A taxonomy of prospection: Introducing an organizational framework for future-oriented cognition

PERSPECTIVE

A taxonomy of prospection: Introducing an organizational framework for future-oriented cognition

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Prospection—the ability to represent what might happen in the future—is a broad concept that has been used to characterize a wide variety of future-oriented cognitions, including affective forecasting, prospective memory, temporal discounting, episodic simulation, and autobiographical planning. In this article, we propose a taxonomy of prospection to initiate the important and necessary process of teasing apart the various forms of future thinking that constitute the landscape of prospective cognition. The organizational framework that we propose delineates episodic and semantic forms of four modes of future thinking: simulation, prediction, intention, and planning. We show 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 our understanding of disorders of future thinking. We conclude by considering basic cognitive processes that give rise to prospective cognitions, cognitive operations and emotional/motivational states relevant to future-oriented cognition, and the possible role of procedural or motor systems in future-oriented behavior.

prospection | simulation | prediction | intention | planning

Over the past decade, the concept of prospection—the ability to represent what might happen in the future—has been the subject of rapidly growing research interest within various subdisciplines of psychology and neuroscience (1, 2). One reason why the concept of prospection has gained so much attention is that the term casts a wide net around a variety of future-oriented cognitions. Studies on topics as varied as episodic simulation (3, 4), affective forecasting (5), intention formation (6), and autobiographical planning (7) have all been described as instances of prospection (1, 2, 8, 9). Although the practice of clumping various forms of future thinking together may be beneficial in terms of highlighting the breadth of the concept of prospection, it also runs the risk of obscuring the manner in which various forms of future thinking relate to one another. The purpose of this article is to directly address this issue and begin the process of developing an organizational framework to draw connections and distinctions between various forms of future thinking that serve different functions for adaptive behavior (10).

Although various works have intimated the need for a taxonomy of prospection (11, 12), prior attempts to parse future-oriented cognition have focused exclusively on relating taxonomies of human memory to future thinking. For instance, Suddendorf and Corballis (12) proposed that episodic, semantic, and procedural memory systems, which are believed to support memory for personally experienced events (episodic), expression of general knowledge about the world (semantic), and motor behavior as well as learning of various kinds of skills (procedural) (13, 14), give rise to corresponding types of future thinking that vary in terms of the flexibility with which they enable the individual to think about the future. These initial steps toward organizing future thinking have served to highlight important questions in the literature (e.g., are episodic and semantic forms of future thinking dissociable from one another?). However, this approach does not provide a means by which to draw connections or distinctions between the various future-oriented cognitions that constitute the broad nature of prospection (e.g., what are the relations between simulation and planning?; how might the episodic–semantic distinction qualify these relations?). In this article, we propose a taxonomy that is intended to both organize and stimulate research and theory across various domains of future-oriented cognition.

Our approach will be to distinguish among four modes of future thinking that encapsulate the bulk of the literature on prospective cognition: simulation, prediction, intention, and planning. These four modes of future thinking support prospective cognition from the initial conception of a possible future event to the process of attaining a goal. Importantly, we will build on past attempts to parse the concept of prospection and relate these four modes of future thinking to two well-characterized types of memory or knowledge that subserve distinct forms of future thinking: episodic and semantic. 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 (e.g., thinking about an upcoming event that will take place over the weekend). 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 how to enhance company profitability). Note, however, that not all instances of memory or future thinking can be strictly classified as either episodic or semantic. For instance, personal semantic knowledge (15) is not associated with a specific episode (e.g., I am a good basketball player) and may be projected forward into the future (e.g., I want to play professional basketball in the future). As with personal semantic knowledge, such hybrid forms of episodic and semantic future thinking are not strictly episodic, in that they do not refer

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to a specific episode, and they are not strictly semantic. Although thinking about the desire to be a professional basketball player refers to a more general future state, that future state is autobiographical in nature. To accommodate such hybrid forms of future thinking, our framework conceptualizes the episodic–semantic distinction as a continuous dimension as opposed to a categorical variable, and we will identify various forms of simulation, prediction, intention, and planning that fall within the purview of this episodic–semantic continuum (Fig. 1). Finally, we do not include procedural forms of future thinking in our taxonomy. The focus of this article is on future-oriented cognitions as opposed to future-oriented motor actions. Nonetheless, we do not rule out the possibility that procedural or motor systems may play a role in future-oriented cognition and will revisit the issue later in the article. Moreover, the translation of future-oriented cognition into action represents an important aspect of prospection, and we highlight relevant issues associated with cognition–action interactions as they become pertinent to the various modes of future thinking discussed below.

