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Prospection and the Present Moment: The Role of Episodic Foresight in Intertemporal Choices Between Immediate and Delayed Rewards

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Humans are capable of imagining future rewards and the contexts in which they may be obtained. Functionally, intertemporal choices between smaller but immediate and larger but delayed rewards may be made without such *episodic foresight*. However, we propose that explicit simulations of this sort enable more flexible and adaptive intertemporal decision-making. Emotions triggered through the simulation of future situations can motivate people to forego immediate pleasures in the pursuit of long-term rewards. However, we stress that the most adaptive option need not always be a larger later reward. When the future is anticipated to be uncertain, for instance, it may make sense for preferences to shift toward more immediate rewards, instead. Imagining potential future scenarios and assessment of their likelihood and affective consequences allows humans to determine when it is more adaptive to delay gratification in pursuit of a larger later reward, and when the better strategy is to indulge in a present temptation. We discuss clinical studies that highlight when and how the effect of episodic foresight on intertemporal decision-making can be altered, and consider the relevance of this perspective to understanding the nature of self-control.

Keywords: episodic foresight, prospection, intertemporal choice, delay discounting, evolution

Preparation for the future is a critical aspect of complex life. The causal directionality of time means that those traits that serve to bolster the survival and reproductive success of an organism in the future are favored by natural selection. It is perhaps unsurprising, then, that cognition in animals is fundamentally future-oriented, expressed in many different types of goal-driven behavior (Seligman, Railton, Baumeister, & Sripada, 2013; Suddendorf & Corballis, 1997). To pursue future rewards, individuals must at times forgo more immediate opportunities and a large body of research has examined how such decisions are made when both human and nonhuman subjects are presented with a choice between smaller but immediate rewards, and larger ones likely available at some point in the future (Berns, Laibson, & Loewenstein, 2007; Loewenstein, Read, & Baumeister, 2003; Peters & Büchel, 2011). In these so-called intertemporal choice tasks, a decision-maker must indicate a preference for one of these options to the exclusion of the other. For instance, pigeons may peck one button to receive some grain now, or peck another button and wait 6 s for a larger payload (Mazur & Logue, 1978). Though human studies typically involve considerably longer delays, the structure of the tasks is often the same. For example, participants may be required to click one button to indicate a preference for $6 now, or another to indicate a preference for $10 after a wait of 30 days (Richards, Zhang, Mitchell, & de Wit, 1999). Such behavioral choices may reflect future-oriented decision-making mechanisms that incorporate information about the costs and benefits of future possibilities. Here we examine how the capacity to mentally simulate future situations influences these decisions.

Humans can engage in mental time travel into the future, or *episodic foresight,* a capacity that allows details of a potential future reward outcome and its context to be simulated and to thereby inform decision-making (Atance & O'Neill, 2001; Schacter, Addis, & Buckner, 2007; Suddendorf, 2010; Suddendorf & Corballis, 1997, 2007; Suddendorf & Moore, 2011). The open-ended capacity to imagine potential future scenarios confronts humans with many opportunities and thus with choices about what to pursue when. Clearly, human intertemporal decision-making can be very complex as a result, involving plans that can span decades, diverse subgoals and if–then contingencies. It remains uncertain, however, whether mental time travel is required to act adaptively even in simple standard intertemporal choice tasks. Indeed, there is now a considerable literature showing that nonhuman animals and people with hippocampal amnesia, who appear to lack or be severely limited in their episodic foresight, are nonetheless able to pursue larger delayed payoffs, at least over short timeframes (Kwan et al., 2012; Stevens & Stephens, 2008). This suggests that simpler mechanisms may drive such choices (Stevens, 2011).

In this review, we argue that even if a capacity for episodic foresight may not be a necessary prerequisite for making future-oriented intertemporal choices, it offers tremendous additional *flexibility* over other mechanisms. We focus on the role of episodic foresight in modifying decisions in standard intertemporal choice situations; that is, when a decision must be made between an immediate and a delayed reward where one option is chosen to the exclusion of the other. Simulating future rewards during intertemporal choice situations may trigger emotions that motivate people to forego immediate pleasures in pursuit of longer-term goals. This

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has been considered a defining factor in the evolution of foresight and a critical human ability (Baumeister & Masicampo, 2010; Boyer, 2008). However, we highlight that imagining the future does not necessarily lead people to forgo immediate temptations. For instance, if one foresees an uncertain or threatening future it may be more adaptive to indulge in the present, given that future rewards may not materialize. Therefore, we argue that episodic foresight affords adaptive flexibility in simple intertemporal choice situations—serving to shift preferences either toward long-term rewards or toward immediate gratification, depending on what one anticipates the future will hold. We discuss the implications of this view with regards to the nature of self-regulatory resources and outline evidence of alterations in the way episodic foresight may shift preferences in the context of clinical psychopathology, neurodegenerative disease and normal adult aging.

Episodic Foresight as Prospective Cognition

Episodic foresight is not a unitary entity, but instead requires a suite of interacting component capacities and operations including some degree of self-awareness, as well as the capacity to entertain metarepresentations and mental attributions (D'Argembeau, Ortoleva, Jumentier, & Van der Linden, 2010; Redshaw, 2014; Suddendorf & Corballis, 1997, 2007; Suddendorf & Redshaw, 2013). Episodic foresight forms part of a general constructive process of mental time travel responsible for the simulation of both past and future episodic events (Buckner & Carroll, 2007; Hassabis & Maguire, 2009; Suddendorf & Corballis, 1997). Evidence from cognitive neuroscience, brain lesion patients, developmental psychology and phenomenological analyses converge to show fundamental links between episodic foresight and episodic memory (e.g., Addis, Wong, & Schacter, 2007; Busby & Suddendorf, 2005; D'Argembeau & Van der Linden, 2004; Hassabis, Kumaran, Vann, & Maguire, 2007; Schacter et al., 2012; Spreng, Mar, & Kim, 2009; Szpunar, 2010). Nonetheless, there are some important differences (Suddendorf, 2010) including differential reliance on cognitive operations such as *recombination* (Weiler, Suchan, Koch, Schwarz, & Daum, 2011). Episodic foresight relies on components from memory to generate potential future scenarios (Hassabis & Maguire, 2009; Schacter et al., 2007; Suddendorf & Busby, 2003), but this is not to say that these simulations can only be mere repetitions of past events. Instead, entirely novel constellations of possibilities can be constructed by recombining various constituent elements, such as actors, actions and objects, just as one can recombine words into novel sentences (Gilbert & Wilson, 2007; Suddendorf & Corballis, 2007; Suddendorf & Redshaw, 2013).

The capacity to imagine various possible future contingencies has critical implications for adaptive decision-making (Suddendorf & Busby, 2005). Indeed, according to Suddendorf and Moore (2011) episodic foresight entails not only the simulation of future scenarios but also the capacity to organize current action in view of anticipated events. In adult humans, such future-directed decisions can be focused on achieving short-term goals such as shopping for tomorrow's dinner or planning a surprise party, as well as long-term goals such as saving for retirement (Suddendorf & Redshaw, 2013; van Slageren, 2003). Episodic foresight occurs voluntarily, but also involuntarily (i.e., without conscious effort) in the course of everyday life (Berntsen & Jacobsen, 2008; D'Argembeau, Renaud, & Van der Linden, 2011; Finnbogadóttir & Berntsen, 2013), and may constitute an ongoing and underlying process of planning and preparing for future possibilities with regards to personal goals (Baird, Smallwood, & Schooler, 2011; Demblon & D'Argembeau, 2014; Smallwood & Andrews-Hanna, 2013; Stawarczyk, Cassol, & D'Argembeau, 2013). Indeed, episodes of future-oriented mind-wandering have been linked to the activity of the "default mode network" of cortical regions usually active during periods of task-unrelated rest. Such findings suggest that people often resort to imagining future possibilities when external task demands are low (Burgess, Dumontheil, & Gilbert, 2007; Corballis, 2012, 2013; Mason et al., 2007; Smallwood & Schooler, 2015; Smallwood, Tipper, et al., 2013; Spreng & Grady, 2010).

