Advanced Review

Episodic memory versus episodic foresight: similarities and differences

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There are logical and empirical grounds that link episodic memory and the ability to imagine future events. In some sense, both episodic memory and episodic foresight may be regarded as two sides of the same capacity to travel mentally in time. After reviewing some of the recent evidence for commonalities, I discuss limits of these parallels. There are fundamental differences between thinking about past and future events that need to be kept in clear view if we are to make progress in understanding the nature of mental time travel. The reviewed evidence suggests that mental time travel is based on a complex system selected not for accuracy about past and future *per se*, but for fitness benefits. Functional analyses promise to lead to fruitful avenues for future research. © 2009 John Wiley & Sons, Ltd. *WIREs Cogn Sci* 2010 1 99–107

'It's a poor sort of memory that only works backwards', the Queen remarked. (Lewis Carroll, 1871, *Through the Looking Glass*)

Does memory work forwards as well as backward? In some sense perhaps it does. Adult humans can not only mentally travel back to experiences of the past but can also cast their minds forwards, as it were, to imagine potential future scenarios. For example, you may remember the last talk you gave and you may also imagine the next presentation you are scheduled to give.[1] Episodic memory and what I suggest we call *episodic foresight*[a] may in fact depend on similar neurocognitive resources.[2–6] Furthermore, an evolutionary perspective suggests that natural selection cannot work on accuracy of past recollections *per se*, but only on what episodic memory does for present and future survival and reproduction. And one thing episodic memory can do is to inform about what is likely to happen in future. Thus, it has been argued that our ability to recollect past events is primarily a design feature of the foresight system.[3,4] Memory that only works backwards may be poor indeed.

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Tulving[7] was the first to note that an amnesic patient, who had no recollection of any event that had ever happened to him, was similarly unable to answer questions about events that he may experience in the future. Suddendorf and Corballis[3] subsequently developed the idea that mental time travel into both past and future are closely linked and proposed that the evolution of this faculty was a key milestone in human evolution. After many decades of preoccupation with memory research, psychologists and neuroscientists are increasingly recognizing the importance of foresight and its relation to memory.[2,4–6,8–10] The last 3 years in particular have seen a surge of new evidence linking memory and imagination of the future. In fact, this topic was singled out as one of the scientific breakthroughs of 2007 (*Science*, December 21, pp. 1848–1849). Commonalities have been uncovered in brain imagining studies, in studies of cognitive impairments, phenomenology, and development (see below).

There are also innovative studies on nonhuman animals that have described connections between memory and future-directed decisions.[11–13] However, these studies deal with the immediate future (e.g., turning one way or the other) and do not measure episodic memory or episodic foresight. In fact, it is unclear whether nonhuman species have a capacity comparable to the human faculty (for reviews, see Refs 1,4,14–17). It remains possible and plausible

that the evolution of mental time travel was a prime mover in human evolution.[18] Both travels into past and future occupy significant parts of human mental life and are critical to many human endeavors ranging from business to law and from religion to agriculture.

Here, I will review evidence for these links between episodic memory and episodic foresight and then highlight some key differences. Such differences need not undermine the power of the recent evidence for links, but are important to qualify the parallels. A functional look at mental time travel predicts both similarities and differences, and points to promising new experimental avenues.

SIMILARITIES BETWEEN EPISODIC MEMORY AND EPISODIC FORESIGHT

Tulving's original descriptions of parallel impairment, in episodic memory and in imagining future events, has been confirmed in subsequent studies on profound amnesia.[7,19–21] For example, when amnesic patients with bilateral hippocampal damage were asked to generate new experiences from cue words, their scores for the detail and coherence of the imagined scenarios fell well below those of a control group.[19] A case study of an amnesic patient who persistently confabulated about the personal past reports similar confabulations about the personal future, but not in other contexts.[22] Abnormalities of mental time travel may be associated with various other psychopathologies.[23] Clinical conditions in which mental time travel in both temporal directions appears to be disturbed include depression[24] and schizophrenia.[25] Even in clinically normal people, a parallel decline of mental time travel detail into past and future is associated with advanced age.[26]

