1

The Past, the Present, and the Future of Future-Oriented Mental Time Travel

Editors' Introduction

KOURKEN MICHAELIAN, STANLEY B. KLEIN, AND KARL K. SZPUNAR ■

This introductory chapter reviews research on future-oriented mental time travel to date (the past), provides an overview of the contents of the book (the present), and enumerates some possible research directions suggested by the latter (the future).

1. THE PAST

In the years since Tulving first argued for episodic memory as a distinct memory system (Tulving, 1983), episodic memory has become a major area of research in psychology. Initially viewed primarily as a distinct store for information deriving from experienced episodes, the definition of episodic memory shifted over time, with researchers increasingly viewing episodic memory as a form of mental time travel into the personal past (Suddendorf & Corballis, 1997), drawing on a range of recently evolved and late-developing cognitive capacities and characterized by a unique form of consciousness: autonoesis, or consciousness of the self in subjective time (Wheeler et al., 1997). At the same time, recognition has grown that mental time travel into the past cannot be understood independently of future-oriented mental time travel (FMTT) (Atance & O'Neill, 2001; Schacter & Addis, 2007; Suddendorf & Corballis, 1997, 2007; Szpunar, 2010); indeed, FMTT may be primary, with our capacity to remember the past being derivative of the more basic capacity to imagine the future (Klein, 2013).

Research on FMTT has exploded over the past decade, with over a hundred articles published in just the last five years. Much of this research has revealed that, despite various differences in the cognitive and neural mechanisms that

characterize future- and past-oriented mental time travel (MTT) (for a review, see Schacter et al., 2007, 2012), there also exist striking similarities. For instance, people tend to think about future and past events that are temporally near, as opposed to temporally distant (Spreng & Levine, 2006); temporally near events are mentally represented in greater detail than temporally distant events, whether those events are oriented toward the future or the past (D'Argembeau & Van der Linden, 2004); and people who are more apt to engage in mental imagery in their daily lives are more likely to generate detailed mental representations of the personal future and past (D'Argembeau & Van der Linden, 2006).

Functional neuroimaging and neuropsychological studies have provided important insights into the close cognitive links between future- and past-oriented MTT. Specifically, functional neuroimaging studies have revealed that a core network of brain regions, sometimes referred to as the default network (Buckner et al., 2008; Raichle et al., 2001), become engaged when people think about their personal future and past (Addis et al., 2007; Okuda et al., 2003; Szpunar et al., 2007; for a recent review, see Benoit and Schacter, 2015). Moreover, neuropsychological observations of patients with damage to specific regions within this network have revealed concurrent deficits of future- and past-oriented MTT (Klein et al., 2002; Tulving, 1985). One striking example of such overlapping deficits comes from hippocampal amnesia (Hassabis, Kumaran, Vann, & Maguire, 2007). Patients with damage to the hippocampus suffer from debilitating deficits of memory, losing the ability to remember details about their personal past and to form new memories following brain damage (Eichenbaum & Cohen, 2001). Evidence for a concurrent deficit in future thinking in hippocampal amnesia suggests that memory, at least the kind of memory that is supported by the hippocampus, plays an important role in future thinking (for further details, see Addis & Schacter, 2012).

The many consistent observations arising from the cognitive neuroscience literature have led to the suggestion that an important adaptive function of human memory is to provide the building blocks that make up the contents of future-oriented cognition (Schacter & Addis, 2007), along with other modes of cognition that rely on memory-based processing (Buckner & Carroll, 2007; for related theoretical interpretations, see Hassabis & Maguire, 2007, 2009). In support of such claims, more recent work with healthy populations that possess underdeveloped or deteriorating episodic memory systems, such as younger children (Atance, 2008; Busby & Suddendorf, 2005; Russell et al., 2010) and older adults (Addis et al., 2008; Gaesser et al., 2011), has likewise shown that these individuals exhibit an impoverished ability to engage in future-oriented MTT. Moreover, populations that possess varying degrees of episodic memory impairment, such as those diagnosed with Alzheimer's disease (Addis et al., 2009), mild cognitive impairment (Gamboz et al., 2010), schizophrenia (D'Argembeau et al., 2008), and post-traumatic stress disorder (Brown et al., 2013), also encounter difficulty in thinking about the future.

Ongoing research in this emerging field is focusing on delineating the extent to which the human brain represents temporal features of future- and past-oriented MTT (e.g., Nyberg et al., 2010; de Vito et al., 2012a, 2012b), the extent to which non-human animals are able to engage in FMTT (Corballis, 2013; Suddendorf, 2013), the role of general world knowledge—also known as semantic memory—and its interactions with episodic memory in supporting future-oriented cognition (Klein, 2013; Irish & Piguet, 2013), and in further decomposing the nature of neural

contributions to FMTT. For instance, recent advances in neuroimaging techniques applied to the study of FMTT have revealed that specific regions of the default network serve to represent details associated with specific components of simulated events (e.g., people, places, and scenarios; Hassabis et al., 2014; Szpunar, St. Jacques, et al., 2014). Lastly, it is important to keep in mind that various modes of thinking about the future can be subsumed under the overarching concept of FMTT. On a daily basis, people simulate events, make predictions about those events, form intentions, and plan for the future. Researchers are busily working to draw links and identify possible interactions among these various modes of future thinking.

Despite the wealth of data that has been amassed concerning FMTT and its relation to episodic memory, there nonetheless exists a lack of theoretical presuppostions and implications of this research. The present volume seeks to redress this imbalance by including chapters that foreground conceptual questions, drawing on the theoretical resources of a wide range of disciplines and speaking to readers based in these diverse fields.

2. THE PRESENT

The 19 contributions to the volume intersect in multiple ways, but we have grouped them into eight sections, determined by the following themes: the varieties of future-oriented cognition; relationships between FMTT and episodic memory; subjective temporality in FMTT; the self in FMTT; and functional, evolutionary and comparative, developmental, and clinical perspectives on FMTT.