The result of our approach 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 and represent key components of the landscape of prospection. In what follows, we (*i*) provide rationales for decomposing prospective cognition on the basis of relevant modes of future thinking and types of memory or knowledge, (*ii*) provide a brief overview of our resulting framework along with discussion of its implications for understanding relations between different modes of future thinking and deficits of future thinking, and (*iii*) consider important caveats to our framework.

Modes of Future Thinking and Types of Memory or Knowledge

Modes of Future Thinking. Over the course of each day, people devote considerable time to thinking about the future (16). People simulate 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. Despite the seemingly innumerable ways in which people think about the future, we propose that prospective cognition may be organized into four modes of future thinking. These four modes of future thinking include 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 our goal is to bring these largely disparate lines of research and theory into meaningful dialogue with one another.

Modes of future thinking are not necessarily orthogonal to one another. Rather, they interact and build on one another at various levels of abstraction and complexity (17). For instance, when planning, people may draw on simulations and predictions and formulate and revise intentions. Given such possibilities, it is all the more surprising that research on these various modes of future thinking has been subject to little cross-talk, although we will discuss important exceptions. We anticipate that an organizational framework will stimulate research programs to consider both connections and distinctions among the modes of future thinking. Of the four modes of future thinking that we have identified, only prediction, intention, and planning may be considered to be strictly future-oriented. Simulation is not necessarily directed toward the future (3) but may be coopted in the service of generating mental representations of possible futures. Later, we will highlight studies showing that detailed simulations of the future can also substantially improve the effectiveness of other modes of future thinking, such as intention formation.

Types of Memory or Knowledge. The distinction between episodic memory and semantic memory or knowledge has a long history in the psychological literature (18), and it continues to be refined by various scholars (19). In relation to future thinking, cognitive neuroscientists and neuropsychologists have generated considerable evidence showing that the capacity to remember past events and imagine future events is closely related, spurring the suggestion that event details can be flexibly extracted and recombined from memory in the service of simulating new events that may take place in the future (20). Here, we extend this proposed relation between memory and future thinking to highlight, as others have done as well (4, 11, 12, 21, 22), that general knowledge about the world (semantic knowledge) may also lay the groundwork for allowing us to reason about what the world may be like in the future. However, much work is needed to show these proposed relations between different types of knowledge and future thinking. For instance, whether episodic and semantic forms of simulation, prediction, intention, and planning represent dissociable phenomena or nominal distinctions regarding the content

	SIMULATION	PREDICTION	INTENTION	PLANNING
EPISODIC	Construction of a mental representation of a specific autobiographical future event.	Estimation of the likelihood of and/or one's reaction to a specific autobiographical future event.	Setting a goal in relation to a specific autobiographical future event.	Organization of steps needed to arrive at a specific autobiographical future outcome.
	Construction of a mental representation of a non-specific autobiographical state.	Estimation of the likelihood of and/or one's reaction to a non-specific future autobiographical state.	Setting a non-specific autobiographical future goal.	Organization of steps needed for some non-specific autobiographical state to arise in the future.
SEMANTIC	Construction of a mental representation of a general or abstract state of the world.	Estimation of the likelihood of and/or one's reaction to a general or abstract future state of the world.	Setting a general or abstract goal, such as the goal of an organization.	Organization of steps needed for some general or abstract state of the world to arise in the future.

