Episodic future thinking

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Thinking about the future is an integral component of human cognition – one that has been claimed to distinguish us from other species. Building on the construct of episodic memory, we introduce the concept of 'episodic future thinking': a projection of the self into the future to pre-experience an event. We argue that episodic future thinking has explanatory value when considering recent work in many areas of psychology: cognitive, social and personality, developmental, clinical and neuropsychology. Episodic future thinking can serve as a unifying concept, connecting aspects of diverse research findings and identifying key questions requiring further reflection and study.

Human memory is often conceived as involving two distinct systems: episodic and semantic (e.g. Ref. 1). Tulving describes episodic memory as the system that allows us to remember personally experienced events, and to travel backwards in time to re-experience those events[2]. By contrast, semantic memory is broadly defined as our 'knowledge of the world'[2]. With respect to memories related to the self, for example, the episodic/semantic distinction would be captured by the difference between 'knowing' the name of the high school I attended (semantic memory) versus 'remembering' a specific episode, for example a humiliating social situation, that occurred while attending the school (episodic memory) (i.e. 'know' versus 'remember' judgments[3,4]). Given that there exists a clear distinction between these two forms of thinking about the past, it is puzzling that an analogous distinction has never been made with respect to thinking about the future.

In this article, we build upon Tulving's conception of episodic memory[1] and introduce what we term 'episodic future thinking'. We argue that episodic future thinking represents an important organizing construct in considering current research in psychology. In particular, we apply the construct of episodic future thinking to research in: (1) Cognitive; (2) Social and Personality; (3) Clinical; (4) Neuro-; and (5) Developmental psychology.

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Characterizing episodic future thinking

Our definition of episodic future thinking is strongly influenced by, and indeed builds upon, Tulving's most recent characterization of episodic memory[2]. Inherent to this characterization is autonoetic consciousness, which Tulving defines as 'the kind of consciousness that mediates an individual's awareness of his or her existence and identity in subjective time extending from the personal past through the present to the personal future' (Ref. 3, p. 1). According to Tulving, it is the combination of autonoetic consciousness and episodic memory that allows an individual to engage in mental time travel. Humans are said to have the ability to 're-experience, through autonoetic awareness, previous experiences as such, and to project similar experiences into the future' (Ref. 5, p. 13).

Although Tulving argues[5] that the episodic memory system underlies the ability to project events that involve the self into the future, what is left unspecified is the nature of such a self-projection, that is, what we will term the 'pre-experiencing' of a future event. Note that in episodic future thinking the imagination is not given free reign, but rather, the projection is constrained. For instance, envisaging my forthcoming vacation might require me to consider such factors as how much spending money I will have, how much work I will have completed before I go, and so on (i.e. constraints).

We hope to provide a more detailed conceptualization of what episodic future thinking entails through our application of this construct to five areas of psychology. In particular, we will highlight how episodic future thinking is distinct from semantic knowledge regarding the future, or, in other words, what could be termed 'semantic future thinking'.

Cognition

Prospective memory

Prospective memory is defined as how we remember to engage in an intended action at a specific point in the future (e.g. remembering to give a friend a message when we see her)[6]. However, it has been characterized as 'more than just memory'[7] and as 'intimately related to human planning and future-oriented behaviours' (Ref. 8, p. S132). Kliegel *et al*.[9] have conceptualized prospective memory as involving three distinct processes: (1) developing a plan, (2) remembering the plan, and (3) remembering at some future point to execute the plan.

The first of these processes has received little attention in the prospective memory literature, yet could be the component most intimately linked with episodic future thinking. Episodic future thinking might be particularly relevant to how we initially choose, or develop, the mnemonic that will allow us to remember our intended action in the future. For instance, suppose I must remember to take my medicine immediately upon returning home from work today. I might therefore decide before I leave the house in the morning to place my medicine bottle on the kitchen counter close to where the glasses are

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kept. To ensure the effectiveness of this mnemonic, however, it is important that I 'pre-experience' the events I am likely to engage in when I get home. If I fail to do this accurately, I might overlook, for example, the fact that, because today is Tuesday, when I get home I will probably go immediately into the living room to watch a favourite television programme, going into the kitchen only when it is over. Thus, in this case, a more effective mnemonic would be for me to put my medicine on the coffee table in the living room rather than on the kitchen counter.

