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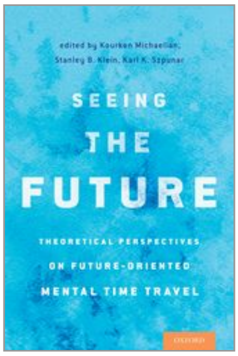

Seeing the Future: Theoretical Perspectives on Future-Oriented Mental Time Travel
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Print publication date: 2016
Print ISBN-13: 9780190241537
Published to Oxford Scholarship Online: June 2016
DOI: 10.1093/acprof:oso/9780190241537.001.0001

Toward a Taxonomy of Future Thinking

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DOI:10.1093/acprof:oso/9780190241537.003.0002

Abstract and Keywords

Chapter 2 presents an overview of a recent framework for organizing the concept of prospection—the ability to represent what might happen in the future. This framework parses prospective cognition into four basic modes of future thinking that vary in the extent to which they draw upon episodic and semantic knowledge: simulation, prediction, intention, and planning. The authors highlight how this framework can be used to draw attention to the ways in which various modes of future thinking interact with one another, generate new questions about prospective cognition, and illuminate the understanding of disorders of future thinking. The chapter concludes by considering the manner in which basic cognitive operations such as mental contrasting can be used to expand the purview of prospective cognition by building on the more basic modes of future thinking.

Keywords: Prospection, simulation, prediction, intention, planning

The contents of the present volume clearly demonstrate that the topic of future-oriented mental time travel has made a significant impact in the fields of philosophy, psychology, and neuroscience. In this chapter, we evaluate future-oriented mental time travel in light of a related concept, namely prospection—the ability to represent what might happen in the future (Gilbert & Wilson, 2007). In so doing, our goal is to highlight that there are many ways in which people are able to think about or *mentally travel into* the future. On a daily basis, people think about and evaluate possible encounters with friends, colleagues, romantic partners, and even their future selves; form intentions to deliver messages, take prescribed medications, and pick up miscellaneous items at the grocery store; and plan daily routines, vacations, and savings strategies for retirement (see D'Argembeau, Renaud, & Van Der Linden, 2011). Despite the vast diversity in the ways in which people think about the future, we recently proposed that prospective cognition can be organized into four basic modes of future thinking (Szpunar, Spreng, & Schacter, 2014): *simulation* (construction of a detailed mental representation of the future); *prediction* (estimation of the likelihood of, and/or one's reaction to, a particular future outcome); *intention* (the mental act of setting a goal); and *planning* (the identification and organization of steps toward achieving a goal state). Historically, these modes of future thinking have been studied in relative isolation, and the main goal of our proposed framework is to bring these largely disparate lines of research and theory into meaningful discourse.

In addition to proposing that prospection can be parsed into four distinct categories, our framework also holds that these modes of future thinking can vary in terms of their representational contents. Specifically, the framework relates simulation, prediction, intention, and planning to two well-characterized types of memory or knowledge: episodic and semantic (Tulving, 1983, 2002). In this context, the term *episodic* is meant to refer to simulations, predictions, intentions, or plans in relation to specific autobiographical events that may take place in the future (p.22) (e.g., thinking about an upcoming event that will take place next week). The term *semantic* is meant to refer to simulations, predictions, intentions, and plans that relate to more general or abstract states of the world that may arise in the future (e.g., thinking about what the environmental state of the world will be like 20 years from now; for a review, see Abraham & Bubic, 2015). Note, however, that not all instances of future thinking can be strictly classified as either episodic or semantic. Specifically, some instances of future thinking represent autobiographical states—general states of the world that are autobiographical in nature (e.g., imagining that one will attain one's career aspirations in the future). To accommodate such hybrid forms of future thinking, our framework conceptualizes the episodic-semantic distinction as a continuous variable. We provide relevant examples of hybrid forms of future thinking throughout.