Future-oriented cognition refers to a multidimensional array of cognitive processes, and attempting to delineate these processes has led to the identification of prospective counterparts to well-established subtypes of memory (Atance & O'Neill, 2001; Osvath & Martin-Ordas, 2014; Raby & Clayton, 2009; Suddendorf & Corballis, 2007; Szpunar, Spreng, & Schacter, 2014). For instance, Suddendorf and Corballis (2007) outline prospective counterparts to episodic, semantic and procedural memory, which differ in the demands they impose on semantic, episodic or procedural knowledge structures, respectively. Szpunar et al. (2014) further taxonomize prospective cognition into semantic and episodic forms of simulation, prediction, intention and planning, where each "mode" of future-oriented cognition has particular distinctive characteristics and component processes. However, the delineations between these different forms of prospective cognition are not absolute. In fact, the various forms are highly interrelated. For instance, it is well established that semantic knowledge plays an important, if not critical, role in the generation of episodic future simulations (Irish, Addis, Hodges, & Piguet, 2012; Irish & Piguet, 2013).

In sum, episodic foresight can be considered a form of prospective cognition that is hallmarked by the explicit mental representation of possible future events or outcomes and their embedding into larger causal narratives (Suddendorf & Corballis, 1997). In intertemporal choice tasks, episodic foresight therefore allows humans to create detailed and vivid mental simulations of possible future rewards and the contexts in which they may be obtained.

Future-Oriented Behavior in the Absence of Episodic Foresight

Examples of behaviors that appear future-oriented are ubiquitous in the animal kingdom. Even single-celled organisms can come to adjust their metabolism or locomotive rate in preparation for changing oxygen levels or periodic humidity, respectively (Saigusa, Tero, Nakagaki, & Kuramoto, 2008; Tagkopoulos, Liu, & Tavazoie, 2008). African termites build complex mounds with sophisticated thermoregulatory ventilation systems that ensure adequate gas exchange and ambient temperature in light of forthcoming changes in environmental conditions (Korb, 2003; Korb & Linsenmair, 1999), and so forth. It is uncontroversial to assume that these activities do not require any explicit mental representation of future events. Instead, these examples illustrate the power of emergent complex systems evolved over successive generations in response to regularities in the environment.

There are, however, more contentious examples of apparent future-directed decision-making and behavior in other nonhuman animals with complex brains. This includes the food caching of Western scrub jays, for instance, and the carrying of stones or sticks by great apes for future use in cracking nuts or termite fishing, respectively (Boesch & Boesch, 1983, 1984; Correia, Dickinson, & Clayton, 2007; Raby, Alexis, Dickinson, & Clayton, 2007). Although impressive, even these behaviors need not necessarily be explained by evoking a capacity for episodic foresight, but may instead reflect fixed action patterns or instinct, learned associations, complex environmental scaffolding, semantic or implicit forms of prospection, and any combination of these (Raby & Clayton, 2009; Suddendorf & Corballis, 2007, 2010).

Whether or not some nonhuman animals have a capacity for episodic foresight, it is clear that many species demonstrate adaptive behavior in situations that can be described as intertemporal choices. Decisions have to be made about whether *now* is the time for actions that may have future benefits (such as building a burrow) that may be in conflict with more immediately reinforcing actions such as seeking food rewards. Foraging itself includes many examples that can be construed as intertemporal decisions. Food caching, for instance, reflects a choice between consuming a reward now or saving it for a later time when its value may be higher, whether or not the animal is aware of this (Stevens & Stephens, 2008). Animals that cache enough food prior to food-scare future months will have a selective advantage over those that do not, and so mechanisms driving appropriate future-directed behaviors can spread. Other examples can be derived from questions about what to eat. An animal may, for instance, either eat an unripe fruit now or wait for it to ripen and reap the benefits of better taste and added nutrition (Dasgupta & Maskin, 2005; Fawcett, McNamara, & Houston, 2012; Stevens & Stephens, 2008). However, just because a behavior can be described as a response to an intertemporal choice in terms of the options available and their consequences does not mean that it must be driven by explicit representations of future outcomes and a deliberate decision between the options (see Stevens, 2011). Unripe fruit may simply taste bad and be shunned without any understanding that it may ripen later.

In this section, we have outlined that many organisms exhibit some predictive capacities for action in the face of an uncertain future and frequently face situations that can be described as intertemporal choices, in which a decision must be made with outcomes that play out over time. Next we turn to the experimental examination of such choices.

Delay Discounting and the Delay of Gratification

When given a choice between a smaller immediate reward, and a larger but delayed one, both humans and nonhuman animals tend to prefer the immediate (albeit smaller) option (Ainslie, 1974; Mazur, 1987; Stephens & Anderson, 2001). However, under some circumstances the delayed option is preferred, especially if the delay is small or the perceived value of the delayed reward large. In humans, delay discounting is most often indexed using intertemporal choice tasks, in which people are presented with a series of hypothetical choices between monetary amounts available immediately or after varying delays. In such tasks, future rewards decrease in subjective value as they move further away in time, a "delay discounting" effect sometimes modeled by an exponential curve, but probably more accurately by a hyperbolic function (Berns et al., 2007; Dasgupta & Maskin, 2005; Green & Myerson, 1996; Mazur, 1987; Shoji & Kanehiro, 2012). The "steepness" of the discounting curve is indicative of individual preferences, such that for an individual with a "steeper discounting curve" rewards more rapidly lose subjective value with increasing delays.

In classic experiments, children have been shown to find "delaying their gratification" difficult when offered a choice between eating a single marshmallow now, or waiting to receive an additional second marshmallow after some time (Mischel, Ebbesen, & Raskoff Zeiss, 1972). Attempting to delay gratification when presented with a tasty reward involves both the initial choice to be patient (akin to the hypothetical money choices discussed above) as well as a subsequent ongoing effort to resist indulging in the face of temptation. The degree to which an individual is prepared to wait in childhood has been found to robustly predict subsequent academic, personal and social successes even 40 years later in life (Mischel et al., 2011; Mischel, Shoda, & Rodriguez, 1989; Schlam, Wilson, Shoda, Mischel, & Ayduk, 2013; Shoda, Mischel, & Peake, 1990). An individual tendency to prefer immediate but smaller rewards over larger but delayed ones has conversely been associated with a range of maladaptive behaviors including substance abuse, physical inactivity and pathological gambling (Bickel & Marsch, 2001; Dixon, Marley, & Jacobs, 2003; Story, Vlaev, Seymour, Darzi, & Dolan, 2014).

The fact that the future is inherently uncertain may be responsible, at least in part, for the phenomenon that rewards become subjectively less valuable with increasing delays until their receipt (Fawcett et al., 2012; Loewenstein et al., 2003). After all, the future rewards may never eventuate or may be inferior to those promised. For instance, another individual may eat some or all of the fruit one has been waiting to ripen. If this is believed to be likely then *immediacy*, defined here as a behavioral tendency to select a smaller but sooner reward in lieu of a larger later one, is the more adaptive response, and delayed rewards will be more steeply discounted as a result (Houston & McNamara, 1988). A preference for, or selection of, immediate smaller rewards has also sometimes been referred to as "impulsivity" (Ainslie, 1974; Rachlin, 1974), although we will argue below that such a preference may also be caused by a consideration of the future.

A tendency to discount the subjective value of delayed rewards has been documented in numerous animal species from fish to great apes (Fawcett et al., 2012; Mühlhoff, Stevens, & Reader, 2011; Rosati, Stevens, Hare, & Hauser, 2007). Most animal species only wait for a few seconds for delayed benefits (e.g., Ainslie, 1974; Mazur, 1987), but at least some species can delay gratification for somewhat longer (Fawcett et al., 2012; Logue, 1988; Rosati et al., 2007; Stevens, Hallinan, & Hauser, 2005). The extent to which an animal species may delay the receipt of rewards appears to be linked to their ecological context. For example, animals that evolved in environments in which delayed rewards were less certain may have an increased propensity toward immediate gratification. As already noted, the more uncertain a larger delayed option is, the more advantageous it is to hold a preference for an immediate reward (Fantino, 1995). On the other hand, an evolved propensity for tool use or for less opportunistic foraging strategies may encourage greater tolerance for delays because these strategies generally require more waiting from the onset of behavior to the acquisition of a reward (Addessi, Paglieri, & Focaroli, 2011; Stevens et al., 2005).