Brain imaging data suggest that there is a strong overlap between activation associated with remembering past events and imagining future events. Okuda et al.'s [27] pioneering positron emission tomography (PET) study found largely equivalent activity in the frontal poles and medial temporal lobes when participants remembered past or imagined future episodes. Thinking about more temporally distant events in either direction is associated with increased activity,[27,28] perhaps because such representation requires more construction efforts. Functional magnetic resonance imaging (fMRI) studies have made further progress at identifying the network involved in constructing both past and future events and point to regions of the medial prefrontal cortex, and lateral and medial parts of the parietal cortex and temporal lobes.[29,30]

Introspective data suggest further similarities. Detail, perspective, coherence, and other phenomenological characteristics appear to have similarities when people travel mentally into past or future. Consider the opening example of imagining the next talk you will give and remembering the last one you did give as an introspective exercise. Studies on the reported phenomenological richness of remembered and imagined events have documented such parallels.[31,32] For example, more distant events tend to be more abstract and decontextualized than events closer in time.[31,33] Furthermore, in a study on the temporal spread of events, participants' reports yielded parallels between past and future distributions.[34]

Finally, while much of children's understanding of time develops relatively late, [35] early milestones in both episodic memory and episodic foresight appear between ages 4 and 5 (for reviews, see Refs 36–38). Busby and Suddendorf[39] adapted the simple questionnaire methodology used with amnesic patients[7,20] to ask young children to report something they did yesterday and something they were going to do tomorrow. The ability to provide a likely correct answer for one coemerged with the ability to do so for the other question.

These observed links between episodic memory and episodic foresight were predicted by early analyses,[3,40] and have recently informed a range of new or revised theories about what might cause them. There are basically two, not mutually exclusive, ways that have been suggested to account for these links. One is to argue that both draw on the same neurocognitive resources. Different proposals have emphasized different shared underlying capacities, ranging from a specific kind of consciousness (autonoetic consciousness) to shared processes required for episodic simulations.[4–6,41,42] What is shared here may not be exclusive to episodic memory and episodic foresight either. It has been proposed that these processes are also involved in theory of mind,[3] and, more recently, in certain forms of navigation,[6] in fiction,[42] and in other cognitive processes that transcend the here and now.[43]

The second way to account for these observed links is to argue that episodic memory is an integral part of the foresight and planning system. Episodic memory may provide the raw material to construct potential future events.[1,3,4,44,45] In a direct way, memory for past episodes can be projected into the future. The reaction my dog had yesterday to my attempt to steal his bone may provide a fair prediction for what will happen tomorrow should I attempt to do the same thing. But humans do not merely predict that what happened in the past will reoccur.

I can imagine events that have never happened to me and evaluate them.[10,46] For example, I might imagine what would happen if I were to distract the dog first and then go for the bone. Humans can entertain reasonable predictions about a virtually infinite number of different future scenarios. For example, you can probably judge if you would enjoy a banana milkshake with horseradish without having had the experience of this combination. Episodic memory (together with other memory systems) may hence provide the vocabulary for episodic foresight. Humans can recursively combine and recombine basic elements into novel scenarios and evaluate these in terms of their likelihood, desirability and so forth.

However, in spite of these reasons to expect links, there are also important differences between episodic memory and episodic foresight that we should not overlook in the excitement about new evidence for parallels. To those we shall turn next.

DIFFERENCES BETWEEN EPISODIC MEMORY AND EPISODIC FORESIGHT

There is of course a most profound causal asymmetry between future and past events. We cannot change the past and we do not have clairvoyant capacities for the future. Time's arrow relentlessly moves in one direction only. The future is more important, but cannot be known with certainty; the past may be knowable, but cannot be changed. These fundamental differences must be taken into account by any efficient neurocognitive system representing temporally displaced events. People are typically not confused about whether they are mentally entertaining a past event or a potential future scenario (or fiction), but it remains unclear how exactly these are distinguished. One phenomenological difference that might be used is that future event representations contain less detail than representations of remembered events.[31] Whatever the mechanism, the distinctions should also be evident in the underlying neuronal processes.

Differences in Brain Imaging Data

Okuda et al.[27] found that areas in the anteromedial frontal pole and medial temporal lobe showed greater activation when subjects imagined future events than when they were asked to remember past events. More recent fMRI studies also found more activation for future tasks in the anterior hippocampus[28] and in regions (e.g., left lateral premotor cortex, left precuneus, and right posterior cerebellum) associated with imagined body movement.[30] Yet, some imaging studies have found greater activity for recalling past events rather than imagining future events.[47–49] However, in these latter studies the future events were not being generated during the scan, but *recalled* during the scan. The participants were asked to imagine future events before going into the scanner. Thus, what is measured here is the memory of episodic foresight.[50,51] Given that memories of imagined events involve typically less details than memories of real experiences,[31] they may thus recruit fewer resources during retrieval.