The result of our approach to delineating prospection is a set of four basic modes of future-oriented cognition that may vary in the extent to which they draw on episodic and semantic knowledge structures (see Figure 2.1; see also Szpunar, Spreng, et al., 2014). In what follows, we (1) briefly elaborate on the various modes of future-oriented thinking that fall within the purview of our classification scheme, (2) demonstrate the manner in which our framework can be used to ask new questions about how different modes of future-oriented cognition interact with one another, and (3) discuss how our framework can be used to provide insights into deficits of future-thinking.

(p.23) 1.

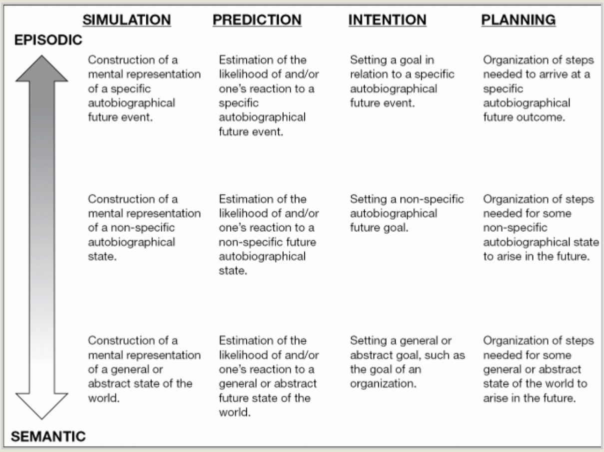

Figure 2.1. A taxonomy of prospective cognition.

source: Szpunar, K. K., Spreng, R. N., & Schacter, D. L. (2014, 18415). A taxonomy of prospection: introducing an organizational framework for future-oriented cognition. *Proceedings of the National Academy of Sciences U S A*, *111*, 18414–18421.

Simulation

The construct of simulation has been used to define the ability to cognitively represent various aspects of personal experience, including real or imagined events (Taylor & Schneider, 1989), the minds of others (Goldman, 2006), and person-environment interactions (Barsalou, 2003). Here, we take simulation to refer to the construction of hypothetical events, both specific and general.

1.1. Episodic Simulation

Episodic simulation is the construction of a detailed mental representation of a specific autobiographical future event (Schacter, Addis, & Buckner, 2008). Considerable work has focused on delineating the relation of episodic simulation to episodic memory and on identifying their common neural correlates. In a seminal case study, Tulving (1985) showed that an amnesic patient was unable to remember details about events from his past or to imagine details about possible events that might take place in his future. One limitation of this observation was that the patient had sustained diffuse brain damage following a motorcycle accident, and it was impossible to know what aspect(s) of the brain damage were related to his episodic memory and simulation deficits. More recently, Hassabis, Kumaran, Vann, and Maguire (2007) tested a set of patients with brain damage largely limited to the hippocampus, a region of the brain known to play an important role in memory for specific experiences, and found that those patients had deficits in constructing coherent mental images about the personal past and future. Although not all hippocampal amnesic patients demonstrate this pattern of results (e.g., Squire et al., 2010), there is good reason to believe that the hippocampus plays a pivotal role in memory for and simulation of specific autobiographical events (for a review, see Addis & Schacter, 2012).

