crucial second and third trials (three versus five and four versus three birds were compared, respectively). So even if there had been an increase in storage of the key food in the data (which there was not), it could have reflected this differential sampling, rather than meaningful changes in individuals' caching behaviour. Second, over the course of the study the animals in the 'same' group were prefed twice on a specific food, whereas the 'different' group were prefed equally on both foods. Thus, the study should probably have included extra feeding between trials to make up for this imbalance in recent feeding. In any case, it should be clear that these data do not amount to a demonstration that the Bischof-Köhler hypothesis is wrong.

This does not mean that such data cannot be obtained in principle. Behavioural criteria for mental time travel have been put forward (Clayton et al. 2003b; Suddendorf & Corballis 2007a) and nonverbal tests have been proposed (Suddendorf & Busby 2005). Given that specific satiety can be successfully manipulated, it may perhaps lend itself to demonstrating future need anticipation in nonhuman animals (if indeed they had it). But the bottom line is that Correia et al. (2007) have not demonstrated anything like it.

Similar caution is warranted for another high-profile claim about scrub-jays' future-oriented capacities (Raby et al. 2007). In this study, eight scrub-jays received breakfast in one cage and no breakfast in another cage, on alternating days. When later offered the opportunity to store food, they cached more in the no-breakfast place. However, the scrub-jays in that study stored food regardless of whether or not they had reason to expect that breakfast was due on the next day: because of counterbalancing, only half of them were due to receive breakfast. Although it remains possible that the birds cache food in anticipation of future appetite, they may simply have cached according to a general heuristic to balance food sources, and this explanation is also consistent with the results of the authors' second experiment (Premack 2007; Suddendorf & Corballis 2007b).

Roberts (2007) cited two further studies as substantiating mental time travel in nonhuman animals. Both are similarly inconclusive. Naqshbandi & Roberts (2006) manipulated drinking water available to their subjects and found that over repeated trials two squirrel monkeys, *Saimiri sciureus*, but not rats, *Rattus norvegicus*, gradually reversed their natural preference for four pieces of thirst-inducing dates over one piece, and argued that the monkeys anticipated their future thirst. However, the gradual learning suggests associative processes (Shettleworth 2007), and is not really behaviour one would expect from an organism that did anticipate the future event (Suddendorf & Corballis 2007b). If future thirst was foreseen, why not continue to select four pieces and adjust consumption? Finally, recent evidence for planning in orang-utans, *Pongo pygmaeus*, and bonobos, *Pan paniscus* (Mulcahy & Call 2006), also lacks the appropriate controls to rule out associative learning (Suddendorf 2006; Premack 2007).

We agree with Roberts that mental time travel into the future is closely related to episodic memory; indeed, episodic memory may be only a design feature of the

ability to conceive of future events, since the capacity to remember past events can only be selected insofar as it benefits current and future survival (Suddendorf & Corballis 1997; Suddendorf & Busby 2003, 2005). However, we are as cautious about evidence for episodic memory in nonhuman animals as we are for foresight. These studies have been criticized in detail elsewhere (Suddendorf & Busby 2003; Suddendorf & Corballis 2007a).

We echo Premack's (2007) recent warning that demonstrations of similarities between animal and human abilities should immediately trigger the question of how the abilities are dissimilar, to prevent us from mistaking similarity for equivalence. The well-documented temporal capacities of scrub-jays, for example, appear all restricted to food caching, whereas human mental time travel is characterized by its domain-general flexibility (Suddendorf & Corballis 2007a). Even within the food-caching domain, scrub-jays seem profoundly limited in their flexibility and foresight. Consider that, in the laboratory setting, there is in fact no point in caching food, given that humans feed the birds in any case and control all caching trays. By the same token, there is little point in engaging in pilfering avoidance strategies, such as caching worms out of sight of another bird in a separate cage (Dally et al. 2006), when it is always humans that remove and replace the caches. The scrub-jays' caches are in fact never pilfered by another bird, making the apparently future-directed 'avoidance strategies' nonsensical. There appear to be profound limits to their future-oriented capacities.

What ability in linking their caching and retrieval they have demonstrated may be more akin to Garcia-type learning than to human mental time travel. Although associative learning typically only relates events that occur within seconds of each other, it is certainly possible that caching specialists such as scrub-jays might have evolved means of linking aspects of the crucial variables of caching behaviour and retrieval results, just like rats, which tend to explore novel food sources keenly and can learn the association between taste and nausea even if the events are hours apart (Garcia et al. 1966; Etscorn & Stephens 1973). This learning in rats is very specific to the ecologically meaningful relation between illness and taste and does not generalize to linking illness to auditory or visual stimuli (Garcia & Koelling 1966). It remains to be seen whether scrub-jays' capacities are similarly limited to caching and retrieval, or can be applied to other contexts (Suddendorf & Busby 2003; Shettleworth 2007).

There is now a rapidly increasing literature on the question of mental time travel in animals (for recent reviews see Dere et al. 2006; Zentall 2006; Suddendorf & Corballis 2007a). Numerous thorny issues are associated with the concept, the cognitive components involved and how one might investigate it empirically in nonverbal animals (see Suddendorf & Corballis 2007a, as well as commentaries and replies). These issues go beyond the scope of the present paper. What we wanted to demonstrate here was that, contrary to recent assertions (Correia et al. 2007; Roberts 2007), new data have not provided sufficient grounds to reverse existing scepticism about the existence of mental time travel in nonhuman animals.

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