ARTICLE

Imagining the future – a bird's eye view

James M. Thom, Nicola S. Clayton, and **Jon S. Simons** on episodic future thinking

The future is where we will live the rest of our lives, so we devote a lot of the present to planning for it. Psychological research has provided insights into such 'episodic future thinking', which can take several forms: maintaining delayed intentions to perform specific actions in the future, imagining future events as a way to help plan for possible eventualities, and thinking about the future to enable us to make better long-term decisions. Understanding of how future thinking works must be complemented by the question of function: What is future-thinking for? We argue that comparisons of future thinking across species are a vital analytical tool. Animal models such as the Western scrub-jay highlight the evolutionary forces driving intelligence, and challenge our assumptions about the uniqueness of human future-thinking, and how good we are at it.

questions

What is episodic future thinking for?

Why has it evolved in the way that it has, and what benefits does it provide in everyday life?

resources

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Plan for the future because that's where you are going to spend the rest of your life.

Mark Twain

From life's big decisions to the more mundane, we are constantly imagining what will happen in the future. For example, when we plan a holiday, we may search a travel agent's website for hotels, looking at the pictures, and imagining ourselves lounging by the pool. Later on however, we will have to consider the practicalities: What should we pack? What will we need? This process of trying to paint a picture of the future is called episodic future thinking (Atance & O'Neill, 2001).

Evidence suggests that this kind of future thought shares a number of processes with episodic memory, the recollection of specific events in one's past. Episodic memory is associated with a vivid re-living of a particular moment, and is distinct from general knowledge about the world. Both episodic memory and episodic future thought appear to be critically dependent upon brain regions such as the frontal lobes and hippocampus (Schacter et al., 2008; Simons & Spiers, 2003). People with specific damage to the hippocampus can be densely amnesic for their own past, while retaining their general knowledge (Vargha-Khadem et al., 1997). This condition, amnesia, has been associated with difficulties in planning for the future, and patients report a feeling of blankness when asked to envision the future (e.g. Atance & O'Neill, 2001; Rosenbaum et al., 2005). Similarly, patients with frontal lobe lesions have frequently been documented to experience deficits in planning and in remembering to carry out intended actions (Burgess et al., 2000, 2005).

The hippocampus appears to facilitate episodic future thinking by providing a spatial framework for an imagined future event. This process is called scene construction (Hassabis & Maguire, 2007), and can be thought of as the first stage of assembling a jigsaw puzzle: finding the corner pieces, and those of the main details, and positioning them relative to each other. The rest of the puzzle can then be assembled with reference to this framework. Unsurprisingly, scene construction is greatly impaired in hippocampal amnesia (Hassabis et al., 2007).

Unlike a jigsaw puzzle, however, we can imagine any number of different versions of a scene. This is obviously important; it would be hard to choose the hotel for our holiday if they all looked the same in our mind's eye. We can perform this feat of imagination because we have an enormous store of different puzzle pieces to call upon, which we can swap and move around at will. Schacter and Addis (2007a, 2007b) argue that this store is an accumulation of life's memories, broken down into individual details. In other words, episodic memories form the stuff of imagination. They are stored in parts that can be distributed around a spatial framework to envision new possible future episodes. Indeed, people are able to generate a far more detailed imagined scene of a situation that they have some familiarity with (and which they can base on many possible memory elements) than they are an unfamiliar one (Szpunar & McDermott, 2008).

Once the basis of an imagined event is established during scene construction, this starting point undergoes a process called 'scene elaboration' (Addis et al., 2007). Scene elaboration is more than just the insertion of the rest of the pieces into a jigsaw puzzle, engaging a variety of brain regions associated with episodic memory.

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Processes governing 'self relevance' in this phase allow us to 'experience' the event in the shoes of our future self. It is this vivid sense of experience, dependent upon projections between the hippocampus and the frontal lobes (Addis et al., 2007), that allows us to give proper weight to the future when we make our plans.

Animals – stuck in the present?