Taking a broader approach, functional neuroimaging studies of episodic simulation and episodic memory provide insights into the neural underpinnings of these related abilities across the entire brain. For instance, using positron emission topography, a neuroimaging technique that requires researchers to inject a non-radioactive tracer into the bloodstream and to track the uptake of the tracer by blood vessels in the brain, Okuda et al. (2003) found that long periods of remembering and future thinking were characterized by similar patterns of brain activity in various frontal and temporal regions of the brain. The subsequent development of event-related functional magnetic resonance imagining (fMRI) (Dale & Buckner, 1997) enabled researchers to associate estimates of neural activity to specific memories and simulated events. Studies using event-related fMRI have demonstrated a striking overlap in medial and lateral regions of frontal, parietal, and temporal cortex as participants remember and imagine events from their past and future (Addis, Wong, & Schacter, 2007; Szpunar, Watson, & McDermott, 2007; for reviews, see Benoit & Schacter, 2015; Schacter et al., 2012). More recently, researchers have been able to parse the contributions of these regions to episodic simulation. Repetition suppression (also called neural adaptation) refers to a phenomenon whereby regions of the brain responsible for processing specific stimuli will show reduced patterns of responding following repeated presentations of those stimuli (Grill-Spector, (p.24) Henson, & Martin 2006). Capitalizing on this phenomenon, Szpunar, St. Jacques, Robbins, Wig, & Schacter (2014) asked participants to repeatedly simulate various aspects of future events (e.g., people and locations) and were able to pinpoint the contributions of stimulus-specific regions of the brain to simulation (e.g., parahippocampal cortex and retrosplenial cortex, regions known to be involved in spatial processing, were particularly sensitive to repeated simulations of simulated locations; see also Hassabis et al., 2014).

The collection of neuropsychological and neuroimaging findings relating episodic simulation to episodic memory have sparked various theoretical considerations. Schacter and Addis (2007) proposed the *constructive episodic simulation hypothesis*, which postulates that a constructive memory system that is prone to errors may nonetheless be adaptive in that it enables the individual to draw flexibly upon elements of past experiences in the service of simulating novel future events. Others have focused on more broadly relating episodic memory and simulation to other constructs. For instance, Buckner and Carroll (2007) identified episodic simulation and episodic memory as forms of self-projection, which, along with theory of mind (i.e., the ability to take the mental perspective of another person; Goldman, 2006) and spatial navigation (i.e., the ability to imagine moving through a familiar spatial location; Ekstrom et al., 2003), allow the individual to experience mental states that are removed from the immediate environment. Still others have focused on illuminating specific cognitive mechanisms involved in episodic memory, simulation, and related constructs such as spatial navigation. For instance, Hassabis and Maguire (2007; see also, Mullally & Maguire, 2014) argue that scene construction—the process of mentally generating and maintaining a complex and coherent scene or event—is a key cognitive mechanism that involves retrieving and integrating disparate details stored in modality-specific regions, a process believed to be mediated by the hippocampus.

1.2. Semantic Simulation

Semantic simulation is the construction of a detailed mental representation of a general or abstract state of the world. Although semantic simulation has not received as much research attention as episodic simulation, evidence suggests that the two may be, at least to some extent, dissociable from one another. For instance, Klein, Loftus, and Kihlstrom (2002) found that an episodic amnesic patient who was unable to reliably express what he might do in the future was nonetheless able to think about problems that might face the world in the future (e.g., global warming). Race, Keane, and Verfaellie (2013) similarly showed that patients with medial temporal lobe damage were able to generate possible issues that the world would face in the future, but also found that their patients were impaired in their ability to elaborate on those issues. This latter finding suggests that episodic amnesic patients may possess more fine-grained deficits in semantic simulation. Notably, Manning, Denkova, and Unterberger (2013) reported preserved episodic simulation but impaired semantic simulation in a patient whose left temporal lobe, a region known to play an important role in representing general or semantic knowledge (e.g., De Renzi, Liotti, & Nichelli, 1987), was resected following epileptic seizures localized to that portion of his brain. The available data suggest that damage to the (p.25) hippocampus and more anterior portions of the temporal lobe may respectively lead to dissociable deficits of episodic and semantic simulation. At the same time, it is important to note that episodic and semantic knowledge may interact in the context of simulation. For instance, Irish and colleagues (Irish, Addis, Hodges, & Piguet, 2012; Irish & Piguet, 2013) have demonstrated that episodic simulation is also impaired with damage to the anterior temporal lobes, a finding that has led to the proposal that semantic knowledge may serve as a scaffold for episodic simulation.