2.1. Varieties of Future-Oriented Cognition

The bulk of the literature on FMTT so far has treated it primarily as a matter of *episodic* cognition, paying less attention to the wide variety of additional forms of future-oriented cognition of which we are capable. In Chapter 2, **Szpunar, Spreng, and Schacter** build on their recent work (Szpunar, Spreng, et al., 2014) to situate episodic FMTT with respect to the latter, developing a novel taxonomy of forms of future thinking and putting it to work in an exploration of interrelationships and interactions among them. Szpunar, Spreng, and Schacter see future thinking as falling into four basic categories: simulation, prediction, intention, and planning. They argue that these four forms of thought interact to support our capacity to think about the future from the initial stage of conceiving of possible future events to the final stage of bringing about the realization of a desired event. In keeping with a theme running through the rest of the volume, moreover, they argue that an exclusive focus on episodic thinking is bound to lead to an incomplete understanding of FMTT. Much of our future thinking is semantic in character, and they suggest that simulation, prediction, intention, and planning are sometimes episodic, sometimes semantic, and sometimes a hybrid of the two. Thus, for example, they review evidence suggesting that semantic simulation may be dissociable from episodic simulation, identifying future-oriented personal semantic cognition (Renoult et al., 2012) as a promising area for further investigation.

Overall, their taxonomy suggests that episodic forms of simulation, prediction, intention, and planning are better understood than their semantic and hybrid counterparts and that there is a need for additional work on the latter. Many of the remaining contributions to the volume take important steps in this direction.

2.2. Relationships Between Future-Oriented Mental Time Travel and Episodic Memory

While Szpunar, Spreng, and Schacter urge us to broaden our focus to include semantic and hybrid forms of future-oriented cognition, research on FMTT grows out of research on episodic memory, and the nature of the relationship between FMTT and episodic memory is still not fully understood. In Chapter 3, **Perrin** delineates two broad schools of thought about this matter. *Continuists* maintain that, despite the various differences between episodic memory and FMTT that have been observed at the neural, cognitive, and phenomenological levels, they are ultimately two instances of a single general capacity for MTT. *Discontinuists*, in contrast, maintain that the differences between them are sufficiently important for episodic memory and FMTT to constitute two distinct capacities.

Continuism is the dominant view in psychology and neuroscience, but Perrin himself favors discontinuism. Drawing on the philosophical literature on memory and mind, he identifies two apparent discontinuities between episodic memory and FMTT. The first is epistemological. Since the identities of the individuals involved in remembered episodes are fixed by the subject's past causal interactions with them, subjects engaged in episodic memory can commit errors of misidentification (Shoemaker, 1968) (i.e., they can make mistakes about the identities of the remembered individuals). In contrast, since the identities of the individuals involved in imagined future episodes are not fixed by past causal interactions, subjects engaged in FMTT cannot commit such errors. The second discontinuity is causal. In line with the causal theory of memory (Martin & Deutscher, 1966), Perrin argues that episodic memory presupposes a causal connection with past experiences, such that the subject who remembers an event must be numerically identical to the subject who experienced it, whereas FMTT presupposes neither causal connection nor identity. This second discontinuity is reflected in a subtle but important difference at the phenomenological level: whereas, in episodic memory, autonoesis is a necessary feature of the process and normally results from automatic, unconscious monitoring, in FMTT autonoesis need not occur and, when it does, it is the result of deliberate, conscious inference.

If discontinuism is right, it is a mistake to treat FMTT and episodic memory as differing only in their respective temporal orientations, and the concept of MTT would at best be misleading when applied to episodic memory. Defending a view of episodic memory as mental time travel (Michaelian, 2016), **Michaelian** in Chapter 4 responds to arguments for both *metaphysical* discontinuism, which posits a difference in kind between episodic memory and FMTT themselves, and *epistemological* discontinuism, which posits a difference in kind between the knowledge of past events produced by memory and the knowledge of future

events produced by FMTT. Against Perrin's argument, he maintains that episodic memory, like FMTT, does not presuppose a causal connection with the relevant event. Against Debus's related argument (2014), according to which episodic memory involves a relationship to a particular past event, while FMTT does not involve a relationship to a particular future event, he defends a unified view of the objects of memory and FMTT. Finally, he maintains that any mechanism capable of producing autonoesis in episodic memory is likewise capable of producing autonoesis in FMTT, and vice versa, concluding, on grounds of parsimony, in favor of a unified account of the phenomenology of FMTT. Turning to epistemological discontinuism, Michaelian responds both to older arguments for quantitative and qualitative differences between our knowledge of past events and our knowledge of future events and to Perrin's claim that immunity to error through misidentification is characteristic of FMTT but not of episodic memory; on the alternative view developed by Michaelian, immunity to error through misidentification is essential neither to episodic memory nor to FMTT, with some but not all instances of episodic memory being vulnerable to error through misidentification and some but not all instances of FMTT being immune to such error.

Continuism may receive further support from **Devitt and Addis**'s investigation of bidirectional interactions between episodic memory and FMTT in Chapter 5. It is natural to focus on the ways in which imagining the future is shaped by remembering the past, but Devitt and Addis urge us to attend equally to the impact that imagining the future can have on remembering the past. Hence their chapter investigates both the ways in which memory contributes to the simulation of future events and the ways in which imagination influences memory. Under the former heading, they point out that, on both the constructive episodic simulation hypothesis (Schacter & Addis, 2007) and the scene construction hypothesis (Hassabis & Maguire, 2007), access to remembered information underwrites our capacity for phenomenologically rich simulation of both past and future events. Under the latter heading, they argue that the characteristics of imagined episodes influence both false memories of events and accurate memories of imagined events. The ability to remember the future is adaptive only given that imagined events are made available, through memory, for future use, and the encoding and retrieval of imagined events are themselves affected by the characteristics of those events, including vividness, plausibility, emotional valence, and field versus observer perspective. When imagined events rate highly on these characteristics, however, they may be mistaken for memories of real events; thus imagination may give rise to false memory, as in imagination inflation (Garry et al., 1996).