Foresight and planning are essential to function properly in societies as complex as human civilisations, and we tend to associate forward-mindedness with intelligence. It is therefore unsurprising that future thought has traditionally been regarded as a uniquely human trait (Suddendorf & Corballis, 1997). The assumption is that animals are stuck in the present, unable to remember their past, and blind to what the future may hold. Research in the last 15 years has done much to challenge assumptions of human uniqueness. The most convincing case of non-human planning comes from a member of the crow family, or corvids, the Western scrub-jay.

Scrub-jays may at first glance seem a surprising candidate for future thought, when compared with our closest relatives, the great apes. However, corvids, like the great apes, have large brains relative to their bodies, and engage in a variety of behaviours that suggest intelligence, including causal reasoning, deception, and tool-use. Indeed, it has been argued that corvid and ape intelligence evolved in response to the need to solve similar sociological and ecological problems (Emery & Clayton, 2004). Perhaps most suggestive of future thinking in scrub-jays is the argument that their memory might resemble our own episodic memory, which, as argued above, is essential for episodic future thinking.

Western scrub-jay

Knowing that it is impossible to assess meaningfully the experience of an animal that can't talk, Clayton and Dickinson (1998) developed a behavioural test based on the original definitions of episodic memory as involving recollection of the content and temporal-spatial relations between events (Tulving, 1972). The scrub-jays showed that they were able to remember what type of food they had stored, where they had stored it, and when they had stored it. This 'episodic-like memory' has since been shown in other corvids (Zinkivskay et al., 2009), as well as rats (Babb & Crystal, 2006) and chimpanzees (Martin-Ordas et al., 2010).

In order to show that an animal is thinking about the future, it is not enough to simply perform an action with future consequences, the animal must do so with the future in mind. For example, many mammals hibernate to survive the winter, but they are unlikely to do so out of fear of the cold and hunger, particularly as they have never been awake during winter. Instead, they are simply genetically programmed to become sleepy in response to the environmental cues that ordinarily predict winter. Importantly, if these cues are disturbed, so is the animal's hibernation. Basic rules such as this are far less flexible than the sort of complex cognition seen in corvids and apes.

Scrub-jays appear to take into account what they will want to eat later when they store food. Like humans, the birds don't always want the same sort of food. After eating lots of savoury food we will often prefer to eat something sweet for dessert. Correia and colleagues (2007) utilised this phenomenon to make sure that the birds wanted one type of food (e.g. pine nuts) in the morning, when they were storing food, but wanted something different (e.g. dog biscuits) in the afternoon, when they recovered their stores. Normally, scrub-jays store whatever they want to eat most at that moment (Clayton & Dickinson, 1999); on the first morning of testing the birds did just that, but on the second morning they preferred to store what they would want in the afternoon, even though they did not want any at the time. This reversal after only one learning experience suggests that the scrub-jays were able to anticipate what they would want in the afternoon, and ignore their current desires. Similar anticipation has since been shown in Eurasian jays, another food-storing corvid (Cheke & Clayton, 2012). By contrast, there is no evidence of planning in mammals such as squirrels, which may be driven to store by simple inflexible drives.

Evolution of intelligence

An obvious question arises: Why does food-storing appear to rely on flexible cognition in scrub-jays, but not in squirrels? More generally, why are corvids clever? Tinbergen (1963) argued that a complete understanding of any behaviour must incorporate knowledge of the evolutionary path that led to it.

Consider the big-brained corvids. Large brains take a lot of energy to support, which means corvids need to eat a lot, making them more vulnerable to starvation. Natural selection would not favour expensive intelligence unless it bestows benefits that outweigh the costs. For example, New Caledonian crows are capable of making and using tools (Hunt, 1996). This undoubtedly intelligent behaviour allows them to access insect larvae hidden inside logs, which would otherwise be out of reach to them.

The complementary relationship between mechanism and function applies

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to all aspects of human psychology too, such as episodic future thinking. In other words, it is insufficient to ask only *how* episodic future thinking works, we must ask *why* it works at all.