Without linguistic instruction, animal studies must rely on the subjects' experience with the rewards and contingencies. For instance, subjects may be presented with a choice between two tools. Pulling one of these tools results in two food pellets, while pulling the other results in six food pellets. Initially, there is no time lag, but then a 1-s delay is added between selecting the larger reward tool and the receipt of the reward each time the subject choses it, allowing for an *indifference point* to be determined where the animal selects the delayed and immediate rewards equally often (Stevens et al., 2005). In *accumulation* tasks a reward is available at any time but *builds up* the longer the animal waits. Gaining a larger reward hence involves inhibiting the taking of the reward, as that would end the accumulation process (e.g., Anderson, Kuroshima, & Fujita, 2010; Beran, 2002; Evans & Beran, 2007; Pelé, Dufour, Micheletta, & Thierry, 2010; Pelé, Micheletta, Uhlrich, Thierry, & Dufour, 2011). Finally, *exchange tasks* require an animal to keep a small reward in their possession for a period of time before trading it back to the experimenter for a bigger reward (Dufour, Pele, Sterck, & Thierry, 2007; Leonardi, Vick, & Dufour, 2012). It remains debatable to what extent these different methodologies track the same capacities (Addessi et al., 2013) and to what extent they are comparable to standard human intertemporal choice tasks. For instance, concern has been raised about how animals interpret the delays within and between trials and there is evidence that patterns of apparent temporal discounting change as a result of changes to the salience of "postreward delays" between trials (Blanchard, Pearson, & Hayden, 2013; Pearson, Hayden, & Platt, 2010).

Notwithstanding debates about the interpretation of particular animal studies (Blanchard et al., 2013), the bulk of the research suggests that several species (e.g., rats, pigeons, dogs, monkeys and great apes) have some capacity to delay gratification in pursuit of larger future rewards, even if only over very short delay periods (Anderson et al., 2010; Evans & Beran, 2007; Leonardi et al., 2012; Osvath & Osvath, 2008; Reynolds, de Wit, & Richards, 2002; Stevens et al., 2005; Stevens, Rosati, Heilbronner, & Mühlhoff, 2011; Stevens & Stephens, 2008). Interestingly, the discounting rates of humans and nonhuman animals are quite similar when rewards are directly consumable food or water rather than money (Jimura, Myerson, Hilgard, Braver, & Green, 2009; Rosati et al., 2007), and in some contexts humans have even been found to be *less* patient than chimpanzees when waiting for food (Rosati et al., 2007). Nonetheless, this should not obscure the fact that most animals only wait for a few seconds for a reward, and chimpanzees for a few minutes (e.g., Dufour et al., 2007), whereas humans can delay their gratification for days, months or even years. Indeed, self-control in the face of immediate temptations continues to be considered a defining human ability (Baumeister, 2014; Baumeister & Tierney, 2011; Herrmann, Misch, Hernandez-Lloreda, & Tomasello, 2014; Vohs et al., 2014).

Neural Mechanisms and the Role of the Hippocampus

A full discussion of the neural mechanisms underpinning intertemporal decision-making is beyond the scope of this article (for review see Peters & Büchel, 2011). However, in brief, mechanistic accounts of delay discounting have been proposed in which separate neural systems are involved in the valuation of immediate versus delayed rewards (McClure, Ericson, Laibson, Loewenstein, & Cohen, 2007; McClure, Laibson, Loewenstein, & Cohen, 2004). Specifically, limbic structures including the striatum may encode the value of immediately available rewards while frontal regions including the dorsolateral prefrontal cortex may encode the value of temporally protracted ones. However, it has also been argued that there may be a single valuation system that weighs the value of rewards, irrespective of the delay to their receipt (Kable & Glimcher, 2007; Peters & Büchel, 2011).

The ventromedial prefrontal cortex (vmPFC; sometimes synonymous with orbitofrontal cortex) and ventral striatum appear to play a crucial joint role in the temporally extended valuation of rewards by encoding or representing their value (Peters & Büchel, 2011). Activity in the ventral striatum and vmPFC is frequently associated with the value of future rewards during intertemporal choice tasks (Kable & Glimcher, 2007), and lesions to the vmPFC increase delay discounting rates (Sellitto, Ciaramelli, & di Pellegrino, 2010). Perhaps most critically, medial temporal (including hippocampal) brain regions usually implicated in the construction of explicit mental scenes are generally not reported to be active during standard intertemporal choice tasks (Ballard & Knutson, 2009; Kable & Glimcher, 2007; Peters & Büchel, 2009). Again, this suggests that when encoding the value of future rewards, the neural regions involved in the episodic mental representation of future possibilities may not necessarily be involved.

Further evidence from studies of people with hippocampal amnesia support the argument that making intertemporal choices generally, and the delay of gratification, are not dependent on episodic foresight (Kwan et al., 2012). Damage to the medial temporal lobes usually results in profound difficulties imagining personal future events (Hassabis et al., 2007; Race, Keane, & Verfaellie, 2011; Verfaellie, Race, & Keane, 2012), but nonetheless patients with this damage can select delayed rewards and do exhibit somewhat normal delay discounting rates (Craver, Cova, et al., 2014; Kwan et al., 2012; Kwan, Craver, Green, Myerson, & Rosenbaum, 2013). On account of findings like these, hippocampal amnesiacs are now no longer considered to be wholly "stuck in time" as was once thought, despite having no ability to imagine personal future events in the most severe cases (Craver, Kwan, Steindam, & Rosenbaum, 2014). Interpretations of these findings, however, should be cautious given that other compensatory strategies for making intertemporal decisions and delaying gratification may have developed in response to the brain damage. Nevertheless, taken together, the most parsimonious explanation for current data as outlined in the preceding sections is that episodic foresight is not necessarily required either for the systematic subjective devaluation of rewards over at least short periods of time, or for electing to receive greater rewards after a delay.

Flexibility in Intertemporal Choice

As mentioned, delay discounting rates may vary between species as a function of their ecological conditions (Fawcett et al., 2012). However, even within the same species (and within the same individual) discounting rates may vary in relation to specific environmental contingencies. In humans, for instance, soldiers in times of active service exhibit steeper delay discounting than demographically matched controls, presumably because of the heightened risk inherent in the personal future of the soldiers (Lahav, Benzion, & Shavit, 2011). Likewise, when a delayed reward becomes less probable in an intertemporal choice task because the administering experimenters have proven to be untrustworthy, bonobos are less prone to delay their gratification (Stevens et al., 2011). Young children are similarly susceptible to changing levels of reward uncertainty, and become less inclined to wait for a second marshmallow if their experimenter fails to uphold a previously assured promise (Kidd, Palmeri, & Aslin, 2013). It makes little sense to be patient for a reward that is unlikely to materialize.

In addition to experimental evidence showing that discounting rates among children are strongly influenced by the probability that a future reward will actually materialize (Kidd et al., 2013; Mahrer, 1956), there is also evidence linking parental reward inconsistency in childhood with steeper discounting rates in later life. Presumably, early exposure to reinforcement uncertainty fosters a preference for immediate rewards as this has proven during development to be the more effective strategy for maximizing resource acquisition (Mauro & Harris, 2000; Patock-Peckham, Cheong, Balhorn, & Nagoshi, 2001; Patock-Peckham & Morgan-Lopez, 2006). One critical aspect of environmental uncertainty is an increased risk of death. When mortality risk is high, behavioral strategies that favor the acquisition of immediately available rewards may be an adaptive response. This is because the individual is less likely to be alive to capitalize on delayed rewards. As such, development in highly uncertain environments has been linked to more present-focused decision-making and behavior, as has exposure to cues of mortality risk (E. M. Hill, Jenkins, & Farmer, 2008; Kruger, Reischl, & Zimmerman, 2008; Pepper & Nettle, 2013, 2014; M. Wilson & Daly, 1997).

In this section, we have outlined how decision-makers may adjust their preferences for immediate and delayed rewards depending on the environmental circumstances in which they developed, or to which they are exposed. Specifically, an individual may come to prefer immediate over delayed rewards more so after learning that future rewards are unlikely to materialize (via development in uncertain environments), or that one may not be around to reap delayed rewards if and when they do arrive (e.g., by inferring one's risk of untimely death). However, humans are also capable of the flexible assessment of the value and likelihood of specific future rewards and the contexts in which they are to be received because they can simulate future possibilities. Episodic foresight allows people to shape the future based on comparisons of multiple future rewards and analyses of future contexts, subgoals and if–then contingencies. In light of imagined future situations, humans can adjust their preferences for immediate and delayed rewards in a highly flexible and adaptive manner—a point to which we now turn.