Some forms of simulation cannot be neatly classified as either episodic or semantic, but rather represent hybrids of episodic and semantic simulation. These hybrid forms of simulation may take the form of personal semantic knowledge (e.g., one may have an interest in business) that is projected into the future (e.g., one may envision playing an important role in business in the future). Such simulations are autobiographical but are not related to specific future episodes. Whereas considerable research has been devoted to investigating the relation of personal semantic knowledge to episodic and semantic memory (Renoult, Davidson, Palombo, Moscovitch, & Levine, 2012), to our knowledge no research has specifically examined the relation of hybrid forms of simulation to episodic and semantic simulation. Prior work has shown that the extent to which personal semantic knowledge is characterized by patterns of neural activity that are similar to episodic and semantic memory can depend on the nature of the information under investigation (e.g., autobiographical facts versus repeated events; Renoult et al., 2012). The extent to which such factors may influence the relation of hybrid forms of simulation to episodic and semantic simulation should provide insights into not only the nature of simulation, but also relations between episodic, semantic, and personal semantic knowledge.

2. Prediction

Prediction is a fundamental task of the brain (Bar, 2009; Friston & Kiebel, 2009). Predictions about the future include short-term predictions about what object may appear next in a scene (Bar, 2007) and prediction errors concerning expected rewards that are crucial to learning (Schultz, Dayan, & Montague, 1997). Our focus is on longer-term predictions about specific events and general or abstract states of the world that may arise in the future and the manner in which such predictions may interact with other modes of future thinking.

2.1. Episodic Prediction

Episodic prediction is the estimation of the likelihood of, and/or one's reaction to, a specific autobiographical future event. Here, we focus specifically on predictions about reactions to events (for further detail regarding predictions of event likelihood, see the following section on Semantic Prediction; see also Szpunar, Spreng, et al., 2014). Perhaps the most clear-cut example of episodic prediction of reactions to events comes from work on affective forecasting, wherein social psychologists have attempted to highlight the shortcomings of the ability to predict our reactions to the outcomes of future events (Wilson & Gilbert, 2003, 2005). Gilbert and (p.26) Wilson (2007) argued that people base their predictions on episodic simulations of the future and succinctly summarized three common limitations of simulations that lead to errors in prediction. Specifically, the authors highlighted that (1) simulations are often based on easily accessible but unrepresentative memories of similar experiences (e.g., remembering a particularly negative experience of having interacted with a particular individual when predicting one's emotional reaction to having to interact with that person in the future); (2) simulations often focus on essential details (e.g., the joys of parenthood) while omitting inessential details that can influence future happiness (e.g., how it will feel to change diapers or go to work not having slept the previous night); and (3) simulations are often abbreviated and tend to focus on the initial aspects of future experience while omitting consideration of how circumstances may change over time (e.g., imagining the positive feeling associated with getting a promotion but failing to consider the extra work that would come with it). Recent studies have shown that people are able to generate more detailed episodic simulations of the future when they have been trained previously to report on episodic details in the context of a cognitive interview about a recently experienced event (Madore, Gaesser, & Schacter, 2014; for review and discussion of induction studies, see Schacter & Madore, in press). Whether such inductions of specificity could be used to enhance predictive accuracy awaits future research. For instance, it may be the case that inductions help to bring to mind non-essential details of simulations that are typically omitted but that could serve to enhance predictive accuracy. Later, we will consider the potentially important implications that episodic prediction might have on other modes of future thinking (i.e., intention and planning).