Thinking ahead allowed Correia and colleagues' scrub-jays to make better decisions when storing food, so that they could eat what they wanted later. An obvious parallel in our own lives would be compiling a shopping list before a trip to the supermarket. However, unlike the scrub-jays, people are actually rather bad at ignoring what they want right now when making decisions for the future. When we go shopping while hungry, we tend to overspend on high calorie foods like biscuits and crisps (Nisbett & Kanouse, 1969). This lack of good planning suggests that our ancestors did not evolve the capacity for episodic future thought to make better decisions about food.

'We are our choices' – Sartre

Boyer (2008) argues that episodic future thinking does help us to make better decisions, but mainly within a social context. Without our episodic future thought, he argues, we would be indifferent to the long-term consequences of antisocial behaviour, such as stealing. Ordinarily, people give less weight to things that will happen in the future. For example, when offered a choice between $50 immediately and $100 in six months, many people would opt for the smaller sum. Boyer's assertion is that imagining future rewards and punishments makes us more likely to take them into account when we choose.

If good decision making is dependent on episodic future thinking, we should expect patients who are unable to imagine future rewards to make atypical choices. However, episodic amnesic KC, who has difficulty imagining future events (Kwan et al., 2010), makes similar monetary choices to healthy control subjects (Kwan et al., 2011). Perhaps this is because such decisions are devoid of the social context that Boyer focuses on.

Peters and Büchel (2010) found that thinking about a future social event, such as a friend's wedding, reduced people's preference for immediate rewards. A study by Benoit and colleagues (2011) asked subjects to think about a particular event in the future, before making a choice involving money. Again, the events were mostly social, such as a trip to the pub or a picnic. The choice was between £25 available immediately, and a larger sum the subject had to wait for. In one condition, subjects were asked to imagine the scene in great detail, which should tap episodic future thinking. In another condition, subjects were asked to list the items they could buy for a given sum of money in that scene, a different, non-episodic way of thinking about the future rewards, and an evaluation that amnesic patient KC could have made. Healthy subjects were most likely to choose to wait for the larger amount of money after imagining an event using episodic future thought. In other words, episodic future thinking improved long-term decision making.

> "Scrub-jays employ a variety of strategies to protect their food stores from potential thieves"

Benoit and colleagues' focus on the sort of social events that we encounter in real life and that, Boyer argues, to be important for the evolution of our intelligence has shed some light on how episodic future thought influences our decision making. Benoit and colleagues' participants reported that episodically imagined scenes were far more emotive than simply listing desirable items. Further, those individuals who experienced particularly vivid or emotionally salient imagined scenes showed the biggest differences in decision-making between the two conditions. fMRI data indicated that these effects were underpinned by activity in part of the anterior prefrontal cortex, which lies right at the front of the brain, just behind the forehead. The authors argued that this region received input from emotionally salient details generated during scene elaboration, and represented the full value of the scene being pre-experienced by the subjects. Supporting this interpretation, there was extensive functional coupling between anterior prefrontal cortex and the hippocampal areas associated with scene construction.

The involvement of an anterior prefrontal region is interesting from an evolutionary perspective because that area of the brain is thought to be disproportionately expanded in humans, even taking into account our large overall brain volume. Despite this, humans appear no more willing to wait for rewards than chimpanzees when tested under similar circumstances (Rosati et al., 2007). This cross-species comparison poses a challenge to a basic, single-process account of this sort of decision making. Clearly, people can wait for more than two minutes for rewards, they just didn't in Rosati and colleagues' study. The problem is therefore unlikely to be a failure of episodic future thinking, but one of patience and motivation. For example, if a dieter breaks their diet when tempted with their favourite food, this doesn't mean they can no longer imagine fitting into their favourite jeans at the end of their diet, or that they don't want to. Rather, they have difficulty controlling their current desire to consume tasty food. Such 'executive control' will often play a crucial role, not only in real-life situations like dieting but also in experimental tasks.