The Role of Episodic Foresight in Modifying Intertemporal Choices

Recent evidence suggests that engaging in episodic foresight while making intertemporal choices can result in significantly reduced rates of delay discounting (Benoit, Gilbert, & Burgess, 2011; Cheng, Shein, & Chiou, 2012; Daniel, Said, Stanton, & Epstein, 2015; Daniel, Stanton, & Epstein, 2013a, 2013b; H. Lin & Epstein, 2014; Liu, Feng, Chen, & Li, 2013; Peters & Büchel, 2010). For instance, in the behavioral component of an fMRI study, Peters and Büchel (2010) provided participants with a series of intertemporal monetary choices between a fixed smaller reward available immediately, and larger rewards delayed by different amounts of time. In half of the trials participants were cued about personally relevant events that were timed concurrently with the delayed options before making their decision, while in the other half of trials participants simply indicated their choice. The event cues were derived from a pretest interview with the participants about real, future scenarios that they had planned for the days of the delayed reward delivery. This meant that participants were presented with a standard intertemporal choice (e.g., either €20 now or €35 in 45 days) and in the episodic condition reminded about events in their personal future (e.g., vacation in Paris) while making this choice. As is typical of intertemporal choice studies, participants were told that one of the trials from the task would be selected at random, and the specified reward allocated after the chosen delay. Results indicated that in the episodic cue condition, participants were more prone to choose larger but delayed rewards. In other words, preferences tended to shift away from immediate gratification and toward long-term outcomes when participants were cued with personally relevant future events before making their choices. This effect was associated with individual differences in the degree of simulated episodic imagery, such that those participants who reported more frequently and more vividly imagining the future during the task were more inclined to choose the delayed rewards. In a separate but similar study, this reduction in discounting rates was also associated with the emotional intensity of the imagined episode, such that more emotionally intense imagery was linked to a greater tendency to choose delayed over immediate rewards (Benoit et al., 2011).

Interestingly, preferences in such modified intertemporal choice tasks have been found to shift toward future rewards whether participants are asked to imagine the actual consumption of a delayed reward (e.g., Benoit et al., 2011; Palombo, Keane, & Verfaellie, 2014), events around the time of future reward receipt (Daniel et al., 2013b; Kwan et al., 2015; Peters & Büchel, 2010), or future events in general (Cheng et al., 2012). For example, in Benoit et al.'s (2011) study, participants were instructed to vividly imagine spending the specified delayed reward amount in a preordained scenario (at the pub) while making their intertemporal choices, whereas in Cheng et al.'s (2012) Experiment One, participants were asked to imagine a typical day in their life 4 years from the present before starting a separate intertemporal choice task. Despite these disparate methods, engaging in episodic foresight shifted preferences toward future outcomes. In one recent study it was found that the extent of this preference shift was unrelated to the amount of previous experience that participants had with the *content* of the simulated future events (Sasse, Peters, Büchel, & Brassen, 2015). Imagining meeting both a celebrity (unfamiliar) and a family member (familiar) in a café attenuated the rate of delay discounting in a similar way.

A number of further studies have replicated the attenuating effect of engaging in episodic foresight on delay discounting, and identified a number of additional factors that may be involved (Daniel et al., 2015; Daniel et al., 2013a, 2013b; Dassen, Jansen, Nederkoorn, & Houben, 2015; H. Lin & Epstein, 2014; Liu et al., 2013). Importantly, some of these recent studies have included more robust control conditions, such as episodic thinking about recent or soon-to-be events (Daniel et al., 2015; H. Lin & Epstein, 2014), or episodic thinking about a story with vivid imagery (Daniel et al., 2013a, 2013b). The effect of episodic foresight on delay discounting has also been documented to have significant real life implications in contexts where a choice must be made between immediate gratification and long-term goals: both obese women and children tempted with gratifying unhealthy foods reduced their caloric intake as a result of episodic foresight during ad libitum eating (Daniel et al., 2013b, 2015). This effect has also recently been shown to occur in a naturalistic food-court setting with obese or overweight women (O'Neill, Daniel, & Epstein, 2015). Similarly, Dassen et al. (2015) report that a group of healthy female undergraduates consumed less calories during free access to snacks when simultaneously engaging in food-related episodic foresight (Dassen et al., 2015).

In addition to the aforementioned experimental effects, recent correlational studies have also suggested a link between individual differences on episodic foresight measures and a preference for delayed over immediate rewards. First, Bromberg et al. (2015) demonstrated that the vividness with which healthy adolescents imagined the future (as assessed using a form of autobiographical interview) was negatively correlated with their delay discounting rate (Bromberg, Wiehler, & Peters, 2015). Second, a greater tendency to engage in task-unrelated mind-wandering (shown to frequently involve mental time travel into one's personal future during everyday life) has also been associated with reduced delay discounting (Smallwood, Ruby, & Singer, 2013). Both of these correlational effects may reflect a similar process to when episodic foresight is explicitly cued during intertemporal choice tasks, such that a greater tendency to generate vivid simulations of the future during daily life may engender a greater consideration of the future consequences of the choices one makes in the present (e.g., Peters & Büchel, 2010).

Kurth-Nelson, Bickel, and Redish (2012) propose a theoretical model that accounts for the effect of episodic simulation on discounting. In this model, a cognitive search process that draws on working memory is responsible for valuing future rewards based on how readily they are located in mental representations of the future. When a reward is episodically simulated, it becomes easier for the search process to find. Empirical support for this model was provided in a study by H. Lin, and Epstein (2014), who found that the effect of episodic foresight on delay discounting was moderated by visual working memory capacity. Specifically, participants with higher working memory capacity derived a greater reduction in discounting rates from episodic foresight. Also consistent with predictions from Kurth-Nelson et al.'s (2012) model about the importance of cognitive resources are studies showing that working memory limitations and load increase discounting rates (Hinson, Jameson, & Whitney, 2003; Shamosh et al., 2008), that working memory training can reduce discounting rates (Bickel, Yi, Landes, Hill, & Baxter, 2011), and that working memory capacity is critically implicated in the mental construction of scenes during episodic foresight (P. F. Hill & Emery, 2013).

Finally, also providing support for a relationship between engaging in imagining future events and a shift toward choosing delayed rewards, people with hippocampal amnesia do not show the same reduction in delay discounting rates seen in neurotypical volunteers when cued to imagine specific future reward outcomes during intertemporal choice tasks (Palombo et al., 2014). As noted earlier, people with episodic amnesia experience profound difficulties imagining novel future events (Hassabis et al., 2007; Race et al., 2011; Verfaellie et al., 2012), so it is perhaps unsurprising that their discounting rates were unaffected by cues to engage in specific episodic imagery about receiving future rewards. However, a recent study by Kwan et al. (2015) cued people with hippocampal amnesia to imagine general future events timed concurrently with delayed options during an intertemporal choice task, and found reduced delay discounting in this condition. Kwan et al. (2015) noted that their cuing paradigm, which asked participants to imagine planned or plausible general future events like a wedding anniversary, diverged from the paradigm used in Palombo et al. (2014), in which amnesic participants were cued to imagine specific reward consumption (e.g., "Imagine spending $42 at a theater in 2 months"). Kwan et al.'s paradigm therefore represents a potentially more challenging episodic foresight task, and this may account for the differences in the results between these two studies. Interestingly, the two individuals with the most extensive bilateral medial temporal lobe damage were least responsive to the effect of instructions to engage in episodic foresight on delay discounting rates in the study by Kwan et al. (2015). Taken together, these studies suggest that the relationship between episodic foresight and intertemporal choice may depend on the content and specificity of what is (or can be) imagined. This said, hippocampal damage in humans has been shown to produce characteristically inflexible and maladaptive decision-making under circumstances that require the recombinant manipulation of information (Rubin, Watson, Duff, & Cohen, 2014), which, as noted earlier, is a process thought to underpin episodic foresight (Suddendorf & Corballis, 1997, 2007). Consequently, while hippocampal amnesia may not preclude the valuation of future rewards, it may impede an ability to *modify* decisions about these rewards by simulating them and the context of their receipt (Kwan et al., 2015).