2.2. Semantic Prediction

Semantic prediction is the estimation of the likelihood of, and/or one's reaction to, a general or abstract state of the world. Semantic prediction represents an important type of future thinking that is highly valued in disciplines such as politics and economics. Research within the domain of affective forecasting has considered not only the manner in which people believe they will react to future events, but also how they may react to future states of the world, such as those brought about in the aftermath of elections. In these contexts, the shortcomings that hamper episodic simulations appear to similarly limit semantic predictions. For instance, Gilbert, Pinel, Wilson, Blumberg, and Wheatley (1998) showed that people overestimated the duration of their emotional reactions to the end of personal relationships and the outcomes of elections. Although we focus on predictions of reactions to events and changes in the state of the world, predictions about the likelihood of the emergence of future events and states of the world also represent an important aspect of prediction. Indeed, interesting questions about individual differences in predictions related to personal events and general states of the world remain to be answered. For instance, are people who are good at predicting the occurrence of personal experiences also good at predicting the occurrence of changes in general states of the world? Such questions can be further extended to the relation of episodic and semantic prediction to predictions about autobiographical states. For instance, how well are people able to predict success/failure in their pursuit of vocational goals? (p.27) Moreover, do predictions for future autobiographical states involve similar or different mechanisms as compared to those that are involved in predicting personal events or general states of the world?

3. Intention

Understanding the conscious determinants of human action has represented a central fixture in psychological research since the cognitive revolution (Ryan, 1970). Considerable research has been devoted to illuminating the nature of the underlying intentions that guide the behavior of the individual (Ajzen, 1991) and also the more general goal setting that is the driving force behind the growth and development of organizations (Locke & Latham, 2002). Next, we provide a brief overview of specific and more general or abstract intentions and identify possible links to other modes of future-oriented cognition.

3.1. Episodic Intention

Episodic intention is the mental act of setting a goal in relation to a specific autobiographical future event. Once goals are contemplated and set, whether or not those goals are actualized represents an important obstacle to adaptive behavior. Hence, one important aspect of setting intentions is remembering that those intentions have been set in the first place. Consider the role of setting and actualizing goals in the context of prospective memory (e.g., I need to remember to pick up bread on my way home from work; for a review, see Kliegel, McDaniel, & Einstein, 2008). Studies of prospective memory have long investigated the extent to which the quality of encoding of episodic intentions predicts the success with which those intentions are carried out in the future. Early research on implementation intentions found that explicitly stating when and where an intention will be carried out (e.g., when *X* occurs, I will perform *Y*) enhanced prospective memory performance (for a review, see Gollwitzer, 1999). Notably, many studies employing implementation intention instructions required participants to generate episodic simulations that revolved around themselves carrying out the future task at hand (Chen et al., 2015), and recent studies that explicitly relate episodic simulation to prospective memory performance have reported similar benefits (e.g., Neroni, Gamboz, & Brandimonte, 2014). It is important to note that implementation intentions may be effective in part because they involve formulating a plan of action. However, as we will highlight later, most conceptualizations of planning ability extend beyond simple if-then statements characteristic of implementation intentions to include the organization of complex action sequences.

3.2. Semantic Intention

Semantic intention is the mental act of setting a general or abstract goal, such as the goal of an organization. To our knowledge, no work has been conducted in the future thinking literature to identify the cognitive determinants that underlie the (p.28) formation of a general or abstract intention for a particular organization (for example, setting a target of 10% industry growth). The development of research programs aimed at identifying the possible overlapping and non-overlapping cognitive and neural mechanisms that give rise to episodic and semantic intentions should have considerable implications for various fields of study, including psychology, business, and economics. As with simulation and prediction, not all instances of intention can be classified as episodic or semantic. For instance, one may possess an inherent interest in business (personal semantics; Renoult et al., 2012) and project that information forward by forming the intention to pursue a relevant career path. The extent to which such hybrid intentions rely on similar or different mechanisms compared with more clear-cut examples of episodic and semantic intention awaits future work. For instance, to what extent might similar mechanisms underlie the acts of forming intentions to pick up bread from the grocery store and to pursue a particular career?