This example highlights the distinction between developing a plan that is geared to one's own specific actions versus one that is geared to a more script-like routine (e.g. putting medicine near water source). Thus, one avenue for future research involves examining whether prospective memory performance is enhanced more by the development of episodic than script-like mnemonic plans.

Judgment and decision-making

When people are asked to predict the completion date for a specific project (e.g. their income tax return), their estimates tend to be overly optimistic (e.g. Refs 10–12). There exist several explanations for this 'planning fallacy'[13]. One is that people tend to base their prediction on only one future plan, or scenario, and neglect to take into account information about the length of time similar events have taken in the past[10]. Another is that people fail to take into account future problems that might interfere with the project's completion date[10].

Not surprisingly, research on the planning fallacy has sought to identify factors that improve prediction accuracy. These methods generally focus on altering the nature of the scenarios that individuals are asked to generate, such as asking participants to envisage both best- and worst-case project completion scenarios before making their predictions (e.g. Ref. 12). These types of manipulations have met with mixed results (see Ref. 14 for a review). Moreover, there is no general consensus on why some of these manipulations are effective, whereas others are not.

Some insight into this problem might be gained by analyzing the content of the scenarios that people generate before making their predictions to determine the extent to which there is evidence for episodic versus semantic future thinking. For instance, in generating a best-case scenario, an individual might be more likely to rely on a script of how the event in question (e.g. completion of an essay) typically unfolds. By contrast, in generating a worst-case scenario, an individual might be forced to contemplate particular constraints that are relevant only to themselves (e.g. their carpal-tunnel injury might flare up again).

Thus, in some cases, people might readily adopt a generalized, or semantic, mode of future thinking that could decrease the accuracy of their predictions. By contrast, prediction accuracy might increase in instances in which individuals are motivated to pre-experience the unfolding of a future plan of events from a personal perspective. This could include, for example, considering the many constraints that are relevant to the self and that will influence how the sequence of events in the plan unfolds (e.g. acknowledging that the completion of an essay will be affected by having to return home on the weekend, where it is difficult to work productively).

People's tendency to engage in episodic future thinking, and in turn the accuracy with which they make predictions about future events, might also be mediated by the temporal proximity of the target event. Liberman and Trope have shown that individuals represent distant future events at a more abstract level than they do immediate future events, even when the amount of information that they possess about the event is held constant[15,16]. Moreover, when planning for future events, people tend to consider time constraints only when these events are in the near future[15]. To our knowledge, temporal proximity of the target event is not a variable that has been considered in planning fallacy research, but its manipulation might reveal that people engage in more episodic future thinking when the event looms nearer.

Goal attainment

Episodic future thinking might be implicated in Gollwitzer's notion of 'implementation intentions', which specify the 'when, where, and how of responses leading to goal attainment' (Ref. 17, p. 494). He stresses the importance of 'pre-deciding' how to implement a future goal, rather than simply thinking about this future goal. Studies have shown that the frequency of positive health-related behaviours is increased through the formation of implementation intentions (e.g. Refs 18,19).

For example Sheeran and Orbell found that participants who had been encouraged to commit themselves to when and where they would take a pill each day missed fewer pills than individuals who had only formed the goal to take a pill each day[18]. Given that the formation of implementation intentions requires individuals to envisage themselves acting at a particular time and place in the future, we would argue that this process is mediated by episodic future thinking. Moreover, findings such as those of Sheeran and Orbell further emphasize the importance of considering the role of episodic future thinking in the formation of mnemonic plans in prospective remembering.