The research reviewed by Devitt and Addis supports a view on which information stored in memory makes symmetrical contributions to the process of remembering the past and the process of imagining the future, with the distinction between remembered and imagined events being an outcome of further processing by the subject. Such a view would appear to favor continuism, but the debate between continuists and discontinuists also depends on a number of more specific issues. One such issue is the role of autonoetic consciousness and subjective temporality more generally in episodic memory and FMTT; this is the focus of the following section.

2.3. Subjective Temporality in Future-Oriented Mental Time Travel

Dalla Barba in Chapter 6 builds on his earlier work on memory, consciousness, and temporality (Dalla Barba, 2002) to argue that information stored in memory, while providing the raw ingredients for both remembering the past and imagining the future, has no intrinsic temporal dimension; the temporal dimension of MTT is a further ingredient, supplied by temporal consciousness. In contrast to *knowing* consciousness, which grounds impersonal awareness of information about past and future events, *temporal* consciousness—closely related to Tulving's (1985) concept of autonoetic consciousness—enables the subject to orient himself to his personal past and future. The absence or distortion of temporal consciousness provides an elegant explanation of the patterns of confabulation observed in amnesic patients, with confabulation resulting from distortion of temporal consciousness (due to damage to the hippocampus), while outright loss of temporal consciousness (due to complete destruction of the hippocampus) does not result in confabulation, since patients with no temporal consciousness have no capacity to orient themselves with respect to subjective time.

Whereas Dalla Barba sees a largely symmetrical role for temporal consciousness in episodic memory and FMTT, **Klein and Steindam** (Chapter 7) see a potential asymmetry, arguing that FMTT involves a diverse range of capacities, only some of which depend on episodic memory and its characteristic form of subjective time. In line with Szpunar, Spreng, and Schacter's taxonomy, they argue against the assumption that FMTT stands in a privileged relationship to episodic memory, citing research that demonstrates the possibility of semantic memory-based FMTT. They argue, moreover, that this research demonstrates that FMTT is not characterized by a unitary form of subjective temporality. On their view, when FMTT does draw on episodic memory, its phenomenology is that of *lived time*: the subject has a pre-reflective sense that he is "pre-living" a possible future, a counterpart of the pre-reflective sense of reliving the past that is characteristic of episodic memory. When it draws on semantic memory, in contrast, the phenomenology of FMTT is that of *known time*, inferential rather than pre-reflective and experienced as impersonal rather than as pre-living (Klein et al., 2002). Lived time maps onto Dalla Barba's concept of temporal consciousness and Tulving's concept of autonoetic consciousness, but known time maps neither onto Dalla Barba's concept of knowing consciousness nor onto Tulving's concept of noetic consciousness, since both of the latter lack a strictly temporal dimension. It does, however, align with the philosophical distinction between the A-series, in which time is experienced as flowing from future to past, and the B-series, in which time is experienced as a fixed before-and-after relationship (McTaggart, 1908). While the distinction between the A-series and the B-series has informed little FMTT research to date, Klein and Steindam's contribution suggests that gains in conceptual clarity are to be had by taking both of these forms of subjective time into account.

While Dalla Barba, on the one hand, and Klein and Steindam, on the other hand, provide distinct accounts of subjective temporality in episodic memory and FMTT, they are in agreement on its centrality. **De Brigard and Gessell**, in contrast, call the centrality of subjective temporality into question in Chapter 8. Their starting point is the now-familiar observation that episodic memory and FMTT engage a common

set of brain regions, the default network. A standard explanation for this observation is the *tensed content* view, according to which the default network is concerned with simulating episodes with explicit temporal content. Against the tensed content view, De Brigard and Gessell invoke evidence that the default network is engaged not only when imagining temporally located episodes but also when imagining episodes with no temporal location, as well as evidence that patients with hippocampal amnesia have an impaired capacity to imagine episodes without an explicit temporal location, despite remaining capable of other forms of temporal thought. Their alternative explanation of the involvement of the default network in episodic memory, FMTT, and other forms of episodic thought is the *dynamic structure* view, which relies on the distinction between intentional contents (how a mental state represents something) and representational vehicles (the brain structure that realizes a mental state with representational content). Contents can be temporal (i.e., the state can have tensed content), but so can vehicles (i.e., the state can itself have a dynamic character), and, on their view, it is the dynamic character of the vehicles of episodic simulation that accounts for the involvement of the default network in simulating both temporally located episodes and episodes with no determinate temporal location. Damage to the default network would thus account for amnesic patients' inability to imagine past, future, and non-temporal episodes, despite their preserved ability to engage in other forms of temporal thought.

While the dynamic structure view will require further investigation, De Brigard and Gessell suggest that it may provide a means of reconciling the constructive episodic simulation hypothesis and the scene construction hypothesis, a suggestion that harmonizes with Devitt and Addis's treatment of the relationship between these hypotheses.

2.4. The Self in Future-Oriented Mental Time Travel

The dynamic structure view is friendly to the idea that FMTT may ultimately depend as much on semantic memory as it does on episodic memory. The role of semantic memory in MTT is examined in detail in Chapter 9 by **Manning**, who further links it to the role of the self. Building on a rich body of empirical and theoretical literature, Manning explores the relationship between, on the one hand, episodic and semantic forms of MTT and, on the other hand, the *I-self*—the phenomenological, knowing self—and the *Me-self*—the conceptual, known self (James, 1890). In a departure from Tulving's (2005) influential view, which focuses on links between FMTT and the I-self and episodic memory, she foregrounds links between FMTT and the Me-self and semantic memory. The Me-self grounds the subject's capacity to think of his or her personal attributes and has a conceptual, semantic character. Specific, episodic memories may provide constraints on what the Me-self can be imagined to become in the future, but semanticized information about the self may also provide a critical input to simulations of future events that are compatible with the subject's self-knowledge. The I-self, in turn, grounds the subject's capacity to project himself or herself into possible past and futures in a phenomenologically rich manner. Ultimately, however, there may be a sense in which episodic memory is primary in MTT, since, while the Me-self and semantic memory provide inputs to simulations of future events, Manning emphasizes that

the semanticized memories that feed into FMTT originate in episodic memories based on the I-self.