4. Planning

For intended behaviors to be carried out in an effective manner, plans are often necessary. Although various scholars have defined the concept of planning (Hayes-Roth & Hayes-Roth, 1979; Mumford, Schultz, & Van Doorn, 2001; Ward & Morris, 2005), most definitions commonly conform to the notion of a plan as a “predetermination of a course of action aimed at achieving some goal” (Hayes-Roth & Hayes-Roth, 1979). Here, we focus on the nature of plans that are aimed at achieving goals in relation to specific autobiographical and more general contexts, and the extent to which other modes of future-oriented cognition may factor into the planning process.

4.1. Episodic Planning

Episodic planning is the identification and organization of steps needed to arrive at a specific autobiographical future event or goal state. One notable aspect of research on episodic planning is that tasks that are used to gauge planning ability can vary considerably in terms of how well they approximate real-life planning. For instance, in the Tower of London test, participants are typically presented with two arrays of beads organized on two separate sets of pegs, with the goal of reorganizing the beads presented in the first array to match the arrangement of the second, or goal, array. The measure of interest is the number of steps taken to achieve the goal state (Shallice, 1982). Other tests strive to more closely mimic real-world planning. For instance, the Six Elements Test (SET) requires participants to carry out a series of laboratory tasks in a specified time frame and order. The Multiple Errands Test is similar to the SET but involves completing daily tasks in a real-world setting (see Shallice & Burgess, 1991). Much of the research on planning has been conducted in the context of testing patients with frontal lobe damage. The fact that frontal lobe patients have trouble with each of the above-noted tasks highlights that processes subserved by the frontal lobes (e.g., executive control) play an important role in planning and future thinking (p.29) more generally. More recent neuroimaging studies (Gerlach, Spreng, Madore, & Schacter, 2014; Spreng, Gerlach, Turner, & Schacter, 2015 Spreng & Schacter, 2012; Spreng, Stevens, Chamberlain, Gilmore, & Schacter, 2010) have examined the neural underpinnings of episodic or autobiographical planning, using a task in which participants mentally construct personal plans containing specific steps in order to achieve particular personal goals (e.g., academic success, getting out of debt). Results indicate that episodic planning is associated with activity in the same core network of brain regions that has been linked previously to episodic simulation (the default network; Andrews-Hanna, Smallwood, & Spreng, 2014; Buckner, Andrews-Hanna, & Schacter, 2008; Spreng, Mar, & Kim, 2009). Moreover, activity in the default network during episodic planning was closely coupled with activity in a distinct frontoparietal control network (Niendam et al., 2012; Vincent, Kahn, Snyder, Raichle, & Buckner, 2008) that has been linked to executive control and goal-directed cognition, and that also supports planning performance on the Tower of London task (Spreng et al., 2010). Finally, real-world episodic planning tasks have further illuminated the extent to which episodic planning draws upon other modes of future thinking. For instance, one study showed that participant descriptions of strategies for completing a pseudo shopping-planning task included simulation, prediction, and intention formation (Simons, Coates, & Channon, 2005). We address this point in further detail in the next section.

4.2. Semantic Planning

Semantic planning is the identification and organization of steps needed for some general or abstract goal state in the world to arise in the future. Semantic planning is perhaps best represented in the context of strategic (Blatstein, 2012) and urban planning (Rydin et al., 2012), tasks during which steps required to achieve a particular goal state for an organization or community are explicitly mapped out. Although there exists a paucity of research related to the cognitive determinants of semantic planning, research with frontal lobe patients has provided some initial data. For instance, patients with frontal lobe damage exhibit difficulty in formulating both episodic plans (see previous section) and financial plans for others (Goel, Grafman, Tajik, Gana, & Danto, 1997). It is important to point out that financial planning, and possibly other forms of semantic planning, may incorporate episodic knowledge (e.g., people may use their own experiences to formulate plans for others; see Goel et al., 1997, 1882). Nonetheless, the results of this study suggest that cognitive functions subserved by the frontal lobes may be important for episodic and semantic planning. To our knowledge, however, no study has directly compared episodic and semantic planning deficits in frontal lobe patients, and so more work is needed to understand the extent to which these forms of planning are supported by similar and different mechanisms. Indeed, the broader literature on planning does not generally distinguish between episodic and semantic planning (for a review, see Mumford et al., 2001) or the extent to which the two may work together in particular contexts (e.g., retirement planning; Wang & Shi, 2014), and research along these lines has the potential to answer novel questions regarding individual differences in planning ability. For example, are people generally good (p.30) planners, or can someone be a good semantic planner but a poor episodic planner, and vice versa?