Social and personality psychology

Future time perspective and future orientation

Although all healthy adults have the ability to think about the future, people appear to differ in their inclination, or orientation, to do so. Two questionnaires that have been developed to assess

Box 1. Future orientation questionnaires

Here we present some sample items from the ZimbardoTime Perspective Inventory (ZPTI) and the Consideration of Future Consequences Scale (CFC).

On both scales respondents are asked to indicate on a 5-point Likert Scale how characteristic the statement is of themselves (e.g. 1 = very/extremely characteristic, 3 = neutral/uncertain, 5 = very/extremely uncharacteristic).

ZPTI (*assesses past, present, and future orientation*)

- I've made mistakes in the past that I wish I could undo.
- I make decisions on the spur of the moment.
- I keep working at difficult, uninteresting tasks if they will help me get ahead. (Ref. a)

CFC (*assesses consideration of future outcomes*)

- I consider how things might be in the future, and try to influence those things with my day to day behaviour.
- I generally ignore warnings about possible future problems because I think that the problems will be resolved before they reach crisis level. (Ref. b)

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this potential individual difference factor are the Zimbardo Time Perspective Inventory (ZPTI)[20] and the Consideration of Future Consequences Scale (CFC)[21] (see Box 1). The 56-item ZPTI assesses a cognitive temporal 'bias' toward being past-, future- or present-oriented, whereas the 12-item CFC focuses only on future orientation and, more specifically, the 'extent to which individuals consider the potential distant outcomes of their current behaviours and the extent to which they are influenced by these potential outcomes' (Ref. 21, p. 743).

Scores on each of these questionnaires have been shown to be related to individual differences in health and environmental attitudes and behaviours. In one study[22], higher scores on the 'Future' Scale of the ZPTI, than on the 'Present' Scales, were related to shorter durations of homelessness. In other studies, scores on the Present Scales were highly related to risky driving[23] and to more frequent smoking, consumption of alcohol, and drug use[24]. Similarly, scores on the CFC Scale have been shown to account for variance in health and environmental behaviours (e.g. number of cigarettes smoked in one week; engagement in recycling and energy-efficient behaviours) over and above four competing individual differences measures including, the Hope Scale[25], the Life Orientation Test[26], the Conscientiousness dimension of the Big Five Personality Inventory[27], and the Stanford Time Perspective Inventory[28].

Such results highlight the importance of individual differences in future orientation in effecting positive behavioural outcomes. However to demonstrate the role of episodic future thinking, in particular, further research might focus on how a 'future orientation' translates into the steps taken by the individual that ultimately lead to the positive behavioural outcomes reported above. For instance, would the manner in which a woman projects herself into the future (e.g. more episodic versus script-based semantic approach) to develop an action plan for seeking breast-cancer screening determine the likelihood that she will indeed do so?

Clinical psychology

In the realm of clinical psychology, greater attention to distinctions among different kinds of future thinking has provided a basis for distinguishing between anxiety and depression, and a more refined understanding of one hallmark feature of depression, namely, a negative outlook with respect to the future.

MacLeod and his colleagues have argued that positive and negative cognitions concerning the future represent two separate dimensions of experience and they assess these separate domains via a measure of future thinking based on an adapted verbal fluency paradigm[29–31]. In this timed task, participants are presented with several future time periods ranging from the next 24 hours to the next 10 years and are asked to generate events they are looking forward to (future positive events) and not looking forward to (future negative events). Anxious individuals tend to generate more negative experiences than controls or depressed individuals, but not fewer positive experiences. By contrast, depressed individuals tend to generate fewer positive experiences than controls or anxious individuals, but not more negative experiences[30–32]. That is, somewhat counterintuitively, depressed participants were distinguished from controls and anxious participants not by an increase in negative future thinking, but by a reduction in positive future thinking.

Future research might reveal not only quantitative but also qualitative differences in the types of positive and negative future outcomes individuals anticipate. For example, it would be of interest to know whether the positive or negative future events anticipated in each disorder differ in terms of being described in a more episodic or semantic (script-like) fashion that, might in turn, increase or decrease, respectively, their salience to the individual.