As the exchange between Perrin and Michaelian demonstrates, both the role of autonoetic consciousness and its determinants are controversial questions. **D'Argembeau**'s Chapter 10 is focused on the latter question, exploring the possibility that autonoesis depends not only on the subject's simulation of an event but also on contextualization of the event within knowledge of the self, with knowledge of personal goals, in particular, playing a central role. Paralleling autobiographical knowledge of the personal past, knowledge of the personal future consists of a variety of components, including the representations of possible selves described by Manning, as well as future life periods, general events, and cultural life scripts. D'Argembeau argues, first, that only when they are consistent with such knowledge are simulations of future events experienced as belonging to the personal future. He argues, second, that knowledge of personal goals plays an especially central role here. In support of the latter claim, he adduces evidence that activating knowledge of personal goals is a common first step in episodic future thinking, with personal goals being used to guide simulation of events, that memories of simulated future episodes are more easily accessed when they are relevant to personal goals, and that autobiographical knowledge plays a role in linking and organizing representations of specific future episodes, as well as neuroimaging evidence supporting the link between FMTT and goal processing. In support of the former claim, he reviews evidence that the importance of a simulated future event with respect to personal goals contributes to the involvement of autonoesis in FMTT.

In addition to reinforcing the plausibility of the claim that semantic memory makes critical contributions to FMTT, Manning's and D'Argembeau's discussions of the role of the self resonate with the suggestion—made in a number of contributions in subsequent sections—that FMTT may have much of its beneficial impact on future-directed decision-making via its interaction with the subject's personal goals.

2.5. Functional Perspectives

In one of several chapters to discuss the impact of FMTT on future-directed decision-making, **Debus**, in an exploration of the nature and the value of FMTT in Chapter 11, cautions that it may in fact have both benefits and costs. Beginning with the nature of FMTT, she echoes De Brigard and Gessell's observation that, in addition to imagining future events, subjects can imagine past events, present events, and events with no determinate temporal location, arguing that imagining future events differs from imagining events of these other types, first, in that the imagined event is subjectively located in the future (the "specific temporal orientation" claim) and, second, in that the future (unlike the past or the present) is, in an important sense, open (the "openness" claim). Rejecting interpretations of the specific temporal orientation claim on which future-orientation is a matter of temporal phenomenology, Debus argues, in line with D'Argembeau's approach, that it is determined by the occurrence of the event in the context of relevant future-directed *beliefs*. Rejecting both metaphysical and epistemological interpretations of the openness claim, Debus argues that the openness of the future is to be understood in agential

terms, in the sense that the subject himself or herself is in principle able to affect the occurrence of the event in question. Turning from the nature of FMTT to its value, Debus argues that the value of imagining future events lies in the effect that doing so can have on their realization, in part by motivating the subject to bring them about. But she also notes that FMTT can in some cases have an opposite, demotivating effect.

In contrast to Debus's focus on the impact of FMTT itself, **Hoerl and McCormack** focus in Chapter 12 on the function of episodic memory in future-oriented decision-making. Though there is little consensus in the literature on the function of episodic memory, there is increasing agreement that its function is in some important sense future-oriented. Hoerl and McCormack's key insight is that the function of episodic memory may be future-oriented, not merely in the sense that it provides the raw ingredients for the simulation of future events, but also in the sense that it is a prerequisite for the ability to feel the emotion of *regret* (e.g., over how a given past event might have turned out differently had one chosen differently), hence shaping decisions (e.g., by leading one to choose differently on future occasions). Picking up on recent work on the role of regret in decision-making, they argue that regret may have an impact on future choices both by motivating one to choose differently when faced with similar choices and, more generally, by motivating one not to miss opportunities. Considering how episodic memory might underlie the ability to experience regret, Hoerl and McCormack argue that experiencing regret presupposes the ability to mentally project oneself into a particular past situation, as well as to understand that the situation might have unfolded differently than it did in fact. Considering how episodic memory might underlie the ability to anticipate regret, they argue that anticipating regret presupposes the ability to project oneself forward into a possible future situation, as well as the ability to imagine one's future self looking back on—remembering—one's present decision. That regret presupposes episodic memory in both of these ways is supported by the research on episodic counterfactual thinking discussed by De Brigard and Gessell, as well as research on the loss of ability to experience regret in episodic amnesia. Having made a case for the view that episodic memory is a prerequisite for the ability to feel regret, Hoerl and McCormack argue that regret is indeed involved in adaptive decision-making, since there is no simpler alternative mechanism that might play the same role.

Like Debus, **Pezzulo** focuses directly on FMTT in Chapter 13. His aim, however, is to situate FMTT in the context of a broader future-oriented perspective on cognition as a whole in order to shed light on the relationship between MTT and *predictive processing*. There is increasing consensus that the brain is functionally oriented toward the future, constantly generating short-term and longer-term predictions. As illustrated by research on internally generated sequences in the rodent hippocampus—which enable rodents not only to revisit spatial paths that they have actually taken but also to explore counterfactual and possible future paths—predictive processing requires the brain to self-generate information, as opposed to extracting it from sensory stimuli. Pezzulo speculates that such internally generated dynamics, which require an ability to detach from the agent's current context, might underlie more sophisticated forms of detached cognition, including past- and future-oriented MTT and episodic counterfactual thought. A link between simpler forms of predictive processing and more sophisticated forms of episodic

cognition could shed light on the evolution of MTT by showing how the latter, highly complex capacity might have emerged on the basis of considerably simpler capacities. With respect to the adaptive benefits of phenomenologically rich FMTT, in particular, Pezzulo suggests that the sense of "pre-experiencing" that is characteristic of FMTT might enable the subject not only to anticipate the outcomes of future decisions but also to evaluate them in the here and now by anticipating his or her own future evaluative responses.

The three chapters in this section contribute to our increasingly sophisticated functional understanding of FMTT. As Pezzulo's chapter suggests, however, function can only be fully understood from an evolutionary perspective, and the chapters in the following section turn to the evolution of our capacity for FMTT.