Remembering to remember

One of the most widely studied examples of a multi-system task involving episodic future thinking is prospective memory: the ability to remember to perform an intended action after a delay. This ability is considered to require at least two distinct cognitive components: cue identification, involving detection of the cue event (e.g. driving past the supermarket) which signals that the

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intended action should be performed; and intention retrieval, the subsequent recovery of the stored intention (e.g. remembering to stop to buy bread) from memory (Einstein et al., 1992). Another distinction that has been proposed is between such 'event-based' prospective memory situations and so-called 'time-based' tasks, in which the future action is not triggered by occurrence of an external event, but must be performed at a specific time (e.g. remembering to take medication at a particular time of day).

Based on this theoretical perspective, episodic future thinking is necessary, but not sufficient, for prospective memory. Also needed is the ability to use executive control processes to coordinate attention (either consciously or automatically) between current and intended actions so that the cue event or time can be detected when it occurs. Much research has identified difficulties with prospective memory in healthy ageing, particularly when participants are required to switch attention between similar or overlapping current and intended tasks (Maylor, 1996). The ageing process is often associated with neural degeneration in brain areas that include the frontal lobes, regions linked with executive functions such as attention, planning and multitasking. Consistent with this, evidence has been found for the involvement of frontal lobe regions in the various components of prospective memory (Okuda et al., 2011; Simons et al., 2006), in particular similar areas of anterior prefrontal cortex to those identified by Benoit et al. (2011).

At a glance, food-storing corvids like scrub-jays seem good candidates for prospective memory in a non-human animal. First, they appear able to anticipate the future, and to do so without being unduly influenced by what they want in the present, suggesting good executive control. Second, scrub-jays employ a variety of strategies to protect their food stores from potential thieves. For example, after another scrub-jay has seen where an individual has hidden their food, that individual will often remove their stores and hide them somewhere else when the observer is no longer looking (Emery & Clayton, 2001). In this instance, the storer may need to remember to come back later and move the stores.

An example of corvid prospective memory would beg two interesting questions: What sort of brain structure is required to support prospective memory? And is the anterior prefrontal cortex special in this regard? Birds do not have the six-layered prefrontal cortex that mammals do, but they do have an equivalent region. As is true for the human prefrontal cortex, the avian equivalent – the nidopallium – is unusually large in corvids, even taking into account their large overall brain volume. Although appearing to serve some of the same functions, the 'avian prefrontal cortex' is nuclear, meaning that it is structured in a clustered pattern, unlike the familiar pattern of folded layers that makes up our own six-layered cortex. Second, what evolutionary forces drove the evolution of prospective memory? Is it restricted to use in food-storing, or could it be tapped for other tasks, such as tool manufacture? Ape and corvid evolution seem to have produced similar arrays of intellectual abilities to solve complex problems (Emery & Clayton, 2004), but an artificial world throws up many challenges that would have held no relevance in our evolutionary past. The degree to which corvid prospective memory processing can adapt to alien challenges may indicate how flexible our own planning behaviour is.

Implications

We believe the contribution of cross-species studies should be seen as complementary to behavioural or neuroimaging studies, and case studies of brain-damaged patients. An evolutionary understanding of what our intelligence is for, informed by comparisons with other species, can help to answer the question psychologists are most interested in: How does the human mind work?

This endeavour does also, however, have a broader relevance. Our minds have evolved to work in the environment of our evolutionary past, not modern life. This may lead to behaviour that our contemporary social and legal standards would consider unhealthy or undesirable. An obvious example discussed above is dieting. Obesity is a burgeoning health crisis in many countries. The reasons for this change are many and varied, but one issue is particularly important: the structure of our minds and bodies did not evolve in an environment with effectively limitless access to high-calorie foods and in which little physical exertion was the norm. Tailoring weight-loss programmes to focus on what our imagination is good at engaging with, like social consequences, could better motivate a healthy lifestyle. Good examples are exercising as a group to discourage missed sessions, or group weigh-ins that provide social feedback to a healthier lifestyle.

In conclusion, the concurrent study of episodic future thinking and decision making in multiple species promises a greater understanding of a plethora of socially important real-world phenomena; from unhealthy habits such as over-eating and binge drinking, to the accumulation of personal debt.

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