Differences in Development

Children appear to discriminate between the times of past events before they can do so for future events.[35] A recent study compared past and future versions of such tasks directly.[52] When asked to place past events on a spatial time line, 3-year-old children placed daily events (e.g., brushing teeth) and annual events (e.g., last birthday) closer to the present than events several years ago. But they failed to discriminate between daily and annual events as well as between the times of future events. Four-year-olds performed like 3-year-olds on the past version, but also demonstrated the first evidence of discriminating future events. They placed daily events (e.g., next dinner) closer to the present than annual events (e.g., next Christmas) and events several years into the future (e.g., getting married). However, they did not place annual events and those several years into the future differently. Children's failures may of course be due to any number of reasons such as difficulties with the spatial metaphor and different knowledge about the events in questions. But above-chance performance does show some competence. By age 5, children demonstrated some capacity for discrimination between all three past and future categories.

A recent study on children's ability to make inferences from temporal order information found that 4-year-olds succeeded at simple versions of the past but not the future task.[53] Children had to determine where an object was left or where an object should be so that a protagonist could achieve a certain goal. Again, by age 5 there was evidence that children could solve both the search and the planning task. Finally, studies on parent–child communication and their relation to children's reporting of past and future events have also produced some evidence to suggest that developments relating to memory precede those relating to foresight.[37,54,55] Parents talking about past events with their children may also serve socioemotional functions (such as bonding) in ways that mutual talk about the future may not.

Even the approach that has documented that children who can report what they did do yesterday also were able to say something they are going to do tomorrow[39] points to some important differences. I recently replicated the main finding and probed children not only for one but for more answers.[56] The results showed a strong association between the quantity of responses for past and future questions. Similar questions that did not have a temporal, episodic component (e.g., 'tell me all the things that you can think of that are round') were included to examine the potential role of verbal fluency, generative abilities, or motivation. The correlation between reported episodic memory and episodic foresight continued to be significant even when controlling for children's capacity to answer nontemporal questions. However, the results also demonstrated a difference. The verbal generativity measure was only associated with reporting future events, not with reporting past events. This suggests that future simulations may require a different measure of creative construction than reconstruction of a past event that has in fact happened in one particular way. Thus, although both past and future mental time travel may draw on a shared capacity for active construction,[4,29] there may be systematic differences because the future is less constrained in possibilities than the past. This difference may also lead to differences in the errors and biases that are typical of episodic memory and episodic foresight, to which we turn next.

Differences in Errors and Biases

A long research tradition has established that episodic memory is not a neutral, accurate account of past events, but is subject to a range of errors and distortions.[57–59] In a review, Schacter[60] classifies these as different types of forgetting (transience, absent-mindedness, blocking), types of distortions (misattribution, suggestibility, bias), and intrusions that are difficult to forget. Some of these errors may reflect adaptive processes associated with imagining the future.[1,44] For example, when presented with words associated with sleep people tend to later mistakenly claim to recognize other words associated with sleep that were not on that original list. This false recognition may reflect that episodic memory stores the gist of events (i.e., there were words associated with sleep on that list) rather than faithful details because there are storage constraints, but also because a system for rote records cannot flexibly simulate novel future events.[61] Episodic memories may be actively constructed in much the same way as future simulations are (e.g., see Refs 3,41), but the flexibility of such a system, while an asset for foresight, may not always serve well for record keeping of past events. As noted earlier, evolution could not have directly selected for accuracy of memory *per se*.

Another difference between past and future that may result in different biases is that, because one's life time is finite and we travel in only one direction, the relative time one has left decreases while the relative time lived increases. When older people are asked to generate past events, they are typically biased toward reporting events from the immediate past and from the period of early adulthood.[62] The formative years may stand out because they tend to contain many novel experiences (e.g., the first kiss) where episodic retention may be particularly important.[4] This phenomenon in the distribution of people's recollection is often called the reminiscence bump and there is no parallel in form of a prospection bump. Thus, in spite of some similarities in the temporal distribution of events one might entertain about the past and future,[34] there must also be notable differences. As one approaches one's death, there is little realistic point in projecting distant personal future events (other than in the hope of an afterlife). There are also motivational changes associated with this realization. For example, people's motivation typically switches from knowledge-related goals to emotional goals in light of foreseen endings.[63] Time's arrow and natural selection place different premiums on approaching events than on preceding events.