Fig. 1. A taxonomy of prospective cognition.

on which these various modes of prospective cognition operate remains to be adjudicated in the literature. Moreover, it will be important to assess the extent to which these types of knowledge may interact with one another in the service of future-oriented cognition. For example, according to the semantic scaffolding hypothesis (21), semantic knowledge provides a framework or scaffolding that helps to organize event details that comprise simulations of future experiences. This kind of hypothesis implies strong interaction and interdependence between episodic and semantic knowledge during prospective thought (23).

Characterizing the influence of episodic and semantic knowledge structures as part of our organizational framework is intended to stimulate novel questions about simulation, prediction, intention, and planning that may turn out to be important (e.g., can someone be a good semantic planner but a poor episodic planner?; to what extent are semantic plans supported by semantic and episodic knowledge?). In what follows, we present our resulting framework. Extending beyond a simple summary of independent lines of research, we propose a framework that highlights naturally occurring forms of future-oriented cognition with additional consideration for their interactions for the emergence of goal-directed behavior.

Varieties of Future Thinking

To help facilitate discussion of our organizational framework of prospection, we present the following hypothetical scenario to highlight the manner in which various forms of our four basic modes of future thinking arise in the context of everyday experience. Monika, who has long sought to play an influential role in business, works as a midlevel executive at a Fortune 500 company. The Chief Executive Officer (CEO) of the company asks Monika if she would join him for a game of tennis over the upcoming weekend. Although Monika is flattered by the offer, she is also anxious about the invitation, because she has not played tennis in over a year and would need to purchase new athletic gear before the weekend. Monika also suspects that her boss will be vetting her for a higher-level position within the company and therefore, plans to brush up on her knowledge of the company before the meeting. In what follows, we define, provide examples of, and briefly discuss relevant research on episodic (Fig. 1, *Top*) and semantic (Fig. 1, *Bottom*) forms of simulation, prediction, intention, and planning. For ease of exposition, we highlight specific aspects of the aforementioned hypothetical scenario that are likely to be near the ends of the episodic–semantic continuum in Fig. 1 for each of four modes of future thinking. However, we stress that any given instance of future-oriented cognition may ultimately evoke both episodic and semantic forms of future thinking. Accordingly, we will conclude our discussion of each mode of future thinking by providing examples of how episodic and semantic forms of future thinking may interact with one another. We will also briefly consider the manner in which hybrid forms of episodic and semantic future thinking (Fig. 1, *Middle*) fit into our framework of prospective cognition. Wherever possible, we provide brief descriptions of the typical methodological approaches used to study the four modes of future thinking. A key step forward in the study of prospective psychology will involve the development of research programs that are able to bridge the gap in existing methodological approaches to the study of simulation, prediction, intention, and planning.

Simulation. The construct of simulation has been used in multiple ways in psychology and neuroscience. For example, Ingvar (24) characterized a "simulation of behavior" as "an inner anticipatory programming of several alternative behavioral modes prepared to be used depending upon what will happen" (ref. 24, p. 21). In a similar spirit, Taylor and Schneider (25) defined simulation as "the imitative representation of the functioning or process of some event or series of events . . . we will use the term to mean the cognitive construction of hypothetical scenarios or the reconstruction of real scenarios" (ref. 25, p. 175). Others have used simulation strictly to refer to processes involved in "mentalizing" or making attributions about another person's mental state (26). Conceiving simulation in a much broader sense, Barsalou (27) contended that "conceptual processing uses reenactments of sensory-motor states—simulations—to represent categories" (ref. 27, p. 521; 28). Our use of the concept of simulation shares most in common with the ideas of Ingvar (24) and Taylor and Schneider (25), focusing on the construction of hypothetical future events both specific and general.

Episodic simulation is the construction of a detailed mental representation of a specific autobiographical future event.

Example of episodic simulation. Before meeting her boss over the weekend, Monika might simulate possible events that are likely to take place (e.g., playing tennis and having a discussion about the company).