5. Interactions Between Modes of Future Thinking

We have already alluded to the fact that simulated representations of the future can be utilized in the context of prediction, intention, and planning. However, the extent to which the level of detail associated with a simulation influences performance in other domains remains to be investigated, particularly in relation to prediction and planning. For example, could specificity inductions (Madore et al., 2014) be used to improve the quality of plans? In a similar vein, next to nothing is currently known about the extent to which predictions associated with the likelihood of the occurrence of a future event might influence the formation and retention of intentions or the quality of plans. For instance, is an intention less likely to influence behavior if the perceived probability of occurrence is less than certain? The development of research programs that strive to answer these and related questions will represent an important step forward for the study of future-oriented cognition.

6. Applications

The organizational framework discussed here provides a benchmark against which clinical populations with deficits in future thinking can be assessed in order to develop a profile of their future-thinking abilities. For instance, some episodic amnesic patients are able to think about the future in more general terms (Klein et al., 2002), although they may have difficulty generating semantic details of future events (Race et al., 2013). Nonetheless, more work is needed to further understand the extent to which such patients are able to engage in semantic prediction and semantic planning. Similarly, although it is well known that frontal lobe patients exhibit considerable deficits in episodic and semantic planning, much less is known about the extent to which such patients are able to generate useful simulations and predictions of episodic and semantic future events (Berryhill, Picasso, Arnold, Drowos, & Olson, 2010). Finally, studies of mood and anxiety-related disorders have historically focused on the fluency with which individuals with depression and anxiety think about positive and negative events that may occur in the future (MacLeod, Tata, Kentish, & Jacobsen, 1997). Although this work has provided important insights into future thinking in these populations, relatively little is known about the extent to which these individuals are able to engage in episodic and semantic forms of simulation, prediction, intention, and planning (for relevant work on episodic predictions, see Marroquín & Nolan-Hoeksema, 2015; Martin & Quirk, 2015; Wenze, Gunthert, & German, 2012). Development of research programs that consider the role of these various modes of future thinking could enhance our understanding of the ability of individuals afflicted with various mood and anxiety disorders to engage in adaptive behavior (e.g., how well are individuals with depression or anxiety able to predict their reactions to future events? How well are they able to formulate episodic or semantic plans for the future?).

(p.31) 7. Conclusions

In this chapter we have summarized a framework for organizing key cognitions involved in thinking about or mentally traveling into the future. We suggest that decomposing prospective cognition in terms of episodic, semantic, and hybrid forms of simulation, prediction, intention, and planning provides a useful framework for discriminating, and developing connections among, various forms of future thinking. Nonetheless, additional cognitive, emotional, and motor processes may contribute to and support future-oriented behavior (see Szpunar, Spreng, et al., 2014), which will likely lead to an expanded and refined taxonomy of prospective cognition. For instance, cognitive operations such as mental contrasting (e.g., Oettigen, 2012) may play an important role in decision-making about the future in contexts wherein predictions about the future are compared with considerations of present states (e.g., delay of gratification, Metcalfe & Mischel, 1999; temporal discounting, Benoit, Gilbert, & Burgess, 2011). For now, we believe that our organizational framework can encourage the cross-fertilization of research and theory across various domains of prospective, clinical, developmental, and comparative psychology, and thereby both broaden and deepen our understanding of the processes that support mental time travel into the future.

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