In spite of the fact that humans rely heavily on foresight,[18] accurate prediction of the future is often impossible. Human predictions are at times spectacularly off the mark, as vividly illustrated by the extreme miscalculations typical of the annual winners of the Darwin awards (http://www.darwinawards.com/). Since Kahneman and Tversky's seminal work (e.g., see Ref 64), everyday heuristics and biases in people's predictions have been extensively studied, although only some of these require episodic processing. People tend to systematically underestimate the time it takes to complete a task in spite of ample previous experience, perhaps to motivate future attempts.[65] In general, humans appear to foresee more positive future events than one can extrapolate rationally from past events. This positivity is associated with specific neural correlates[66] and may have profound selective advantages over more negative but realistic expectations. Conversely, there may be an advantage to overestimate future regret to motivate current goal pursuits. Indeed, people systematically overestimate the amount of regret they would feel if a future event did not turn out to be a success.[67]

Biases in *affective forecasting* have been examined in a range of recent studies. In their review, Gilbert and Wilson[10] concluded that simulations of future events tend not to be based on representative sampling, but are typically extrapolations of the most recent or most salient past memory of related events. For example, when asked to imagine missing a train, people tend to recall the last time such an event occurred or their most extreme experience of that sort. This leads them to expect the next train-missing event be more painful then one should if estimates were based on the average past experience. The salience of the most recent memory for prediction is particularly strong. Salience may also explain the hindsight bias, the misconception that an event was more predictable than in fact it was before it took place. What in fact happened is more salient than what did not happen, and thus may be thought of as more predictable. This may be an adaptive bias in that it encourages the learning of prediction (even if it overestimates the likelihood of success).

In spite of long learning histories, however, there appear to be systematic differences between anticipated and retrospective views on events and their affective consequences. For example, compared to how people feel once an event has happened, people tend to overestimate how happy they will be if it is a desired event and how unhappy if it is an undesired event. A main reason for this may be that contextual factors other than the event itself tend to influence how one will actually experience and remember an event.[10] Gilbert and Wilson[10] highlight that foresight tends to be essentialized and abbreviated. Mental simulations of future events typically reflect the gist of an event and not the details and contexts. Although we can fill in detail, we tend to focus on the defining characteristics of a future event. For example, we may imagine going on a holiday to a particular place, without simulating details about how to get there, where to bank and so forth. In abbreviating episodic foresight, we may overlook details crucial to the hedonic nature of the actual experience.

It should be clear from these examples that it is not the accuracy of our predictions *per se* that have been selected for, but fitness benefits. Over- and underestimations of the sorts discussed here may reflect useful biases from an evolutionary perspective. Episodic foresight can only affect fitness if it influences action. It therefore must compete with the other current motivators.[68] Exaggeration of positive and negative outcomes may help selection of adaptive future-directed actions. So there is a parallel with the errors and biases in episodic memory in that an evolutionary perspective on both episodic memory and episodic foresight suggests that accuracy is not the key yardstick, but fitness consequences are. These consequences, however, resulted in different sets of characteristic errors and biases.

The fitness benefit of episodic memory may not be restricted to informing episodic foresight however. Episodic memory may affect current decision making in other adaptive ways.

ADAPTIVE EPISODIC MEMORY

There is evidence to suggest that cognitive forms fit evolutionary functions. Consider for example the research on basic perceptual judgments about distance. One might expect that humans would make some errors, but are reasonably consistent in their assessments. However, it has become clear that people's goals and current states systematically influence such judgments. Thus, an object appears farther away, for instance, when one is wearing a heavy backpack than when one is not; and it appears farther away when one intends to throw a heavy ball rather than when one intends to walk there.[69] The effort involved in performing distance relevant actions as well as the person's intentions influence perceptual judgments. An adaptive function of perception would appear to be to inform about immediate future potentials. Episodic memory may similarly harbor characteristics that point to adaptive functions.

Klein and colleagues have conducted some pioneering work on this possibility. One aspect of episodic memory they examined is its potential function in the context of judging the traits of other people and they devised a clever priming paradigm to study this.[70] Retrieval of episodic information at the appropriate time is naturally important. The study found evidence to suggest that when people retrieve generalizations about character traits, episodes that are inconsistent are primed. For example, the generalization 'I am a generous person' may prime memory of occasions when I was stingy. Although good predictions can be made on the basis of trait summaries, these inconsistent episodes effectively offer boundary conditions for such generalizations and hence allow for more measured predictions of future action (e.g., will I be generous in this future situation?). Thus, while semantic generalizations may offer a speedy trait summary, episodic information provides a detailed context for appropriate decision making.