Research on episodic simulation. As we alluded to earlier, considerable work over the last decade has shown a close relation between episodic memory and episodic simulation (20). Episodic memory and episodic simulation engage similar brain networks, and deficits of episodic memory are typically accompanied by deficits of episodic simulation (recent reviews in refs. 3, 4, and 10). Considerable research has focused on the extent to which the hippocampus and related medial temporal lobe structures, long associated with episodic memory (13), are also important for episodic simulation: hippocampal and medial temporal lobe regions are typically engaged during episodic simulation, and some amnesic patients with damage to these regions exhibit impairments of episodic simulation (discussion in refs. 29–31). It is important to note that episodic simulation need not be directed toward the future (3). For instance, one could simulate how the past could have turned out differently (i.e., counterfactual simulation) (32, 33). Nonetheless, episodic simulation is often directed at the future, and even past-oriented episodic simulations are often carried out in service of the future (34). Hence, episodic simulation represents an important form of prospective cognition.

Semantic simulation is the construction of a detailed mental representation of a general or abstract state of the world.

Example of semantic simulation. In anticipation of the upcoming discussion with her boss, Monika envisions the future direction of the company.

Research on semantic simulation. Although semantic simulation has not received as much research attention as episodic simulation (11, 22), evidence suggests that the two are, at least to some extent, dissociable from one another. One study 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) (35). Although the results of this important study suggest that episodic and semantic simulations differ in some fundamental way, a subsequent study that used additional measures of semantic prospection points toward deficits in amnesic patients (36). Interestingly, a recent case study of temporal lobe epilepsy revealed impaired semantic simulation in the face of preserved episodic simulation (37). Other research has pointed toward differences between episodic and semantic simulation based on analysis of details that comprise future simulations using the Autobiographical Interview (38). The Autobiographical Interview distinguishes between two major types of details that people typically report

when they remember a past experience or imagine a future experience: internal or episodic details (i.e., details concerning people, places, and actions that constitute an event) and external or semantic details (i.e., related facts, general knowledge, and commentary). Several studies have shown internal and external details can be dissociated. For example, when young and older adults construct future simulations, young adults produce more internal details than older adults, whereas the opposite pattern is observed for external details (39–41). More recent work has shown that an episodic specificity induction—brief training involving a cognitive interview about a recent experience that guides individuals to focus on recollecting specific details of that experience—selectively increases the number of internal details that young and older adults generate when they construct future simulations while having no effect on external details (42). Nonetheless, more research is needed to help discriminate episodic and semantic simulation in terms of their phenomenological characteristics, susceptibility to cognitive manipulations, and neural correlates. As with episodic simulation, semantic simulation also does not need be but often is directed at the future (e.g., imagining what the world might be like in 10,000 y).

As emphasized earlier, 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., Monika has always had an interest in business) that is projected into the future (e.g., Monika envisions herself playing a more important role in her company). Such simulations are autobiographical but not related to specific future episodes. Finally, each of the examples highlighted in this section may potentially evoke episodic, semantic, and hybrid forms of future thinking. For instance, in the context of simulating the future direction of her company, Monika may not only simulate general or abstract information associated with company growth but also, envision herself eventually taking over as CEO of the company (hybrid) and performing particular actions that she might enact in that role (episodic).

Prediction. Prediction is a fundamental task of the brain (43, 44). Predictions about the future include short-term predictions about what object may appear next in a scene (45) and prediction errors concerning expected rewards that are crucial to learning (46). 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.

Episodic prediction is the estimation of the likelihood of and/or one's reaction to a specific autobiographical future event.

Example of episodic prediction. In anticipation of meeting with her boss, Monika may vacillate in making a determination about whether the meeting will go well and how the outcome that she thinks is most likely will make her feel.