Episodic Foresight Can Shift Preferences Toward Immediate Rewards

The previous section outlines how episodic foresight may engender a greater tendency to select larger but delayed rewards in intertemporal choices. Indeed, Boyer (2008) argues that the main adaptive function of episodic foresight may be to encourage future-oriented behavior by countering the discounting of delayed rewards. However, such intensive research focus on how episodic foresight may facilitate delayed gratification may have obscured the *flexibility* that episodic foresight promotes during intertemporal choices. Simulating future possibilities may result in either a decreased or an increased preference for immediate rewards (Lempert, Porcelli, Delgado, & Tricomi, 2012; Liu et al., 2013; Miloyan, Bulley, & Suddendorf, 2015). As discussed earlier, a preference for immediate gratification can at times be adaptive. Imagining a future where delayed rewards are less likely to materialize, have less value, or negative emotions are anticipated (thereby indicating negative future contexts), may produce a shift in preferences toward immediate rewards.

Some initial experimental evidence supports this proposition. For instance, imagining negatively valenced possible future events during an intertemporal choice task can lead to *increased* delay discounting rates (Liu et al., 2013), as can high levels of explicit worry (Worthy, Byrne, & Fields, 2014). Liu et al. (2013) reported that when participants engaged in episodic foresight about emotionally aversive events such as an illness or a traffic accident, they were significantly more prone to choose immediate over delayed rewards while making intertemporal choices. Analogously, Worthy et al. (2014) demonstrated that high levels of worry (a preoccupation with thoughts about potential negative future events) were related to an increased preference for immediate rewards. Furthermore, participants have been found to have a greater preference for immediate (smaller) rewards after engaging in future thinking about a stressful upcoming event, but not a neutral one (Lempert et al., 2012). Lempert et al. (2012) suggest that in contrast to studies illustrating amplified preferences for delayed rewards after the simulation of positive future events (e.g., Benoit et al., 2011; Peters & Büchel, 2010), foreseeing a *stressful* future context may "precipitate a bleak view of the future" and shift preferences toward immediately available rewards. These findings show that prospection during intertemporal decision-making need not equate to an enhanced preference for delayed rewards. Instead, engaging in episodic thinking about potential negative future possibilities may serve to underscore the uncertainty of the future (or reduce the perceived probability of the future reward), triggering immediacy in the present moment as a strategy to secure available and certain resources (Lempert et al., 2012; Liu et al., 2013).

Episodic foresight means humans are capable of imagining their own death, and doing so may dramatically influence intertemporal choices for the obvious reason that it makes salient the natural end of how long it makes sense to delay gratification. In the context of imagining potentially fatal occurrences such as an illness or traffic accident (e.g., Liu et al., 2013), immediacy may become more adaptive given that the limit of one's own future time horizon has been made salient and, ecologically speaking, patience is less likely to pay off when mortality risk is high (E. M. Hill et al., 2008; Kruger et al., 2008; Pepper & Nettle, 2013, 2014; M. Wilson & Daly, 1997). More direct tests are now needed to determine if simulating specific negatively valenced content flexibly adjusts discounting rates toward increased immediacy. For instance, does repeatedly imagining one's promised second marshmallow being eaten by another child (over and above priming this risk) lead children to adjust their preferences toward the sure thing: the marshmallow they already have in their possession? Furthermore, does explicitly imagining one's own untimely death result in a preference for immediate rewards? If so, campaigns aimed at reducing maladaptive health behaviors such as cigarette smoking by highlighting the risk of early death may paradoxically intensify preferences for immediate rewards (i.e., another cigarette). This is consistent with evidence showing increased delay discounting rates among participants from low socioeconomic backgrounds when exposed to mortality priming (Griskevicius, Tybur, Delton, & Robertson, 2011), and increased smoking intensity among individuals with strong cravings after cueing them with reminders of their mortality (Arndt et al., 2013).

In this section we have presented evidence that imagining future episodes might differentially shift preferences depending on the content of these imagined episodes. During an intertemporal choice, if one mentally envisages a rosy future where promised delayed rewards materialize, are of high quality, and are consumed, then a preference for larger delayed rewards becomes the better decision because patience in this context is more likely to pay off (Benoit et al., 2011; Daniel et al., 2013b; Peters & Büchel, 2010). However, we posit that if an imagined future is grim, with promised rewards withheld or of low quality, interruptions likely, or anticipated negative emotions rife (indicating negative future contexts), securing immediate rewards becomes a more adaptive decision-making strategy (Liu et al., 2013; Worthy et al., 2014). In sum, episodic foresight enables humans to consider diverse situations from various points in time and their links to present decisions. This confronts humans with complex intertemporal choices that can be prudently exploited. However, this is not to say that the adaptive function of episodic foresight is only the far-sighted delay of gratification in pursuit of large future rewards (see Ainslie, 2007; Baumeister & Masicampo, 2010; Boyer, 2008). Episodic foresight enables humans to flexibly respond to anticipated contingencies, which can also include an increased tendency to indulge in immediate temptations when the content of prospective images is grim.

How Does Episodic Foresight Influence Decision-Making in Intertemporal Choice Situations?

For episodic foresight to modify choices in the present moment it must necessarily interface with evolutionarily older decision-making mechanisms evolved for the regulation of behavior (Suddendorf & Busby, 2005). To this end, we highlight that mental simulations of possible future events provide value and likelihood information that influence decision-making. Specifically, the affective relevance, or emotional significance, of an imagined future contains *value* information about the outcome and context in question (Boyer, 2008; Gilbert & Wilson, 2007), while a gauge of the *likelihood* of various possible future outcomes may be deduced from imagining their occurrence and running simulations of possible steps to those futures (Kahneman & Tversky, 1982). How these two sources of information may adjust decisions in intertemporal choice situations is now outlined in turn.

Affective Relevance

"All animals are on a voyage through time, navigating toward futures that promote their survival and away from futures that threaten it. Pleasure and pain are the stars by which they steer" (Gilbert & Wilson, 2007, p. 1351).

The emotional significance of a particular stimulus or event is an indicator of its biological value, providing a common appraisal metric for a diverse array of environmental occurrences (Panksepp, 1998). Value, in this biological sense, relates directly to the survival and reproductive success of an organism, and emotions may serve as signals by proxy of how a particular state, behavior, stimulus or event relates to these fundamental fitness goals (Damasio, 2009). In immediate terms, this means that perceived environmental stimuli are assigned affective value to guide behavioral responses. Episodic foresight, however, enables the temporally extended ascription of value to imagined potential future occurrences, as well (W. Lin, Horner, Bisby, & Burgess, 2015; Suddendorf & Busby, 2005). In other words, humans can determine whether or not a future possibility is good or bad long in advance of its occurrence by the way it makes us feel when we imagine it. As such, anticipated emotional reactions are commonly evoked in the process of planning appropriate action and making decisions (Baumeister, Vohs, DeWall, & Zhang, 2007; Berns et al., 2007; Gilbert & Wilson, 2007; Mellers & McGraw, 2001; Rick & Loewenstein, 2008). Imagining a valenced stimulus is sufficient to trigger a cascade of physiological processes that constitute an emotional reaction (Damasio, 1994; Damasio et al., 2000). For example, imagining the experimenter eating one's promised marshmallow feels bad, and this present-moment emotional reaction can be used to infer what one might *later* feel were one to encounter this event in reality (Gilbert & Wilson, 2007).

It is therefore unsurprising that theoretical accounts of the mechanisms underpinning the effect of episodic foresight on delay discounting have placed emotion center-stage. Indeed, it has been suggested that emotions caused by the episodic image of a positive future outcome may engage a "motivational brake" on decisions in the present—serving to counteract present-oriented or "impulsive" choices from taking precedence (Baumeister & Masicampo, 2010; Boyer, 2008). In essence, the positive affective experience evoked by imagining a future payoff may spur continued patience in the pursuit of this temporally protracted outcome. However, imagining negatively valenced aspects of a future reward possibility, such as a reward being lost, may cause emotions in the present moment as well—serving to spur immediacy instead. Put simply, imagined scenarios can generate affective signals that imbue possible future eventualities with value, with this value information then flexibly guiding present-moment decision-making (Ainslie, 2007; Boyer, 2008; Miloyan & Suddendorf, 2015; Pezzulo & Rigoli, 2011; Suddendorf & Busby, 2005).