An important adaptive advantage of episodic memory probably is that it allows us to learn from the same event more than once. We can mentally

revisit events and compare them to similar and related episodic memories. In the light of new information, we may then revaluate past events and what they can teach us. Klein et al.[71] showed that whereas trait summaries may be formed across many experiences, access to detailed episodes makes it possible to connect events and reassess them as a whole. For example, frequent visits and helpful behavior of an acquaintance tend to be reevaluated when one learns that this person is attracted to one's partner. The experimenters tried to examine this ability by presenting participants with two brief stories about a character. Considered by themselves the stories create a positive impression (e.g., the protagonist is with a lover), but when considered together they reveal a different picture (e.g., the protagonist is cheating). When presented with the stories 1 h apart, participants changed their assessment of the protagonist from the original assessment, but when the delay was 1 month and subjects lacked detailed recollection, they did not. Klein et al. also gave such a task to an amnesic patient (D.B.) and found that upon repeated exposure he could form a positive impression of a person. However, lacking episodic memory, he was unable to reassess this in light of new information. The authors conclude that one important evolved function of episodic memory is its role in evaluating and predicting social others. Other functions may have more to do with the self.

Storage constraints make it of course impossible to retain every episode one experiences. Thus, what and how we remember likely reflects fitness benefits.[72] Recent studies have suggested that memory for survival-related information may in fact be better than memory for other types of information.[73] I argue that foresight is a key human survival strategy for humans[18] and episodic memory may indeed have evolved to support that system. Klein et al. (in prep) found that memory is improved if there is a future-directed purpose involved. Participants studied the same list of object words in the context of one of four conditions. In three of the conditions, they were asked to imagine a future camping trip, to remember a past camping trip, or to imagine a trip without a temporal placement. Finally, a fourth condition drew attention to the survival-related value of the objects. The future-oriented condition resulted in significantly higher recall than any of the other conditions. This bias substantiates the claim that memory evolved in aid of the foresight system. In fact, humans often take advantage of opportunities in ways that suggest some form of predictive encoding: the storing of pending goals and associated anticipated environmental features.[74] This allows for quick recognition of opportunities to achieve those goals in future.

We have recently begun to study the development of the use of episodic memory for future-directed decision making in young children.[75] Children were given an opportunity to prepare now, based on memory of a specific past experience, for what might happen in the future. Three and 4-year-old children were given a problem (e.g., a puzzle box) that they can solve when presented with the opportunity right away. However, when children were distracted for 15 min before given the chance to secure a solution, only 4-year-olds performed above chance. These children selected the right object to take back to the problem: selecting a solution they had not seen before to a problem they could no longer see. Their own verbal reports support the conclusion that they remembered the novel problem sufficiently enough to recognize a solution and select that solution in anticipation of applying it to the future problem. This is an example, then, of linking episodic memory to inform present choices with an eye to the future. Children need to learn to make such connections for themselves but also to understand (and predict) why other people act the way they do. Lagattuta,[76] for instance, showed how preschoolers increasingly come to appreciate why someone else is worried when an object that harmed this person in the past reappears. This linking of past, present, and future deserves far more empirical attention than it has received thus far.

The relation between memory and foresight is very complex. The separation between past and future is not absolute but dynamic because the future becomes the past. Today's plans become memories of plans tomorrow, and next week they may be memories of plans for events that have already passed. People reason about the match or mismatch between memory of what was expected and memory of what actually occurred and this analysis informs their next anticipations. This cycle of prediction, comparisons between memories, updating of explanations, and forming new predictions, is extremely powerful. In fact much of human's outstanding learning might draw on this. The cycle depends, though, on updating and not confusing the different representations of future, presence, and past (not to mention the complicating issues of fiction and other people's communicated event representations).