Neuropsychology

Is it possible to lose the ability to engage in episodic future thinking, whilst retaining semantic knowledge about the future? In at least four intriguing case studies, a patient has been reported to have lost the ability to plan for their personal future, although having retained semantic knowledge about the future

Table 1. Neuropsychological case studies

	Patient N.N.* (Ref. 3)	Patient R. (Ref. 48)	Patient M.L. (Ref. 4)	Patient D.B. (Ref. 49)
Location of damage	Multifocal (including superior frontal parietal)	Frontal lobe	Right ventral frontal cortex	Mild central and peripheral atrophy
Semantic memory	Has knowledge of his past (e.g. where he spent his summer in his teens)	Performs relatively well on memory tests such as the Wechsler Memory Scale	Can learn significant facts from his own past, as evidenced by high recall of 'personal semantic' events	Performs well on semantic memory tasks (e.g. Galton Crovitz memory cueing task) and questions about ' 'known past' (i.e. past issues/events in public domain)
Episodic memory	Cannot remember a single episode/event from the past	Not reported	Inability to re-experience any events pre-dating his injury	Cannot remember a single experience from any point in his life (i.e. from 'lived past')
Semantic future thinking	Can provide a reasonably good script of going to a restaurant or making a long-distance telephone call	Knowledge of the future intact. R. could analyze facts about her own situation and make appropriate recommendations concerning her daily life and employment	Can apply 'structured routines' to aid in resuming former responsibilities (e.g. parenting)	Can answer questions about 'known future' (i.e. future issues/ events in public domain likely to take place, such as new medical breakthroughs)
Episodic future thinking	Unable to answer any questions about his personal future	'[The] most significant disturbance occurred in one aspect of self-awareness: the use of the knowledge she possessed in relation to decisions about her future' (Ref. 48, p. 77)	Scored low on a 'strategy application measure' (modeled on Shallice and Burgess's Six-Element Task) described as a self-regulatory task	Largely unable to respond to questions about 'lived future' (e.g. Who are you going to see this evening? What are you going to do tomorrow?)
Frontal lobe tests	Near-normal performance on the Wisconsin Card Sorting Test	Performed well on frontal lobe tests, including the Porteus Maze and Wisconsin Card Sorting Test	Performed well on frontal lobe tests, including the Wisconsin Card Sorting Test, and the Stroop Interference Procedure	Not reported

*In later publications, patient N.N. is referred to as K.C.

(see Table 1). (Note that other case studies and cases of frontal lobe impairment might also be relevant[33–35], but these studies do not present evidence to allow us to distinguish semantic versus episodic future thinking ability).

Three of these patients are reported to perform adequately on traditional frontal lobe tasks such as the Wisconsin Card Sort that are argued to require planning[36]. This finding suggests that it might be possible to lose the ability to plan for personal (i.e. episodic) future events, while maintaining a reasonable level of performance on other types of planning measures. Thus, it could be valuable to develop a clearer characterization of the extent to which various tasks, all currently falling under the rubric of 'planning', require episodic future thinking. Indeed, Haith has noted that the existing planning literature rarely makes reference to the domain of future thinking or differentiates possible types of future thinking[37].

One factor that might influence the extent to which episodic future thinking is required in a planning task is the novelty of the task. Fuster has argued that patients who suffer damage specifically to the dorsolateral area of the prefrontal cortex cannot formulate future action plans that deviate from routine[38]. We would argue, in addition, that when faced with a planning task for the first time, we might be especially likely to engage in episodic future thinking. However, if faced with the same planning task numerous times, decisions might become more routine and a function of semantic future thinking.

Box 2. Forethought in primates?

Do primates share our ability to travel in time to anticipate a future event? One chimpanzee behaviour argued to demonstrate the ability for flexible forethought is the fashioning of pointed tools from sticks at one place for use later in termite fishing (Ref. a; for a review see Ref. b). But others argue that such behaviour can be explained as the result of a present- rather than future-oriented drive state [e.g. animal's present hunger according to the 'Bischof–Koehler hypothesis' (Ref. c, p. 150)] and that primates show no evidence, before acting, that they understand *how* the tool will produce the effects on the environment[d].