Research on episodic prediction. The process of engaging in episodic prediction is perhaps most clearly shown in the affective forecasting literature in which researchers assess how well people are able to predict their emotional reactions to future events. These predictions are typically captured by ratings on numerical scales (e.g., on a scale of one to nine, how happy do you think you will be at your child's first soccer match?). This line of work has shown that people are generally limited in this ability. Specifically, people commonly think that upcoming future events will make them feel better or worse than they actually do, because they tend to overlook seemingly minor details that turn out to be important (e.g., a young couple anticipating the joys of parenthood fails to consider how it will feel to change diapers or go into work not having slept the previous night; 5). It has been argued that people base their predictions on episodic simulations of the future and that episodic simulations of the future are often imperfect and hence, result in errors in prediction (e.g., essentialized simulations of parenthood that focus on the rewarding aspects of childrearing; 1). As noted earlier, recent studies have shown that people are able to generate more detailed simulations of the future when they are trained to report those details in the context of a cognitive interview about a recent experience (42). Whether specificity inductions could be used to enhance predictive accuracy awaits future research. Finally, although less attention has been paid to the likelihood that people ascribe to the potential occurrence of events, an independent line of research has shown that repeated simulation of the future can boost judgments of perceived likelihood—the more often an event is simulated, the more likely people think the event will take place (47, 48). Importantly, the expectation of positive future outcomes has been linked to the successful attainment of significant personal milestones (e.g., acquiring gainful employment and finding a romantic partner) (49), whereas passive fantasizing about positive future events can impede success in these domains (review in ref. 50). Additional development in understanding the precise relations between passive thinking about the future, repeated simulation, expectation, and action awaits future work. Later, we will consider the potentially important implications that perceived plausibility of event occurrence might have on other modes of future thinking (e.g., intention and planning).

Semantic prediction is the estimation of the likelihood of and/or one's reaction to a general or abstract future state of the world.

Example of semantic prediction. Monika predicts that the future of the company that she works for would best be served by merging with a partner company.

Research on semantic prediction. Semantic prediction represents an important type of future thinking that is highly valued in disciplines such as politics (e.g., who will win the election?) and economics (e.g., what stocks should people invest in?). One important question that our framework raises is whether episodic and semantic predictions are based on different or similar mechanisms. In one study, different patterns of neural activity uniquely characterized episodic (e.g., is it likely that you will still go clubbing at the age of 40?) and semantic (e.g., is it likely that Sydney will have a Disneyland in 50 y?) predictions (51). However, these differing neural signatures may have more to do with underlying differences in the content of the mental representations that such predictions are based on as opposed to mechanisms that underlie the predictions themselves. Indeed, repeated simulation has a similar influence on the perceived plausibility of specific events (see above) and general states of the world (e.g., the more often people imagine a particular candidate winning an election, the more likely they are to think the candidate will be elected) (52). Moreover, positive fantasies about an idealized future in the context of newspaper reports and presidential addresses have been shown to predict negative economic downturns (53). At this point, considerable work remains to be carried out to develop an understanding of the extent to which episodic and semantic predictions about the occurrence of future events and states of the world differ beyond the content on which they operate (e.g., are people who are good at predicting general states of the world that may arise in the future also good at predicting the likelihood of occurrence of specific autobiographical events?). Studies that have assessed predictions of emotional reactions to specific autobiographical events and general autobiographical or nonautobiographical states of the world (e.g., how happy

does Monika think that she will be once she achieves a particular level of vocational success?) have shown similar errors in predictive accuracy (54), suggesting that similar mechanisms may be at work. Finally, we note that each of the examples of prediction highlighted in this section could potentially give rise to episodic, semantic, or hybrid forms of prediction or simulation (or intention or planning). For instance, in the process of attempting to predict the possible success of a merger, Monika might imagine a specific future meeting between members of her company and a partner company (episodic simulation). Such examples highlight the ways in which various modes of future thinking may interact with one another to support adaptive cognition.

Intention. Understanding the conscious determinants of human action has represented a central fixture in psychological research since the cognitive revolution (55); considerable research has been devoted to illuminating the nature of the underlying intentions that guide behavior of the individual (56) and also, the more general goal setting that is the driving force behind the growth and development of organizations (57). Next, we provide a brief and necessarily selective overview of specific and more general or abstract intentions and identify possible links to other modes of future-oriented cognition.

Episodic intention is the mental act of setting a goal in relation to a specific autobiographical future event.

Example of episodic intention. Before meeting her boss over the weekend, Monika realizes that she needs a new pair of sneakers and sets the goal of purchasing new sneakers on her way home from work on Friday evening.