CONCLUSION

The relationship between episodic memory and episodic foresight is complex and dynamic. In the last 3 years, many commonalities have been documented. Here, I have also emphasized some of the differences in

the hope of contributing to a clearer understanding of the nature of the links that have been observed. There are grounds to argue that both episodic memory and episodic foresight draw on the same neurocognitive resources. However, episodic memory may also be an integral part of the foresight system. This is reflected in various differences, for instance, in development and in typical errors and biases. New evidence suggests that episodic memory has a range of future-oriented adaptive characteristics. A functional analysis deserves more research attention. We are only beginning to document the nature of the similarities and differences between episodic memory and episodic foresight.

NOTE

[a]A variety of expressions have been used such as *episodic future thinking*,[77] *envisioning the future*,[6] *episodic simulation of future events*,[2] and *mental time travel into the future*.[3] I suggest we refer to *episodic foresight* because the brevity of this expression matches that of *episodic memory* and because dictionary definitions of foresight (e.g., Webster's) point to both the act or power of foreseeing, as well as to action with reference to the future. The latter has particular relevance as discussed in this review.

REFERENCES

1. Suddendorf T, Busby J. Mental time travel in animals? *Trends Cogn Sci* 2003, 7:391–396.
2. Schacter DL, Addis DR, Buckner RL. Remembering the past to imagine the future: the prospective brain. *Nat Rev Neurosci* 2007, 8:657–661.
3. Suddendorf T, Corballis MC. Mental time travel and the evolution of the human mind. *Genetic Soc Gen Psychol Monographs* 1997, 123:133–167.
4. Suddendorf T, Corballis MC. The evolution of foresight: what is mental time travel and is it unique to humans? *Behav Brain Sci* 2007, 30:299–313.
5. Tulving E. Episodic memory and autonoesis: uniquely human? In: Terrace HS, Metcalfe J, eds. *The Missing Link in Cognition*. Oxford: Oxford University Press; 2005, 3–56.
6. Buckner RL, Carroll DC. Self-projection and the brain. *Trends Cogn Sci* 2007, 11:49–57.
7. Tulving E. Memory and consciousness. *Can Psychol* 1985, 26:1–12.
8. Dudai Y, Carruthers M. Memory: some systems in the brain may be better equipped to handle the future than the past. *Nature* 2005, 434:567.
9. Suddendorf T, Busby J. Making decisions with the future in mind: developmental and comparative identification of mental time travel. *Learn Motivation* 2005, 36:110–125.
10. Gilbert DT, Wilson TD. Prospection: experiencing the future. *Science* 2007, 317:1351–1354.
11. Johnson A, Redish AD. Neual ensembles in CA3 transiently encode paths forward of the animal at a decision point. *J Neurosc* 2007, 27:12176–12189.
12. Eichenbaum H, Fortin NJ. The neurobiology of memory based predictions. *Phil Trans Roy Soc., B: Biol Sci* 2009, 364:1183–1191.
13. Lisman J, Redish AD. Prediction, sequences and the hippocampus. *Phil Trans Roy Soc., B: Biol Sci* 2009, 364:1193–1201.
14. Dere E, Kart-Teke E, Huston JP, Silva MAD. The case for episodic memory in animals. *Neurosci Biobehav Rev* 2006, 30:1206–1224.
15. Zentall TR. Mental time travel in animals: a challenging question. *Behav Process* 2006, 72:173–183.
16. Clayton NS, Bussey TJ, Emery NJ, Dickinson A. Prometheus to Proust: the case for behavioural criteria for 'mental time travel'. *Trends Cogn Sci* 2003, 7:436–437.
17. Suddendorf T, Corballis MC. New evidence for animal foresight? *Animal Behav* 2008, 75:e1–e3.
18. Suddendorf T. Foresight and evolution of the human mind. *Science* 2006, 312:1006–1007.
19. Hassabis D, Kumaran D, Vann SD, Maguire EA. Patients with hippocampal amnesia cannot imagine new experiences. *Proc Nat Acad Sci U S A* 2007, 104:1726–1731.
20. Klein SB, Loftus J, Kihlstrom JF. Memory and temporal experience: the effects of episodic memory loss on an amnesic patient's ability to remember the past and imagine the future. *Soc Cogn* 2002, 20:353–379.
21. Rosenbaum RS, Kohler S, Schacter DL, Moscovitch M, Westmacott R, et al. The case of KC: contributions of a memory-impaired person to memory theory. *Neuropsychologia* 2005, 43:989–1021.
22. Dalla Barba G, Cappelletti JY, Signorini M, Denes G. Confabulation: remembering 'another' past, planning 'another' future. *Neurocase* 1997, 3:425–436.
23. Brune M, Brune-Cohrs U. The costs of mental time travel. *Behav Brain Sci* 2007, 30:317–318.
24. Williams JMG, Ellis NC, Tyers C, Healy H, Rose G, et al. The specificity of autobiographical memory

and imageability of the future. *Memory Cogn* 1996, 24:116–125.