Doubt has also been cast on the interpretation of some primate behaviours as instances of 'tactical deception' suggesting action, cooperation and/or alliance with future benefits in mind (see Ref. e for a review).These behaviours, it is argued, can often be explained as responses to behavioural cues (e.g. ritualized communicative displays) and other contextual cues whose significance is learned from experience[d].This type of foresight is also argued to be limited by the fact that it is not aimed at the intentions or mental states of other conspecifics[d].

At present, the consensus appears to be that primates are solely present-oriented[f,g].Tulving has suggested that our ability to re-experience the past, and project ourselves into the future has been a driving force in the evolution of culture and civilization[h]. Demonstrations of foresight in the use of tools by primates would raise interesting questions about whether culture is a uniquely human phenomenon – a debate that has indeed begun given observations that different populations of chimpanzees habitually use different tools to accomplish similar goals (see Ref. i for a review).

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Indeed, Raichle *et al.* have demonstrated that when individuals are presented with a novel task, blood flow to the frontal lobes is highest, but decreases as the task becomes more familiar[39].

Development of episodic future thinking

By the third year of life, both children's talk and various aspects of their behaviour (e.g. preparing for a future event) reflect an awareness of the future[40–43]. By 3 years of age, children's talk also appears to include an understanding that the future is not simply a recapitulation of the past, but is, by nature, uncertain[44]. In examining children's use of modal terms such as 'maybe' and 'probably' to indicate uncertainty, we found that, between the ages of 2 yrs and 2 yrs 11 months, children expressed uncertainty in connection with ongoing events in the physical world[44] (e.g. '*probably in there*') and with respect to future intentions (e.g. '*maybe I'll go away*') and events (e.g. '*Mommy, what might happen if doctors are sick*?'). Thus children's construction of the future was not based solely on past events but also included novel projections, predictions, and hypotheses.

Children's accounts of a script and a plan increasingly differ from 3 to 5 years of age. In a pretend play scenario, Hudson *et al.*[45] asked children to provide a 'script' (e.g. '*Can you tell me what happens when you go grocery shopping*?') or a 'plan' (e.g. '*Can you tell me a plan for going grocery shopping*?'). By 5 years of age, children's accounts in the planning condition (but not the script condition) included significantly more preparatory and decision-making activities than those of the younger children. Children's ability to provide a prevention for a given common mishap (e.g. forgetting your money) also increased with age.

Preschool-aged children also reveal a growing ability to consider the future consequences of their current behaviour[46,47]. In one such study, children were given a modified delay of gratification task in which they were offered the option of obtaining one sticker immediately, or two stickers in the future[46]. Only by 4 years of age did children begin to prefer the larger delayed reward over the smaller immediate one. The authors argued that the 3-year-olds were impeded, in part, 'by the introduction of a situation in which they were required to imagine future desires that conflicted with their current desires' (Ref. 46, p. 207).

Thus, as early as age 2, children's talk and behaviour reveal an awareness of the future, but it does not appear to be until 4 or 5 years of age that children begin to demonstrate more sophisticated planning and anticipatory behaviours.

Conclusion

Episodic future thinking, as we have defined it, refers to an ability to project the self forward in time to pre-experience an event. It may be a distinguishing feature of our species (see Box 2). We have argued that episodic future thinking can hold explanatory value when considering recent work on such diverse topics as prospective memory, the planning fallacy, goal pursuit, and depression and anxiety. Neuropsychological evidence suggests that the frontal lobes constitute an important part of a wider neuronal network involved in episodic future thinking. Its developmental emergence might take place by the age of 5 yrs. The importance of episodic future thinking to human experience and behaviour remains to be fully explored, but glimpses of its potential importance for adaptive human functioning (e.g. positive health practices) can be found in current research.