Balancing imagined with actual, perceptible outcomes is a difficult process, especially considering that mental representations become progressively more abstract and less detailed as they move temporally further into the future (D'Argembeau & Van der Linden, 2004; Trope & Liberman, 2010). Indeed, people are consistently unable (or unwilling) to weight future indulgences as highly as those in the present moment (Irving, 2009), often expressed as beliefs that later pleasures will be less intense than those of today (Kassam, Gilbert, Boston, & Wilson, 2008). This is particularly the case in some highly substance-dependent individuals, who have been shown to heavily underweight potential future consequences (Bechara, 2005; Bechara & Damasio, 2002; Petry, Bickel, & Arnett, 1998). Indeed, in order to balance the value of immediately perceptible versus imagined rewards one must be able to infer how one will feel upon the receipt of a delayed reinforcement. As such, some authors have postulated that the same "theory of mind" mechanisms involved in inferring the thoughts and feelings of other people may be used to simulate the motivational state of one's "future self," as well as the emotional reaction of this future self to the receipt of delayed rewards (Ersner-Hershfield, Wimmer, & Knutson, 2009; Loewenstein, 1996; O'Connell, Christakou, & Chakrabarti, 2015; Suddendorf, 1994).

At a neural level, areas of the prefrontal cortex, particularly the vmPFC and medial rostral prefrontal cortex, as well as the anterior cingulate cortex (ACC), are thought to be involved in the valuation of imagined possibilities by signaling their affective properties (Benoit et al., 2011; Benoit, Szpunar, & Schacter, 2014; W. Lin et al., 2015; Sasse et al., 2015), and consequently may be critical for attributing emotional value to mental representations of future events—even those pertaining to temporally distant long-term goals (D'Argembeau, Xue, Lu, Van der Linden, & Bechara, 2008; Hare, Camerer, & Rangel, 2009). For instance, in one recent fMRI study with healthy participants, enhanced vmPFC activation during imagined primary reward consumption (drinking imaginary fruit juice) was found to positively correlate with lower monetary delay discounting rates in a separate intertemporal choice task (Hakimi & Hare, 2015). In addition, the effect of episodic foresight on delay discounting has been shown to reflect a neural system underpinned by connectivity between such frontal regions involved in decision-making and valuation, and medial temporal regions that are highly active during simulations of future events (Benoit et al., 2014; Peters & Büchel, 2010; Sasse et al., 2015). For example, Sasse et al. (2015) report that functional coupling of the hippocampus with valuation signals in the ACC predicted delay discounting when participants imagined unfamiliar future events timed concurrently with the day of the delayed reward receipt during an intertemporal choice task. Furthermore, recent evidence suggests that the activity of brain regions linked consistently with episodic foresight form a functional network with reward processing regions during self-generated "outcome" simulations of achieving future goals (Gerlach, Spreng, Madore, & Schacter, 2014). Taken together, current evidence suggests that medial temporal lobe structures including the hippocampus play a key role in the valuation of future outcomes because of their involvement in the generation of simulations (see also Johnson, van der Meer, & Redish, 2007). These simulations may then come to be afforded affective relevance and influence decision-making by connectivity with prefrontal cortical regions such as the vmPFC, rmPFC and ACC.

Aside from the "anticipated emotions" discussed above (i.e., predicted emotions in response to a future event), people's decisions are also influenced both by the emotions they feel in the present moment with reference to a specific future event ("anticipatory emotions" like excitement about the upcoming treat), and emotions based on contextual factors or mood (Loewenstein & Lerner, 2003). While the distinction between anticipated and anticipatory emotions is relevant because of their differential content (Barsics, Van der Linden, & D'Argembeau, 2015), and differential association with subsequent behavior (Carrera, Caballero, & Munoz, 2012), the distinction is not absolute. As we have seen, anticipated emotions often involve an immediate emotional component that people use to predict their response to the future event if and when it were to occur (Damasio, 1994; Gilbert & Wilson, 2007; Miloyan & Suddendorf, 2015; Van Boven & Ashworth, 2007).

Nonetheless, the content of one's imagined future scenarios and one's mood appear to influence each other (Barsics et al., 2015; Miloyan, Pachana, & Suddendorf, 2014; Quoidbach, Wood, & Hansenne, 2009). This fact has long been recognized: "when we are self-satisfied, we do fondly rehearse all possible rewards for our desert, and when in a fit of self-despair we forebode evil" (James, 1890, p. 306). As such, in the context of intertemporal choices made under conditions of episodic future simulation, mood may be an important moderating variable (see also Hirsh, Guindon, Morisano, & Peterson, 2010). Likewise, anticipatory emotions like anxious worrying about the prospect of losing a risky delayed reward may have a complex influence on intertemporal preferences. However, a consideration of the roles of "anticipatory" emotions, and mood has been largely sidelined in theoretical and empirical accounts of the interaction between episodic foresight and intertemporal decision-making (though see Pezzulo & Rigoli, 2011). For example, it remains unclear how positive or negative affect specifically relating to an imagined future scenario may shift intertemporal decision-making *relative to* a similar affective state triggered by one's immediate environment.

Likelihood Information

"The ease with which the simulation of a system reaches a particular state is eventually used to judge the propensity of the (real) system to produce that state" (Kahneman & Tversky, 1982, p. 2).

Although humans can explicitly calculate probabilities and rationally compare different likelihoods, most assessments appear to be based on fast and frugal heuristics (Gigerenzer & Goldstein, 1996; Gigerenzer & Todd, 1999). As Kahneman and Tversky (1982) note, mentally simulating a possible future event may provide information about the likelihood of its occurrence. For instance, the "ease" with which a mental model of a possible future event comes to mind may act as a heuristic or "best guess" of the likelihood of it happening. Experimental evidence shows how imagined events that are more easily simulated may come to be estimated as more plausible, probable or likely (Raune, MacLeod, & Holmes, 2005), and that imagining a possible future occurrence can bolster its subjective plausibility. For example, imagining emotional future interpersonal interactions makes them seem more plausible, (Szpunar & Schacter, 2013). Similarly, imagining the result of a presidential election or football game makes that outcome seem more likely (Carroll, 1978), and vividly picturing being arrested, contracting a disease, or winning a contest leads these events to be rated as more probable to actually occur (Gregory, Cialdini, & Carpenter, 1982; Sherman, Cialdini, Schwartzman, & Reynolds, 1985).

These modified likelihood perceptions can directly affect intentions, decisions and behaviors. For instance, the repeated simulation of helping behaviors appears to increase intentions to help others (Gaesser & Schacter, 2014), and homeowners who imagine themselves using a cable TV service in the future are more likely to subscribe to such a service when given the opportunity (Gregory et al., 1982). When making decisions in an intertemporal choice situation, this is predicted to manifest as increased preferences for delayed larger rewards after repeated positive outcome simulations. However, it may also lead to more immediacy in decisions after repeatedly imagining negative possibilities. In each case, this is expected partly as a result of the increased subjective plausibility that repeated simulations incur: for example, repeatedly imagining a future reward being lost may increase the subjectively perceived likelihood of this eventuality. Subsequently, the perceived high likelihood of losing the future reward might lead to discounting of that reward in favor of more immediate and certain options. Indeed, several studies have shown that anxious individuals, a group that is prone to repetitive negative future-oriented thinking and a reduced tolerance of risk and uncertainty (Miloyan et al., 2014), more steeply discount delayed rewards (Luhmann, Ishida, & Hajcak, 2011; Rounds, Beck, & Grant, 2007; Worthy et al., 2014). However, given that the content of prospective imagery among clinically anxious people is often highly negatively valenced, the respective importance of repeated simulation (likelihood) and emotionality in this context remains unclear (see Wu, Szpunar, Godovich, Schacter, & Hofmann, 2015).