25. D'Argembeau A, Raffard S, Van der Linden M. Remembering the past and imagining the future in schizophrenia. *J Abnormal Psychol* 2008, 117:247–251.
26. Addis DR, Wong AT, Schacter DL. Age-related changes in the episodic simulation of future events. *Psychol Sci* 2008, 19:33–41.
27. Okuda J, Fujii T, Ohtake H, Tsukiura T, Tanji K, et al. Thinking of the future and past: the roles of the frontal pole and the medial temporal lobes. *Neuroimage* 2003, 19:1369–1380.
28. Addis DR, Schacter DL. Effects of detail and temporal distance of past and future events on the engagement of a common neural network. *Hippocampus* 2008, 18:227–237.
29. Addis DR, Wong AT, Schacter DL. Remembering the past and imagining the future: common and distinct neural substrates during event construction and elaboration. *Neuropsychologia* 2007, 45:1363–1377.
30. Szpunar KK, Watson JM, McDermott KB. Neural substrates of envisioning the future. *Proc Nat Acad Sci U S A* 2007, 104:642–647.
31. D'Argembeau A, Van der Linden M. Phenomenal characteristics associated with projecting oneself back into the past and forward into the future: Influence of valence and temporal distance. *Consciousness and Cognition* 2004, 13:844–858.
32. D'Argembeau A, Van der Linden M. Individual differences in the phenomenology of mental time travel: the effect of vivid visual imagery and emotion regulation strategies. *Consciousness and Cognition* 2006, 15:342–350.
33. Trobe Y, Liberman N. Temporal Construal. *Psychological review* 2003, 110:403–421.
34. Spreng RN, Levine B. The temporal distribution of past and future autobiographical events across the lifespan. *Memory Cogn* 2006, 34:1644–1651.
35. Friedman WJ. Developmental and cognitive perspectives on humans' sense of the times of past and future events. *Learn Motivation* 2005, 36:145–158.
36. Atance CM. Future thinking in young children. *CurrDirections Psychol Sci* 2008, 17:295–298.
37. Nelson KD, Fivush R. The emergence of autobiographical memory: a social cultural developmental theory. *Psychol Rev* 2004, 111:486–511.
38. Moore C, Lemmon K, eds. *The Self in Time: Developmental Perspectives*. Mahwah, NJ: Lawrence Erlbaum Associates; 2001.
39. Busby J, Suddendorf T. Recalling yesterday and predicting tomorrow. *Cogn Dev* 2005, 20:362–372.
40. Wheeler MA, Stuss DT, Tulving E. Toward a theory of episodic memory: the frontal lobes and autonoetic consciousness. *Psychol Bull* 1997, 121:331–354.
41. Schacter DL, Addis DR, Buckner RL Episodic simulation of future events: concepts, data, and applications. *Annals of the New York Academy of Sciences* 2009, 12:2660–2671.
42. Hassabis D, Maquire EA. Deconstructing episodic memory with construction. *Trends Cogn Sci* 2007, 11:299–306.
43. Liberman N, Trope Y. The psychology of transcending the here and now. *Science* 2008, 322:1201–1205.
44. Schacter DL, Addis DR. The cognitive neuroscience of constructive memory: remembering the past and imagining the future. *Phil Trans Roy Soc., B: Biol Sci* 2007, 362:773–786.
45. Schacter DL, Addis DR, Buckner RL. Episodic simulation of future events—concepts, data, and applications. *Year Cogn Neurosci* 2008, 2008:39–60.
46. Suddendorf T, Corballis MC. Mental time travel across the disciplines: the future looks bright. *Behav Brain Sci* 2007, 30:335–351.
47. Botzung A, Denkova E, Manning L. Experiencing past and future personal events: functional neuroimaging evidence on the neural bases of mental time travel. *Brain Cogn* 2008, 66:202–212.
48. D'Argembeau A, Xue G, Lu ZL, Van der Linden M, Bechara A. Neural correlates of envisioning emotional events in the near and far future. *NeuroImage* 2008, 40:398–407.
49. Hassabis D, Kumaran D, Maguire EA. Using imagination to understand the neural basis of episodic memory. *J Neurosc* 2007, 27:14365–14374.
50. Suddendorf T, Addis DR, Corballis MC. Mental time travel and the shaping of the human mind. *Phil Trans Roy Soc., B*, 364:1317–1324.
51. Schacter DL, Addis DR. On the nature of medial temporal lobe contributions to the constructive simulation of future events. *Phil Trans Roy Soc., B: Biol Sci* 2009, 364:1245–1253.
52. Busby Grant J, Suddendorf T. Preschoolers begin to differentiate the times of events from throughout the lifespan. *Eur J Dev Psychol* 2009, 6:746–762.
53. McColgan KL, McCormack T. Searching and planning: young children's reasoning about past and future event sequences. *Child Dev* 2008, 79:1477–1497.
54. Hudson JA. The development of future time concepts through mother-child conversation. *Merrill-Palmer Q J Dev Psychol* 2006, 52:70–95.
55. Salmon K, Champion F, Pipe ME, Mewton L. The child in time: the influence of parent-child discussion about a future experience on how it is remembered. *Memory* 2008, 16:549–561.
56. Suddendorf T. Linking yesterday and tomorrow: Preschooler's ability to report temporally displaced events. *Brit J Dev Psychol*. In press.