2.6. Evolutionary and Comparative Perspectives

Thom and Clayton in Chapter 14 review the ongoing debate over MTT in animals. In the debate so far, the main challenge for partisans of animal MTT has been to identify clear counterexamples to the Bischof-Köhler hypothesis, according to which animals cannot anticipate future needs that differ from present needs (Suddendorf & Corballis, 2007). Identifying such counterexamples is problematic due to the difficulty of ruling out the possibility that apparently future-oriented behavior is in fact governed by current drive states. Seeking to resolve this difficulty, proponents of animal MTT have employed ingenious experiments to provide evidence of FMTT in great apes, other primates, and birds, but the evidence so far remains inconclusive. Rather than seeking further evidence of the same sort, Thom and Clayton suggest that the lack of firm conclusions in this area may in part reflect the limitations of the Bischof-Köhler hypothesis itself, arguing that consideration of the case of *human* FMTT shows that dissociating from current needs is neither necessary nor sufficient for engaging in FMTT. As opposed to looking at the evolutionary emergence of the capacity for MTT as a whole, they maintain, we would do better to focus on the emergence of the more specific cognitive capacities that give rise to it—if these, taken individually, have adaptive benefits, it becomes increasingly plausible to see animal and human MTT as continuous.

A similarly optimistic take on animal MTT is developed by **Martin-Ordas** in Chapter 15. Focusing on autonoesis, she points out that treating the presence of autonoetic phenomenology as a criterion for MTT makes it difficult to determine whether non-human animals, who cannot provide verbal reports on their phenomenology, are capable of MTT in the same sense as humans. Guided by the Bischof-Köhler hypothesis, researchers have therefore focused on criteria such as flexibility, learning from single experiences, and the absence of relevant stimuli in the present environment. Building on some of the same studies discussed by Thom and Clayton, Martin-Ordas similarly argues both that there is some evidence for MTT in animals and that the Bischof-Köhler hypothesis has important limitations. But whereas Thom and Clayton argue that dissociation from current needs is neither necessary nor sufficient for FMTT, Martin-Ordas argues that tests based on the hypothesis presuppose distinctions between episodic and semantic memory and between memory and foresight, which may ultimately be less than clear. In light of these points, standard criticisms of evidence for MTT in animals—especially

great apes—begin to look less convincing. Martin-Ordas does not deny that human MTT is considerably more complex than animal MTT. But, adopting an anthropological perspective, she does suggest that this additional complexity might derive not from autonoesis but rather from semantic knowledge, since human planning, especially long-term planning, often depends less on episodic than on semantic knowledge. Much of the latter, in turn, is intergenerationally transmitted, opening up the possibility of cultural variability in FMTT. Thus Martin-Ordas suggests that, in addition to investigating similarities and differences between FMTT in animals and in humans, we investigate similarities and differences between FMTT in different human populations.

Like Martin-Ordas, **Corballis** (Chapter 16) is optimistic with respect to animal MTT, even while calling our attention to the unique features of human MTT. Drawing on some of the same research on the rat hippocampus cited by Pezzulo, Corballis suggests that at least basic forms of MTT may not be unique to humans, indeed that they may go far back in evolution. Human MTT, however, is clearly more complex than any form of MTT for which we have evidence in animals, in part because it is linked to more general forms of mind wandering, which greatly augment the powers of MTT, allowing us to anticipate not only likely future events but also a much broader range of possible events, thus preparing ourselves for the unexpected. Mind wandering overlaps with theory of mind, which in turn is a prerequisite for linguistic communication, since language use requires us to anticipate the mental states of others. And language, in turn, allows us to share the results of our mind wandering, which we do primarily through storytelling. It may ultimately be the link with storytelling that is the most distinctive feature of human MTT; indeed, the emergence of the capacity for storytelling may have marked a key step in human evolution (Scalise Sugiyama, 2011). Thus the overall message that emerges from Corballis's contribution, as well as the other contributions in this section, is that, while there may be precursors of MTT in other species, human MTT has important unique features.

2.7. Developmental Perspectives

Studying MTT in animals presents many of the same challenges as studying it in children. Bridging evolutionary and developmental perspectives, **Suddendorf, Brinums, and Imuta** in Chapter 17 investigate the role of FMTT in enabling the subject to shape his or her future self through the deliberate practice of motor skills. They point out that, while the improvement of such skills depends on changes to procedural systems, practice that results in changes can itself be triggered by imagining a future self with improved skills. There are controversies over the role of deliberate practice in enabling subjects to achieve the highest levels of performance, but it is clear that practice is an important factor in enabling us to achieve some level of improvement in our performance in various areas. Similarly, there are controversies over the ability of non-human animals to engage in FMTT, but it is clear that flexible, long-term foresight is restricted to humans. Hence the improvement of motor skills through deliberate practice is likely to be uniquely human. Indeed, Suddendorf, Brinums, and Imuta argue that deliberate practice, enabled by FMTT, might well have been a prerequisite for the emergence, in evolutionary

time, of recognizably human culture, given that it is critical to the characteristically human ability to specialize in order to respond to shifting environmental demands (and to reshape the environment itself). Turning from evolution to development, Suddendorf, Brinums, and Imuta describe the gradual emergence of deliberate practice in children through the development of the multiple capacities that it presupposes, suggesting that the building blocks of deliberate practice are in place around the time children start formal schooling. Finally, they describe an initial study (Davis et al., in press) on the development of deliberate practice in children, which provides some confirming evidence for this suggestion.

A more general take on FMTT in children is provided in Chapter 18 by **Atance and Mahy**, who review both verbal and behavioral approaches to studying children's capacity to mentally project into the future. Verbal methods have provided evidence that, while they are able to anticipate the future, 3-year-olds have difficulty *accurately* anticipating the future. Due to concerns about the appropriateness of using verbal methods with children who have an imperfect grasp of the meanings of temporal terms, researchers have also investigated FMTT in children using behavioral methods—akin to those used to study MTT in non-human animals—inspired by Tulving's (2005) "spoon test," which requires the subject to act now in anticipation of a situation likely to be faced in the future. Such behavioral methods have provided evidence that memory limitations—the inability to remember relevant past information—may account for children's failures in some episodic future thinking tasks, and there is indeed evidence for a correlation between children's ability to think about the past and their ability to think about the future. In addition to episodic memory, however, the development of theory of mind and executive function may be important to explaining the development of FMTT in children. As there is little developmental work on the contributions of these factors, this remains an important area for future research.