Figure 1 illustrates how episodic foresight may feed back information about the affective relevance and likelihood of future rewards to adjust decision-making mechanisms and preferences in intertemporal choice situations. Note that these two sources of information probably interact in a number of important ways (e.g., Buechel, Zhang, Morewedge, & Vosgerau, 2014; Szpunar & Schacter, 2013). For example, Szpunar and Schacter (2013) report that while imagining potential future interpersonal experiences increases the subjective plausibility of these possibilities, this is only the case for positively and negatively emotional events, not

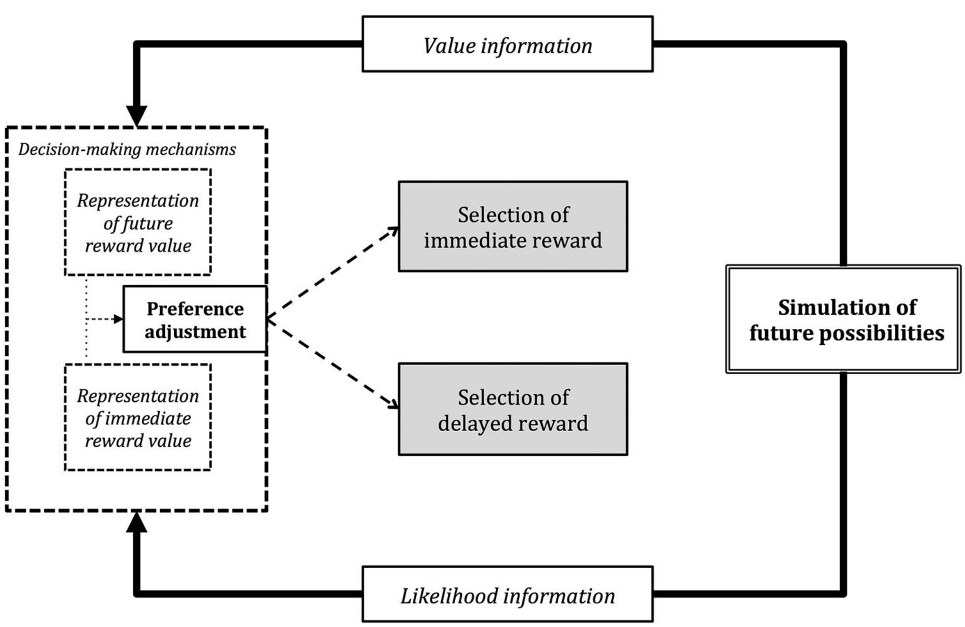

Figure 1. Simulations of future reward outcomes and contexts feed back value and likelihood information into decision-making mechanisms. These mechanisms are responsible for executing the behavioral selection of immediate or delayed rewards, and preferences for these rewards may shift differentially depending on what is simulated.

neutral ones (see also Wu et al., 2015). However, the precise manner in which affective and likelihood information about a simulated future event interact so as to influence intertemporal preferences, for example in terms of their respective weighting by decision-making mechanisms, remains unknown.

The Role of Systematic Biases in Foresight

Despite the ubiquity of human attempts to model or represent future possibilities, such predictions are often wrong in innumerable ways. In part, this is because the future is inherently uncertain and people can only make approximations of what may unfold. However, humans have also been shown to exhibit systematic *biases* in their forecasts that may have some ultimate benefits. First, people tend to consistently overestimate the intensity and duration of their emotional responses to both positive and negative future events (T. D. Wilson & Gilbert, 2003, 2005). This so-called *impact bias* is pervasive, and has been found to apply to predictions about events ranging from sporting victories to limb amputations (Halpern & Arnold, 2008; T. D. Wilson & Gilbert, 2005). Second, people have a consistent tendency to overestimate the likelihood of positive events and underestimate the likelihood of negative events occurring to them (Sharot, Korn, & Dolan, 2011; Taylor & Brown, 1988; Weinstein, 1980). This *optimism bias* is also widespread, occurring when people make predictions about the longevity and outcomes of their relationships (Baker & Emery, 1993), their estimated life expectancy (Puri & Robinson, 2007), and the promise of their business initiatives (Lovallo & Kahneman, 2003).

These biases may serve functional roles in the orchestration of flexible intertemporal decision-making (see also McKay & Dennett, 2009). Attempting to wait for a desirable future reward in the face of competing temptations is difficult, requiring patience and self-control. Overestimating both the likelihood and positive emotional significance of receiving a desired future reward may thereby serve to motivate behavior in its pursuit (Miloyan & Suddendorf, 2015; Morewedge & Buechel, 2013). In a similar vein, people strategically (though probably not consciously) overestimate their likelihood of goal success when they expect to encounter more obstacles in the pursuit of that goal (Zhang & Fishbach, 2010). Furthermore, the negative emotional impact of an imagined future threat may be wisely exaggerated to incentivize its avoidance (Miloyan et al., 2015), according with the "smoke detector" principle that it is better to over respond to a potential threat than to not respond to a real one (Marks & Nesse, 1994). The impact bias may therefore have adaptive evolutionary significance insofar as it "transforms the trivial into the consequential" (Hoerger, Quirk, Lucas, & Carr, 2010, p. 10), motivating appropriate decisions in light of temporally protracted possible events (Miloyan & Suddendorf, 2015; Morewedge & Buechel, 2013). The decision of whether to indulge in an immediate reward or wait for a future one that is in opposition to it may draw on the exaggerated glee or despair one imagines they will feel if that future reward *does* or *does not* materialize, respectively.

The Flexible Allocation of Self-Control as a Function of Episodic Foresight

As already noted, a capacity for self-control in the face of competing temptations is widely considered to be a fundamental and critical human capacity (Baumeister & Tierney, 2011; Diamond, 2013; Herrmann et al., 2014; Tangney, Baumeister, & Boone, 2004; Vohs & Baumeister, 2011). Deciding to indulge in immediate rewards in favor of larger but delayed ones has often been considered as resulting from a lack of self-control (Logue, 1988; Mazur & Logue, 1978; Rachlin, 1974), or to reflect a reduced capacity for self-regulation in the face of impulses (Tangney et al., 2004). However, although the capacity to delay gratification has been consistently linked to positive life outcomes (Mischel et al., 1989, 2011; Schlam et al., 2013; Shoda et al., 1990), delaying gratification is only adaptive in certain environmental circumstances (Fantino, 1995; Fawcett et al., 2012; Logue, 1988).

Furthermore, for the delay of gratification to be functional, it must eventually cease: One cannot wait indefinitely for food, for instance, as that would lead to starvation while "waiting for the windfall" (Santos & Rosati, 2015, p. 337). This extreme example illustrates the more general point that, eventually, a decision-maker must cease exercising self-control and capitalize on an opportunity. In humans, aspects of higher trait impulsivity are related to positive social and occupational outcomes (Gullo & Dawe, 2008), especially in areas that may benefit from a propensity to capitalize on opportunities such as in entrepreneurial endeavors (Stewart & Roth, 2001). Simulating different aspects of a future reward and its context can aid assessment of whether or not to delay gratification in its pursuit. In situations where a future reward is imagined as particularly valuable and likely, one may be best off allocating self-regulatory resources to inhibit responses to other temptations en route to this goal (Baumeister & Masicampo, 2010; Boyer, 2008). However, in imagining a future reward as less valuable or likely, one may be better off reserving those self-regulatory resources. This is consistent with views of self-control as a resource that partially depletes with use and is selectively allocated (Baumeister, 2014; Baumeister, Bratslavsky, Muraven, & Tice, 1998), as engaging in episodic foresight may provide information about whether or not to allocate this limited resource in a particular circumstance.

At least two aspects of the intertemporal choice and delayed gratification research paradigms may have obfuscated the role of episodic foresight we have outlined. First, both paradigms are usually posed as a choice between two rewards that are certain to materialize (though see Reynolds & Schiffbauer, 2004). The real world, at least the ancient ecological context in which decision-rules evolved, does not tend to present such clear-cut choices. Instead, different degrees of uncertainty are an inherent property of natural future outcomes (Loewenstein et al., 2003). For instance, there is always some intrinsic uncertainty about food rewards until they are inside one's mouth. More distant future outcomes are obscured, intangible, and remain uncertain when viewed through the fog of time (Rick & Loewenstein, 2008). Thus, intertemporal choices are not just choices between reward value and time, but also between different perceived probabilities. It remains to be seen if tasks in which the certainty of acquiring delayed rewards is systematically manipulated are more sensitive to individual differences in episodic foresight. For instance, when high uncertainty is built *explicitly* in to future rewards, one possibility is that people who more vividly imagine negative future possibilities may be more prone to shift their preferences toward immediate rewards, on account of imagining the eventuality of future loss. To test this hypothesis, cues to engage in episodic foresight could be presented during intertemporal choices where future rewards vary explicitly in their likelihood, such as in a combined delay and "probability discounting" paradigm or an "experiential discounting task" (see McKerchar & Renda, 2012; Reynolds & Schiffbauer, 2004).