57. Bartlett FC. *Remembering: A Study in Experimental and Social Psychology*. Cambridge: Cambridge University Press; 1932.
58. Loftus EF. When a lie becomes memory's truth: memory distortion after exposure to misinformation. *Curr Directions Psychol Sci* 1992, 1:121–123.
59. Roediger HL III, McDermott KB. Creating false memories remembering words not presented in lists. *J Exp Psychol: Learn Memory Cogn* 1995, 21:803–814.
60. Schacter DL. The seven sins of memory—insights from psychology and cognitive neuroscience. *Am Psychologist* 1999, 54:182–203.
61. Schacter DL, Addis DR. The ghosts of past and future. *Nature* 2007, 445:27–27.
62. Rubin DC, Schulkind MD. Distribution of important and word-cued autobiographical memories in 20-, 35-, and 70-year-old adults. *Psychology Aging* 1997, 12:524–535.
63. Carstensen LL, Isaacowitz DM, Charles ST. Taking time seriously: a theory of socioemotional selectivity. *Am Psychologist* 1999, 54:165–181.
64. Tversky A, Kahneman D. Judgment under uncertainty—heuristics and biases. *Science* 1974, 185:1124–1131.
65. Buehler R, Griffin D, Ross M. Exploring the planning fallacy—why people underestimate their task completion times. *J Personality Soc Psychology* 1994, 67:366–381.
66. Sharot T, Riccardi AM, Raio CM, Phelps EA. Neural mechanisms mediating optimism bias. *Nature* 2007, 450:102–106.
67. Gilbert DT, Morewedge CK, Risen JL, Wilson TD. Looking forward to looking backward. *Psychol Sci* 2004, 15:346–350.
68. Ainslie G. Forsight has to pay off in the present moment. *Behav Brain Sci* 2007, 30:313–314.
69. Proffitt DR. Distance perception. *Curr Directions Psychol Sci* 2006, 15:131–135.
70. Klein SB, Cosmides K, Tooby J, Chance S. Decisions and the evolution of memory: multiple systems, multiple functions. *Psychol Rev* 2002, 109:306–329.
71. Klein SB, Cosmides L, Gangi CE, Jackson B, Tooby J, et al. Evolution and episodic memory. *Soc Cogn* 2009, 27:283–319.
72. Anderson JR, Schooler LJ. Reflections of the environment in memory. *Psychol Sci* 1991, 2:396–408.
73. Nairne JS, Pandeirada JNS. Adaptive memory—remembering with a stone-age brain. *Curr Directions Psychol Sci* 2008, 17:239–243.
74. Seifert CM, Patalano AL. Opportunism in memory: preparing for chance encounters. *Curr Directions Psychol Sci* 2001, 10:198–201.
75. Suddendorf T, Nielsen M, von Gehlen R. Children's capacity to remember a novel problem and to secure its future solution. *Dev Sci*. In press.
76. Lagattuta KH. Thinking about the future because of the past: young children's knowledge about the causes of worry and preventative decisions. *Child Dev* 2007, 78:1492–1509.
77. Atance CM, O'Neill DK. Episodic future thinking. *Trends Cogn Sci* 2001, 5:533–539.