2.8. Clinical Perspectives

Insights into the nature and mechanisms of FMTT can be gleaned not only from comparisons between humans and non-human animals and between adults and children, but also from comparisons between clinical and non-clinical populations. The final two contributions to the volume present clinical perspectives on FMTT.

Integrating findings on FMTT in clinical populations with functional neuroimagining studies of FMTT in healthy individuals, **Irish** in Chapter 19 examines the pivotal role played by semantic memory in FMTT. Going back to Tulving's foundational work (Tulving, 1972), semantic memory has been understood as lacking a conscious temporal dimension, and the standard view is that episodic memory, via autonoetic consciousness, provides the essential foundation for MTT into both past and future. There is, however, mounting evidence of significant interplay between episodic and semantic memory (e.g., overlap between the semantic memory system and the core network). Moreover, semantic representations, which are abstracted from multiple experiences, are more flexible and hence well suited to projection into future contexts; indeed, due to the lesser flexibility of episodic representations, it is plausible that semantic memory may not only facilitate FMTT but may even be essential to it. Irish therefore argues that we should expect to find that semantic

memory makes important contributions to FMTT. After briefly reviewing relevant neuroimagining evidence, she turns to studies of amnesia and semantic dementia, which show that patients with episodic amnesia may be capable of temporal consciousness based on semantic memory, whereas patients with semantic dementia have impaired FMTT despite preserved episodic memory. These findings support the *semantic scaffolding* hypothesis, according to which semantic knowledge provides the framework enabling simulation of past and future events (Irish & Piguet, 2013). The semantic scaffolding hypothesis, in turn, fits with the taxonomy developed by Szpunar, Spreng, and Schacter in Chapter 2, which situates episodic and semantic forms of FMTT as points on a continuum.

In Chapter 20, **Ernst and Manning** review the findings of behavioral and neuroimaging studies of FMTT impairments in multiple sclerosis (MS) patients. MS is accompanied by a variety of cognitive impairments, and Ernst and Manning argue that there is indeed a neural and cognitive basis for FMTT impairment in MS, ruling out a psychological basis on the ground that similar patterns of impairment are observed in MS patients in both FMTT and autobiographical memory. A comparison of FMTT impairments in MS patients and FMTT impairments in other clinical populations leads them to suggest that MS primarily affects the early stages of the process of simulating future events, with patients having difficulty extracting and recombining details into novel and coherent events. At the structural level, they argue that the impairments result from changes to a widespread brain network, consistent with the diffuse nature of the brain lesions characteristic of MS. Finally, they turn to strategies for improving autobiographical memory functioning to assess the possibilities for cognitive rehabilitation of FMTT in MS patients, finding that the use of mental visual imagery provides a particularly promising means of improving not only autobiographical memory but also FMTT.

3. THE FUTURE

What is likely to come next in FMTT research? Collectively, the contributions to this volume identify a number of promising areas for future research.

- *The diversity of FMTT*: There are important differences and complex interactions among different forms of FMTT. Future research is unlikely to focus only on episodic forms of FMTT or to assume that episodic memory is necessarily involved in every form of FMTT. In particular, we are likely to see more research on the contribution of semantic memory to FMTT and on semantic and hybrid forms of FMTT.
- *The basis of MTT*: Restricting our attention to episodic MTT, there are arguments both in favor of the primacy of episodic memory and in favor of the primacy of FMTT. This question is particularly thorny, as it intersects in complex ways with comparative, developmental, and clinical questions.
- *Subjective temporality*: Multiple frameworks for understanding temporal phenomenology are on offer; it is unclear to what extent these can be reconciled. More broadly, it remains to be seen whether the temporal

dimension of MTT is to be understood primarily in terms of phenomenology, content, or representational vehicles.

- *The self and time*: Both the self and time are usually viewed as being essential to FMTT. It is becoming increasingly evident that there are multiple forms of self and multiple forms of time that might be involved in MTT, and there are arguments for viewing neither the self nor time as being essential to the basic capacity underlying MTT. Untangling the relations among the various forms of MTT, self, and time is likely to be an especially challenging theoretical task.
- *Function and evolution of MTT*: A range of costs and benefits of FMTT have been identified, and many competing explanations of the evolution of FMTT have been proposed; it remains to be seen to what extent these accounts can be reconciled with each other.
- *Components of FMTT*: The relationship of FMTT to more basic forms of future-oriented cognition is another area that will feed back into our evolutionary understanding of the capacity. Evolutionary, developmental, and clinical studies are also increasingly taking into account the way in which various more fine-grained cognitive capacities interact to give rise to the capacity for the kind of FMTT we find in adult humans. This might represent a way out of the impasse over MTT in non-human animals.

In our view, three general points should be kept in mind going forward. First, while FMTT has often been taken to be a general neurocognitive capacity whose different manifestations are largely a function of situational and motivational contingencies, there are conceptual and empirical difficulties for this view. The contributions to the volume suggest that FMTT has a number of distinct neurocognitive underpinnings and that the diversity of its empirical presentation is not merely superficial variation resulting from task demands; rather, it reflects the fact that there is not a single, uniform capacity for FMTT—there are different ways of imagining the future, underwritten by distinct mechanisms. Compare, for example, imagining what one will do tomorrow with imagining what will happen on a camping trip with imagining what one will be like in 10 years. These and other forms of FMTT may be only loosely related in virtue of their concern with possible futures. Research on FMTT has often assumed that episodic memory is the common factor that lends an underlying unity to this apparent diversity. But, as a number of the contributors argue, this assumption is increasingly ill supported. At this stage, a possibility deserving of serious consideration is that the treatment of FMTT as a unified psychological faculty is largely a matter of methodological convenience, together with a desire for theoretical parsimony. While parsimony is a laudable goal in theory construction, it may nevertheless turn out to be the case that the search for a common mechanism underlying the various forms of FMTT is futile.