Research on episodic intention. Perhaps the most common example of such goal setting occurs in the context of prospective memory, in which people form intentions to achieve some outcome(s) in the context of specific future events (e.g., I need to pick up bread on my way home from work) (a comprehensive overview is in ref. 58, and a more general discussion surrounding intentions is in ref. 57). Of course, the focus of the prospective memory literature is not simply on the formation of intentions but rather, on how well those intentions are later accomplished (e.g., remembering to make a follow-up appointment with an experimenter, colleague, or doctor). Indeed, 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 (review in ref. 6). More recently, researchers have shown that mentally simulating this contextual information in an episodic manner provides a similar benefit (59, 60; further discussion in ref. 61). Hence, although simulation may not necessarily be as closely tied to action as intention, simulation may be used to facilitate action in the context of achieving intentions. As we discuss later, these exciting lines of work highlight the importance of studying interactions between different modes of future thinking. Note also that implementation intentions may be effective in part, because they involve formulating a plan of action. However, as we will highlight below, most conceptualizations of planning ability extend beyond the simple if–then statements characteristic of implementation intentions to include the organization of complex action sequences.

Semantic intention is the mental act of setting a general or abstract goal, such as the goal of an organization.

Example of semantic intention. Before meeting her boss over the weekend, Monika contemplates the goals of her company over the coming fiscal year.

Research on semantic intention. Research on goal setting in organizations has a long history in the psychological and business literature (57, 62). Much of this research, however, has focused on enhancing the productivity of individual members of an organization as opposed to identifying the cognitive determinates that underlie the formation of a general or abstract intention for a particular organization (63). Nonetheless, the ability to generate semantic or strategic intentions is considered to be an important aspect of running a successful business (64). Hence, the development of research programs aimed at identifying the possible overlapping and nonoverlapping 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. After a semantic intention is formed, the process of semantic planning may then be engaged to determine the necessary steps to accomplish the goal.

As with simulation and prediction, not all instances of intention can be classified as either episodic or semantic. For instance, it is likely that, at some point in her past, Monika formed the intention to pursue a career in business (a hybrid form of episodic and semantic intention). 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 milk from the grocery store and pursue a career in business?

Planning. For intended behaviors to be carried out in an effective manner, plans are often necessary. Although various works have defined the concept of planning (65–67), most definitions commonly conform to the notion of a plan as "a predetermination of a course of action aimed at achieving some goal" (65). Here, we focus on the nature of plans that are aimed at achieving goals in relation to specific autobiographical and more general or abstract contexts and the extent to which other modes of future-oriented cognition may factor into the planning process.

Episodic planning is the identification and organization of steps needed to arrive at a specific autobiographical future event or outcome.

Example of episodic planning. Before meeting with her boss over the weekend, Monika devises a meticulous plan about what steps she needs to take to prepare for the meeting (e.g., finding time during the week to read up on her company and related companies and finding time to purchase new athletic gear and practice her tennis game).

Research on episodic planning. Research on the concept of episodic planning has a long history in cognitive psychology and neuropsychology (65). One notable aspect of this literature is that planning tasks vary considerably in terms of how well they approximate real-life planning, ranging from tasks that are completely removed from everyday experience (e.g., Tower of London) (68) to tasks that mimic episodic planning in the laboratory (e.g., Six Elements Task) (69) to tasks that involve carrying out episodic plans in real-world settings (e.g., planning and preparing a meal) (70). Much of the research on planning has been conducted in the context of frontal lobe dysfunction. The fact that patients with frontal lobe damage have trouble with each of these tasks highlights that processes subserved by the frontal lobes (e.g., executive control) play an important role in planning and future thinking more generally. More recent neuroimaging studies (7, 71) have examined the neural underpinnings of episodic or autobiographical planning using a task in which participants mentally construct plans containing specific steps to achieve specific autobiographical

goals (e.g., academic success). 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) (72, 73). Moreover, activity in the default network during episodic planning was closely coupled with activity in a distinct frontoparietal control network (74) that has been linked to executive control and goal-directed cognition and also supports planning performance on the Tower of London task (7). Finally, real-world episodic planning tasks have further illuminated the extent to which episodic planning draws on other modes of future thinking. One study showed that participant descriptions of strategies for completing a pseudoshopping/planning task included simulation, prediction, and intention formation (75). We address this point in additional detail below.