Second, there is an important opportunity cost associated with some varieties of patient waiting that is not usually modeled in laboratory paradigms. In natural environments, if an animal spends time attempting to access one reward, opportunities to access other rewards are diminished. For example, the time taken to crack open a shell to retrieve the food reward within results in reduced opportunities to engage in the pursuit and acquisition of other food sources (Stevens & Stephens, 2008). This opportunity cost may be factored into intertemporal decision-making mechanisms in animals and may be one of the key reasons why delayed rewards become less subjectively valuable over time, whether or not the animal knows this (Fawcett et al., 2012; Stephens, 2002). However, the explicit and episodic simulation of this opportunity cost may further influence human decision-making during intertemporal choice. Choosing a delayed reward in most laboratory intertemporal choice tasks does not forego other reward-seeking opportunities. If it did, however, we predict that when people are cued to engage in episodic foresight of this opportunity cost they may be more inclined toward immediacy than individuals not engaging in episodic thinking. In other words, explicitly simulating the other rewards one *could* be pursuing instead of waiting may also produce a flexible modification of preferences toward smaller but sooner rewards.

In this section we have suggested that episodic foresight may act as a mechanism for determining the best allocation of self-regulatory or "self-control" resources. By imagining a possible future reward or the context of its receipt, a decision-maker can better determine whether or not it is worth being "patient" and restricting access to other indulgences in its pursuit. Furthermore, we have outlined how the lack of (a) uncertainty and (b) an explicit opportunity cost in laboratory studies of intertemporal choice may have somewhat obscured the flexibility afforded by episodic foresight over intertemporal preferences.

Clinical Considerations

A wide body of literature has now documented that episodic foresight is impaired in certain populations. Older adults show deficits in episodic foresight (Lyons, Henry, Rendell, Corballis, & Suddendorf, 2014), most likely as a result of cortical deterioration in the regions thought to support this capacity (Schacter, Gaesser, & Addis, 2013). Experimental findings indicate that older adults have greater difficulty imagining the future rather than imagining experiences per se (Rendell et al., 2012). Episodic foresight appears to even more impaired in age-related neurodegenerative disorders, such as Alzheimer's disease (Addis, Sacchetti, Ally, Budson, & Schacter, 2009; Irish & Piolino, 2015), in which the capacity to imagine the future may deteriorate alongside the capacity to evoke episodic memories. We might predict individuals suffering from a reduced capacity to imagine the future due to aging or age-related neurodegenerative disease to derive less flexibility over intertemporal choices when cued to engage in episodic foresight (e.g., Peters & Büchel, 2010).

There are also qualitative differences in episodic foresight among clinical subgroups that retain the ability to imagine the future, with regards to the detail and content of imagined episodes. For instance, one recent study showed that long-term opiate users were selectively impaired in their ability to vividly imagine details of the future, without any associated deficits in episodic memory (Mercuri et al., 2014). A similar reduction in the richness of episodic simulations, alongside a reduction in activity of corresponding brain regions, has been reported in individuals with depression (Hach, Tippett, & Addis, 2014). This latter group has also been shown to be less likely to generate positive future events in a fluency paradigm relative to controls (MacLeod & Byrne, 1996). Selective generation of particular content is also found in anxious individuals, who are more likely to imagine negative or threat-related affective content, but not fewer positive experiences than controls (Miloyan et al., 2014). Interestingly, anxiety may also be associated with heightened generality of thought content (i.e., more semantic than episodic details). Individuals with posttraumatic stress disorder, for instance, have been shown to generate highly general content when imagining the future (Brown, Addis, et al., 2013; Brown, Root, et al., 2013).

The use of episodic foresight to flexibly adjust intertemporal decision-making may be particularly heterogeneous in the populations outlined above, though the degree to which this is true remains largely unknown. For example, we might expect people with higher trait anxiety or depression to more readily shift their preferences toward immediate rewards when imagining the future during an intertemporal choice situation, considering that these individuals are prone to repeatedly generating negatively valenced future thoughts (Miloyan et al., 2014, 2015; Roepke & Seligman, 2015). We might also expect both individuals with posttraumatic stress disorder and depression, who typically report overgeneralized future thinking with reduced episodic specificity (Brown, Addis, et al., 2013; Brown, Root, et al., 2013; Hach et al., 2014), to derive less flexible modification of discounting considering they may be unable to generate the detailed episodic imagery usually associated with these effects (Peters & Büchel, 2010). Patients with bilateral amygdala lesions who demonstrate a marked lack of anxiety (Bach, Hurlemann, & Dolan, 2015; Feinstein, Adolphs, Damasio, & Tranel, 2011) might however also be predicted to receive very little modification of discounting from the imagination of a negative future event (e.g., increased immediacy after ruminating on the loss of a future reward), because of an inability to integrate affective anxiety appraisals with simulated mental images.

Future Directions and Conclusions

A number of additional questions and directions for future research remain about the role of episodic foresight in intertemporal choice. For instance, it will be important to tease apart the relative contributions of episodic and semantic forms of prospection in modifying intertemporal choices. This is underscored by a recent study by Kwan and colleagues (2015) who found that hippocampal amnesiacs with an impaired ability to imagine the future may still derive some flexible modification of discounting when cued to engage in episodic foresight, perhaps as a function of intact semantic or implicit prospective mechanisms. As such, in what ways and to what extent does episodic foresight modify choices over and above semantic priming of the future? Similarly, what is the role of vivid mental simulation of future outcomes relative to a verbal or semantic "consideration" of the future that does not involve engaging in fully fledged episodic simulation? (Strathman, Gleicher, Boninger, & Edwards, 1994; Zimbardo & Boyd, 1999). Studies of intertemporal choice in animals and in hippocampal lesion patients may prove to be fruitful avenues for delineating the relative contribution of different prospective mechanisms to future-oriented behavior (Cheke, Thom, & Clayton, 2011; Osvath & Martin-Ordas, 2014; Palombo, Keane, & Verfaellie, 2015; Thom & Clayton, 2014).

Furthermore, the role of episodic foresight has yet to be explored in other intertemporal choice paradigms such as the accumulation and exchange type tasks used in much of the animal literature, in choices between immediate and delayed punishments (rather than rewards), or in a diverse range of other contexts such as when multiple future rewards are on offer. Because very young children are often extremely steep delay discounters, it would also be relevant to explore the developmental trajectory by which episodic foresight becomes an avenue for adjusting intertemporal preferences (Bar, 2010). In general, between 3 and 4 years of age children become increasingly capable of delaying their gratification in pursuit of delayed rewards (Atance & Jackson, 2009; Hongwanishkul, Happaney, Lee, & Zelazo, 2005; Imuta, Hayne, & Scarf, 2014). Furthermore, some recent evidence suggests that between 3.5 and 4.5 years of age, children begin to *adapt* their intertemporal choices and saving behaviors based on changing risk contingencies (Lee & Carlson, 2015). Interestingly, this is around the same time that children appear to acquire the main cognitive components required to construct mental scenarios of future events and embed them into larger narratives (Suddendorf & Redshaw, 2013). As such, future research should explore the specific relationship between the development of episodic foresight and the capacity to flexibly adjust intertemporal preferences in early childhood (see also Garon, Longard, Bryson, & Moore, 2012; Lemmon & Moore, 2007). Finally, much remains to be determined about the role of variables such as working memory capacity: For instance, how will episodic foresight modify discounting rates under conditions of high cognitive load, given that working memory capacity appears crucial in the effect of episodic foresight on delay discounting (H. Lin, & Epstein, 2014)?

Although episodic foresight may not be required for some short-term adaptive intertemporal choices, we have argued that it provides critical flexibility in future-directed decision-making. Imagining future events and embedding them into larger narratives enables humans to compare diverse possibilities and probabilities, to derive prudent plans of action. While the role of episodic foresight in facilitating self-control in pursuit of long-term goals has previously been emphasized as critical, we have here pointed out that it may also result in a shift in preferences toward immediate rewards. In light of a positive imagined future, preferences may shift toward desired long-term goals. However, when a negatively valenced future is anticipated, the acquisition and consumption of immediately available rewards may be prioritized because future ones are expected to be less likely to materialize. The most adaptive option in intertemporal choice situations can change in response to assessments of the value and likelihood of possible future rewards brought about by simulating the future. In this way, episodic foresight provides humans with adaptive flexibility when faced with intertemporal choice situations in a way that extends the fundamental evolutionary logic of delay discounting and delayed gratification.

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