Second, as a number of the chapters in this volume indicate, it is becoming increasingly clear that greater consideration is needed of those aspects of consciousness that enable retrieved mental content to be imagined and considered with respect to its implications for future behavior. It remains to be seen whether this is Tulving's autonoetic consciousness, Dalla Barba's temporal consciousness, or Klein and Steindam's lived temporality, but it is likely to be the case that no single form of

subjective temporality can account for all FMTT in its various manifestations. The sooner we begin sustained investigation of the conscious processes that enable us to transcend the present, the sooner we will come to terms with exactly what it means to engage in the act of mental time travel.

Finally, we suggest caution with respect to the tendency to assume that empirical studies are sufficient by themselves to shed light on the nature of FMTT. The history of psychological science suggests that the mere accumulation of data, often in support of very local theories, has sometimes stood in for the development of more global understanding of the phenomena in question. If they are to be fully appreciated, the diverse phenomena constituting acts of FMTT need to be securely situated in a broader understanding of the workings of the mind. It is our hope that the present volume moves us significantly closer to this goal.

REFERENCES

Addis, D. R., Sacchetti, D. C., Ally, B. A., Budson, A. E., & Schacter, D. L. (2009). Episodic simulation of future events is impaired in mild Alzheimer's disease. *Neuropsychologia*, *47*, 2660–2671.

Addis, D. R., & Schacter, D. L. (2012). The hippocampus and imagining the future: where do we stand? *Frontiers in Human Neuroscience*, *5*, 173.

Addis, D. R., Wong, A. T., & Schacter, D. L. (2007). Remembering the past and imagining the future: common and distinct neural substrates during event construction and elaboration. *Neuropsychologia*, *45*, 1363–1377.

Addis, D. R., Wong, A. T., & Schacter, D. L. (2008). Age-related changes in the episodic simulation of future events. *Psychological Science*, *19*, 33–41.

Atance, C. M. (2008). Future thinking in young children. *Current Directions in Psychological Science*, *17*, 295–298.

Atance, C. M., & O'Neill, D. K. (2001). Episodic future thinking. *Trends in Cognitive Sciences*, *5*(12), 533–539.

Benoit, R. G., & Schacter, D. L. (2015). Specifying the core network supporting episodic simulation and episodic memory by activation likelihood estimation. *Neuropsychologia*, *75*, 450–457.

Brown, A. D., Root, J. C., Romano, T. A., Chang, L. J., Bryant, R. A., & Hirst, W. (2013). Overgeneralized autobiographical memory and future thinking in combat veterans with posttraumatic stress disorder. *Journal of Behavioral Therapy and Experimental Psychiatry*, *44*, 129–134.

Buckner, R. L., Andrews-Hanna, J. R., & Schacter, D. L. (2008). The brains default network: anatomy, function, and relevance to disease. *Annals of the New York Academy of Sciences*, *1124*, 1–38.

Buckner, R. L., & Carroll, D. C. (2007). Self-projection and the brain. *Trends in Cognitive Sciences*, *11*, 49–57.

Busby, J., & Suddendorf, T. (2005). Recalling yesterday and predicting tomorrow. *Cognitive Development*, *20*, 362–372.

Corballis, M. C. (2013). Mental time travel: a case for evolutionary continuity. *Trends in Cognitive Sciences*, *17*, 5–6.

D'Argembeau, A., Raffard, S., & Van der Linden, M. (2008). Remembering the past and imagining the future in schizophrenia. *Journal of Abnormal Psychology*, *117*, 247–251.

D'Argembeau, A., & Van der Linden, M. (2004). Phenomenal characteristics associated with projecting oneself back into the past and forward into the future: influence of valence and temporal distance. *Consciousness and Cognition*, *13*, 844–858.

D'Argembeau, A., & Van der Linden, M. (2006). Individual differences in the phenomenology of mental time travel: the effects of vivid imagery and emotion regulation strategies. *Consciousness and Cognition*, *15*, 342–350.

Dalla Barba, G. (2002). *Memory, consciousness, and temporality*. Boston: Kluwer.

Davis, J. T. M., Cullen, E., & Suddendorf, T. (In press). Understanding deliberate practice in preschool aged children. *The Quarterly Journal of Experimental Psychology*. DOI: 10.1080/17470218.205.1082140.

de Vito, S., Gamboz, N., & Brandimonte, M. A. (2012a). What differentiates episodic future thinking from complex scene imagery? *Consciousness and Cognition*, *21*, 813–823.

de Vito, S., Gamboz, N., Brandimonte, M. A., Barone, P., Amboni, M., & Della Sala, S. (2012b). Future thinking in Parkinson's disease: an executive function? *Neuropsychologia*, *50*, 1494–1501.

Debus, D. (2014). "Mental time travel": remembering the past, imagining the future, and the particularity of events. *Review of Philosophy and Psychology*, 5(3), 333–350.

Eichenbaum, H. E., & Cohen, N. J. (2001). *From conditioning to conscious recollection: memory systems of the brain*. New York: Oxford University Press.

Gaesser, B., Sacchetti, D. C., Addis, D. R., & Schacter, D. L. (2011). Characterizing age-related changes in remembering the past and imagining the future. *Psychology and Aging*, *26*, 80–84.

Gamboz, N., de Vito, S., Brandimonte, M. A., Pappalardo, S., Galeone, F., Iavarone, A., & Della Sala, S. (2010). Episodic future thinking in amnesic mild cognitive impairment. *Neuropsychologia*, *48*, 2091–2097.

Garry, M., Manning, C., Loftus, E., & Sherman, S. (1996). Imagination inflation: imagining a childhood event inflates confidence that it occurred. *Psychonomic Bulletin & Review*, *3*(2), 208–214.

Hassabis, D., Kumaran, D., Vann, S. D., & Maguire, E. A. (2007). Patients with hippocampal amnesia cannot imagine new experiences. *Proceedings of the National Academy of Sciences U S A*, *104*, 1726–1731.