Semantic planning is the identification and organization of steps needed for some general or abstract state in the world to arise in the future.

Example of semantic planning. Monika explains to her boss what steps, in her opinion, would need to be taken for the company to successfully merge with a partner company and maximize profitability in the future.

Research on semantic planning. Semantic planning is perhaps best represented in the context of strategic (76) and urban planning (77). Although there exists a paucity of research related to the cognitive determinants of semantic planning, research concerning patients with frontal lobe damage has provided some initial data. Patients with frontal lobe damage exhibit difficulty in formulating both episodic plans (see above) and financial plans for others (78). It is important to point out that financial planning for others may incorporate both episodic and semantic features of planning (e.g., people may use their own experiences to formulate plans for others) (ref. 78, p. 1,882). Nonetheless, the results of this study suggest that cognitive functions subserved by the frontal lobes may be important for both episodic and semantic planning. To our knowledge, however, no study has directly compared episodic and semantic planning deficits in frontal lobe patients, and therefore, 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 (review in ref. 66) or the extent to which the two may work together in particular contexts (e.g., retirement planning) (79), and research along these lines has the potential to answer novel questions regarding individual differences in planning ability. For example, are people generally good planners, or can someone be a good semantic planner but a poor episodic planner and vice versa? Finally, we highlight that some forms of planning represent hybrid instances of episodic and semantic planning, such as planning for one's own retirement. Such instances of planning are neither strictly episodic (i.e., they do not refer to specific episodes) nor strictly semantic (i.e., the general state of the future being planned for is autobiographical in nature).

Interactions Between Modes of Future Thinking. Episodic, semantic, and hybrid forms of simulation, prediction, intention, and planning flexibly interact with one another to support prospective cognition. The extent to which such interactions serve to support/hinder adaptive behavior will represent an important avenue for future research. Simulated representations of the future can be used 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. Could specificity inductions (42) be used to improve the quality of plans? In a similar vein, relatively little is currently known about the extent to which the perceived likelihood of the occurrence of a future event might influence the formation and retention of intentions or the quality of plans. Is an intention less likely to influence behavior if the perceived probability of occurrence is less than certain? Studies examining the frequency of occurrence of prospective memory probes suggest that perceived probability of occurrence may not play an appreciable role in determining prospective memory performance (80). Additional work, however, is needed to test the context of prospective memory tasks (e.g., laboratory vs. daily life) and the manner that perceived plausibility of occurrence is manipulated (e.g., frequency of occurrence vs. explicit instruction).

Applications. This organizational framework provides a benchmark against which clinical populations with deficits in future thinking can be assessed 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 (35), although they may have difficulty generating semantic details of future events (36). 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 patients with frontal lobe damage exhibit considerable deficits in episodic and semantic planning, less is known about the extent to which such patients are able to generate useful simulations and predictions of episodic and semantic future events (81). 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 (82). 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, semantic, and hybrid forms of simulation, prediction, intention, and planning. 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?).

Caveats

The purpose of our organizational framework for future-oriented cognition is to provide an impetus toward delineating the multidimensional ways in which the various modes of future thinking interact with one another in the service of adaptive behavior. Nonetheless, additional cognitive, emotional, and motor processes may contribute to and support future-oriented behavior. In future discussions of fractionating prospective cognition into its constituent parts, these additional factors may require a revised taxonomy pending future research. Although a comprehensive discussion of these factors is beyond the scope of this article, we briefly draw attention to each of these issues below.