Questions for future research

- Clearer terminological distinctions are needed to differentiate between closely related concepts pertaining to future thinking, such as projecting, planning, anticipating, envisaging, simulating, imagining, fantasizing, supposing and hypothesizing. For example, what kind of future thinking best describes what a computer programmed to play chess is doing?
- Although a future orientation is generally considered to be adaptive, might there be negative consequences associated with an excessive focus on future events? How do differences in the balance between future, present and past orientation translate into people's different life choices (e.g. career, investment decisions).
- How is episodic future thinking related to one's sense of self? If one loses the ability to engage in episodic future thinking, does one lose one's sense of self? What types of laboratory-based planning tasks require episodic future thinking? Is it sufficient that the task is a novel one, or must it also require the individual to make an explicit link between the self and the actions to be carried out?
- When do children first begin to engage in episodic future thinking? When can children anticipate a future event that deviates from a well-known routine or script? What experimental paradigms will dissociate episodic future thinking from semantic future thinking? Does episodic future thinking emerge at the same time as episodic memory? Does children's developing understanding of causal relations contribute to their ability to relate current states of the self to future ones?
- Is episodic future thinking a unique human ability that distinguishes us from all other species (see Box 2)?

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Sequential learning in non-human primates

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Sequential learning plays a role in a variety of common tasks, such as human language processing, animal communication, and the learning of action sequences. In this article, we investigate sequential learning in non-human primates from a comparative perspective, focusing on three areas: the learning of arbitrary, fixed sequences; statistical learning; and the learning of hierarchical structure. Although primates exhibit many similarities to humans in their performance on sequence learning tasks, there are also important differences. Crucially, non-human primates appear to be limited in their ability to learn and represent the hierarchical structure of sequences. We consider the evolutionary implications of these differences and suggest that limitations in sequential learning may help explain why non-human primates lack human-like language.

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Sequential learning, by which we mean the ability to encode and represent the order of discrete elements occurring in a sequence, is a ubiquitous facet of cognition. Many of the events that we observe, as well as the behaviors we produce, are sequential in nature. From learning a particular behavioral sequence, such as a dance routine, to encoding meaning from a speech stream, sequential learning processes are at work. In humans, the ability to deal with complex sequential structure is perhaps most evident in language acquisition and processing (see Box 1). But sequential learning is not confined to humans. In order to adapt and survive, all higher organisms must learn to operate within a temporally bounded environment where sequential events occur.

To understand human sequential learning more fully, comparative studies of non-human primates are essential. After all, human cognition is merely one specific instance of primate cognition in general[1]. By exploring the abilities and the limitations that other primates have for processing sequential information, we can begin to understand the origins of such capabilities in humans as well as the unique aspects of human sequential processing.

Although there has been ample research aimed at investigating sequencing skills in non-human primates (for reviews, see Refs 2,3), few studies have provided direct comparisons with humans. The focus of this paper is to review data from research involving both non-human primates (hereafter, 'primates') as well as humans. We organize the data into three progressively more complex abilities: learning fixed sequences, encoding statistical regularities of sequences, and learning hierarchical structure.

Learning fixed sequences

Perhaps the simplest type of sequential learning has to do with the learning of an arbitrary, fixed sequence. In humans, this type of sequential learning corresponds to remembering a phone number or producing a stereotyped sequence of actions.

Learning action sequences by observation

A series of studies has examined learning in capuchin monkeys (*Cebus apella*), chimpanzees (*Pan troglodytes*), and human children (ages 2, 3, and 4 yrs) using a task designed to simulate natural sequential feeding behaviors[4–6]. These experiments used an 'artificial fruit' that functionally approximated food found in the wild. Subjects observed the experimenter bypassing one or more of the fruit's defenses using a particular arbitrary sequence of actions; afterwards, the subjects were allowed to manipulate the fruit in order to procure a treat contained within.

In general, when the artificial fruit consisted of only two sub-components, both non-human and human subjects copied the two-action, fixed sequence that they observed[4,6]. However, the human children copied the details of the actions more faithfully than did the primates (but see Box 2,

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