Hassabis, D., & Maguire, E. A. (2007). Deconstructing episodic memory with construction. *Trends in Cognitive Sciences*, *11*(7), 299–306.

Hassabis, D., & Maguire, E. A. (2009). The construction system of the brain. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, *364*(1521), 1263–1271.

Hassabis, D., Spreng, R. N., Rusu, A. A., Robbins, C. A., Mar, R. A., & Schacter, D. L. (2014). Imagine all the people: how the brain creates and uses personality models to predict behavior. *Cerebral Cortex*, *24*, 1979–1987.

Irish, M., & Piguet, O. (2013). The pivotal role of semantic memory in remembering the past and imagining the future. *Frontiers in Behavioral Neuroscience*, *7*(27).

James, W. (1890). *The principles of psychology*. New York: Holt.

Klein, S. B. (2013). The temporal orientation of memory: it's time for a change of direction. *Journal of Applied Research in Memory and Cognition*, *2*(4), 222–234.

Klein, S. B., Loftus, J., & Kihlstrom, J. F. (2002). Memory and temporal experience: the effects of episodic memory loss on an amnesic patient's ability to remember the past and imagine the future. *Social Cognition*, *20*(5), 353–379.

Martin, C. B., & Deutscher, M. (1966). Remembering. *The Philosophical Review*, *75*(2), 161–196.

McTaggart, J. E. (1908). The unreality of time. *Mind*, *17*(68), 457–474.

Michaelian, K. (2016). *Mental time travel: episodic memory and our knowledge of the personal past*. Cambridge, MA: MIT Press.

Nyberg, L., Kim, A. S., Habib, R., Levine, B., & Tulving, E. (2010). Consciousness of subjective time in the brain. *Proceedings of the National Academy of Sciences U S A*, *107*, 22356–22359.

Okuda, J., Fujii, T., Ohtake, H., Tsukiura, T., Tanji, K., Suzuki, K., Kawashima, R., Fukuda, H., Itoh, M., & Yamadori, A. (2003). Thinking of the future and past: the roles of the frontal pole and the medial temporal lobes. *NeuroImage*, *19*, 1369–1380.

Raichle, M. E., MacLeod, A. M., Snyder, A. Z., Powers, W. J., Gusnard, D. A., & Shulman, G. L. (2001). A default mode of brain function. *Proceedings of the National Academy of Sciences U S A*, *98*, 676–682.

Renoult, L., Davidson, P. S. R., Palombo, D. J., Moscovitch, M., & Levine, B. (2012). Personal semantics: at the crossroads of semantic and episodic memory. *Trends in Cognitive Sciences*, *16*(11), 550–558.

Russell, J., Alexis, D., & Clayton, N. S. (2010). Episodic future thinking in 3- to 5-year-old children: the ability to think of what will be needed from a different point of view. *Cognition*, *114*, 56–71.

Scalise Sugiyama, M. (2011). The forager oral tradition and the evolution of prolonged juvenility. *Frontiers in Psychology*, *2*(133).

Schacter, D. L., & Addis, D. R. (2007). The cognitive neuroscience of constructive memory: remembering the past and imagining the future. *Philosophical Transactions of the Royal Society of London B: Biological Sciences*, *362*(1481), 773–786.

Schacter, D. L., Addis, D. R., & Buckner, R. L. (2007). Remembering the past to imagine the future: the prospective brain. *Nature Reviews Neuroscience*, *8*(9), 657–661.

Schacter, D. L., Addis, D. R., Hassabis, D., Martin, V. C., Spreng, R. N., & Szpunar, K. K. (2012). The future of memory: remembering, imagining, and the brain. *Neuron*, *76*, 677–694.

Shoemaker, S. (1968). Self-reference and self-awareness. *Journal of Philosophy*, *65*, 555–567.

Spreng, R. N., & Levine, B. (2006). The temporal distribution of past and future autobiographical events across the lifespan. *Memory & Cognition*, *34*, 1644–1651.

Suddendorf, T. (2013). Mental time travel: continuities and discontinuities. *Trends in Cognitive Sciences*, *17*, 151–152.

Suddendorf, T., & Corballis, M. C. (1997). Mental time travel and the evolution of the human mind. *Genetic, Social, and General Psychology Monographs*, *123*(2), 133–167.

Suddendorf, T., & Corballis, M. C. (2007). The evolution of foresight: what is mental time travel, and is it unique to humans? *Behavioral and Brain Sciences*, *30*, 299–313.

Szpunar, K. K. (2010). Episodic future thought: an emerging concept. *Perspectives on Psychological Science*, *5*(2), 142–162.

Szpunar, K. K., Spreng, R. N., & Schacter, D. L. (2014). A taxonomy of prospection: introducing an organizational framework for future-oriented cognition. *Proceedings of the National Academy of Sciences*, *111*(52), 18414–18421.

Szpunar, K. K., St. Jacques, P. L., Robbins, C. A., Wig, G. S., & Schacter, D. L. (2014). Repetition-related reductions in neural activity reveal component processes of mental simulation. *Social Cognitive and Affective Neuroscience*, *9*, 712–722.

Szpunar, K. K., Watson, J. M., & McDermott, K. B. (2007). Neural substrates of envisioning the future. *Proceedings of the National Academy of Sciences U S A*, *104*, 642–647.

Tulving, E. (1972). Episodic and semantic memory. In E. Tulving & W. Donaldson (eds.), *Organization of memory* (pp. 381–403). New York: Academic Press.

Tulving, E. (1983). *Elements of episodic memory*. Oxford: Oxford University Press.

Tulving, E. (1985). Memory and consciousness. *Canadian Psychology/Psychologie canadienne*, *26*(1), 1–12.

Tulving, E. (2005). Episodic memory and autonoesis: uniquely human? In H. S. Terrace & -J. Metcalfe (eds.), *The missing link in cognition: origins of self-reflective consciousness* (pp. 3–56). Oxford: Oxford University Press.

Wheeler, M. A., Stuss, D. T., & Tulving, E. (1997). Toward a theory of episodic memory: the frontal lobes and autonoetic consciousness. *Psychological Bulletin*, *121*(3), 331–354.