Cognitive Processes That Give Rise to Prospective Cognitions. An important avenue of future work will be to identify the manner in which basic cognitive processes are strung together in the service of various modes of future thinking. We have already highlighted the important role that extracting details from episodic memory plays in the context of episodic simulation. However, other cognitive processes, such as causal reasoning (83), manipulating extracted episodic details through executive resources

(84), and scene construction (85), have also been proposed to feature prominently in the context of episodic simulation (additional discussion in ref. 12). This approach could provide additional clarity as to how various modes of future thinking are ultimately related to one another and also, understanding of patterns of deficits of future thinking. For instance, it will be important for future work to identify the overlapping and nonoverlapping contributions of specific executive resources to episodic simulation and planning.

Cognitive Operations and Emotional/Motivational States. Related to the above point, it will also be necessary to consider cognitive operations that build on the core modes of future thinking that we have identified and emotional/motivational states that arise or perhaps, give rise to these core modes of future thinking. For instance, in the process of simulating a desired autobiographical state (e.g., I want to be a good tennis player), one may compare and contrast the vision of the future self with the current self in an effort to stir motivation (50). Although mental contrasting is not necessarily a future-oriented cognitive operation, it may, nonetheless, enhance future-oriented behavior. As another example, mentally contrasting the short- and long-term consequences to impending actions can serve to enhance far-sighted decision-making (86, 87). Although a thorough treatment of the vast decision-making literature is beyond the scope of this article (recent reviews in refs. 88 and 89), we view decisions as end points of a process that may, depending on the influence of various heuristics and biases, use the various forms of future thinking discussed in this article (e.g., simulation, prediction, and planning) in the service of adaptive behavior (additional discussion in ref. 34).

In terms of emotional/motivational states, whether one experiences hope, apprehension, or some other emotional state in relation to various future-oriented cognitions will depend largely on dispositional and situational factors that are governed by emotional/motivational systems that are outside of the domain of mental representations of the future. Prior work has shown that people who approach their lives with the future in mind (90) or believe that their future will turn out well (91) tend to be particularly well-adjusted in terms of psychological and physical health. Disruptions to the status quo (such as unexpectedly losing a job) likely cause a flurry of motivated future-oriented thinking to reestablish a stable state. The manner in which emotional/motivational systems interact with systems that support the various representations of the future that we have outlined here represents an important direction for future work (discussion in ref. 92).

Procedural System and Future Behavior. Looking beyond episodic and semantic forms of prospection, we note that the procedural or motor system may also play an important role in certain kinds of prospection (6). In our hypothetical scenario, Monika could engage in mental practice or simulation of her tennis serve and also generate procedural predictions, intentions, and plans in the course of her actual match. Considerable research has shown that mental practice may benefit later performance (93) and that prefrontal and parietal regions of the brain seem to play an important role in representing motor predictions, intentions, and plans (relevant reviews in refs. 94–96). Nonetheless, we resist the temptation to include procedural forms of prospection in our framework, because it is not clear the extent to which procedural predictions, intentions, and plans contribute to future-oriented cognitions as opposed to impending motor actions. For instance, it has been shown that intentions to make a motor movement may be encoded in the brain up to 10 s before those intentions enter conscious awareness (97). The extent to which motor intentions contribute to higher-level or conceptual thoughts about the future awaits additional investigation (discussion relevant to social cognition is in ref. 98). Clearly, however, prospective cognition must inform immediate motor behavior at some junction to organize immediate behavior and accomplish many of the future-oriented thoughts considered (12). Understanding how future-oriented cognition is translated into action and how particular modes of future thinking, such as simulation, can be used to enhance the successful attainment of desired future goals and states represents an important mission of the field of prospective psychology.

Conclusion

The purpose of this article is to provide an initial framework for organizing key components that fit under the general concept of prospection. We suggest that conceiving an episodic–semantic gradient within which simulation, prediction, intention, and planning operate provides a useful framework by which to discriminate and develop connections among various forms of future thinking that constitute the landscape of research on prospective cognition. It is our hope that our organizational framework will provide insights into disorders of future thinking in humans, encourage more in-depth considerations of the manner in which future-thinking capacities in human and nonhuman animals overlap and diverge (99), and encourage cross-fertilization of research and theory across various domains of prospective psychology (100).

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