# Chapter 8
# Toward Narrative Theory: Interventions for Reinforcer Pathology in Health Behavior

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*O God, that men should put an enemy in their mouths to steal away their brains!*
—the character Cassio from Shakespeare's Othello, Act II Scene iii

## Introduction

In Shakespeare's Othello, Cassio laments that man knowingly chooses to consume harmful substances without regard for the consequences. Nonetheless, human consumption of psychoactive drug compounds is as old as the compounds themselves (Crocq 2007). Although drug use is immediately rewarding, its delayed consequences can be devastating. When I (W.K.B.) was a postdoctoral fellow at Johns Hopkins University, an interaction with one particular man exemplified this concept and became a pivotal moment in my career. The man, a chronic heroin user I will call "Dennis," was a participant in an ongoing study in the laboratory.

Dennis tested positive for illicit opioids and had visible track marks on his neck from intravenous heroin injection into his jugular vein. The veins at other, less conspicuous injection sites had collapsed due to Dennis' long history with heroin use; thus, his jugular vein was one of the last viable options through which to administer his fix. When I inquired about Dennis' positive urine sample and his wounds, he said that the local paper, *The Baltimore Sun*, reported that a spate of fatal heroin overdoses in the area was due to an increase in the availability of high-purity heroin. Dennis went on to say that if the heroin was *that* pure, he definitely needed to try some. As I listened to Dennis' enthusiasm, I could not help but wonder how someone could do something so risky without regard for the consequences. Did Dennis devalue his life that much? Perhaps, many cascading

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issues that come with chronic heroin use made his life intolerable. However, the ultimate consequence of overdose for a chemically induced high is arguably not a rational valuation of any life. So, again, I asked, “Why?”

Dennis’ myopic behavior was a self-control failure that could lead to the ultimate sacrifice. Dennis and others like him seek immediate rewards from drugs of abuse while sacrificing delayed outcomes such as improved health, employment, or stable family and social relationships. Such shortsighted behavior demonstrates a lack of concern for, or a devaluation of, the future. To explore this phenomenon, we empirically measured responses to a future time perspective task (Petry et al. 1998). Specifically, we read the beginnings of a number of open-ended stories and asked 34 heroin-addicted participants and 59 healthy control participants to generate the ending of these stories. In particular, one of the stories during this task began, “After awakening, Bill began to think about his future. In general, he expected to…” Participants in the study were asked to complete the story in any way they wish and then give an approximation of the time in which the story took place. We, as researchers, were not interested in the story’s content, but rather its *time frame*. The healthy control participants’ stories took place, on average, 4.7 years in the future. In contrast, heroin-addicted participants’ stories took place only 9 days in the future, demonstrating the significantly shorter time horizon observed in drug addiction. From this perspective, one could ask how an individual who cannot see beyond the next nine days would value a reward that is beyond that frame? Dennis may have been incapable of valuing a healthy life because he may not have been able to imagine a future past next week.

Myopic time horizons and valuation of the future can be more finely measured by examining temporal (or delay) discounting, the process in which the value of a reward declines with increasing delay to its receipt (Kirby 1997; Bickel and Marsch 2001; Madden and Johnson 2010). For example, an immediately available reward may be highly valued, whereas having to wait for the same reward decreases its value with increasing wait times. The rate of the decline in reward valuation can be measured using a choice task that estimates the rate at which individuals discount delayed rewards (see Box 8.1). If Dennis had completed a discounting task, we would likely have observed rapid devaluation of delayed rewards. Unfortunately, however, Dennis’ perspective is not uncommon among individuals with self-control failure and is the basis for a large and still growing field of research examining discount rates and maladaptive behaviors.

In this chapter, we expand our understanding of temporal discounting both as a behavioral process and as a tool to measure impulsive decision making. The extant evidence indicates that excessive discounting of delayed rewards is a trans-disease process, that is, a process evident in a wide range of diseases, disorders, and maladaptive health behaviors. We describe the evidence supporting this claim and discuss how this process can be explained using a common mechanism, the competing neurobehavioral decision systems (CNDS). Next, we expand our discussion to reinforcer pathology, the interaction between temporal discounting and the overvaluation of specific commodities, such as drugs of abuse. Finally, we end by presenting a review of recent evidence that temporal discounting and reward valuation can be altered using methods of *narrative theory*, a novel intervention framework which entails examining the impact of participant- and researcher-generated narratives on measures of reinforcer pathology.

**Box 8.1: Temporal Discounting**

**Temporal discounting** is the process in which a delayed reward loses its value as a function of the delay to its receipt. The rate at which the delayed reward loses its value can be empirically measured using one of several hypothetical or potentially real choice tasks (Koffarnus and Bickel 2014; Madden and Johnson 2010).

One of these tasks used to measure delay discounting is the **adjusting-amount task**. This task offers repeating choices between a smaller, immediate reward and a larger, delayed reward. Across trials, the amount of the larger, delayed reward stays constant (e.g., $100 in one week from now), while the amount of the smaller, immediate reward is titrated until an **indifference point** is reached (Richards et al. 1997; Bickel et al. 1999; Du et al. 2002). That is, some smaller immediate amount of money now will be subjectively equivalent to the delayed $100. Figure 8.1 provides example trials from this task; for space, we present only three trials, although six trials are most commonly used to estimate an indifference point (Du et al. 2002). This titration procedure is iterated over multiple delays (e.g., one day, one week, one month, three months, one year, and 25 years) to obtain a discounting curve (i.e., discounted value as a function of delay). Derivations of this task have also been studied in which a number of parameters have been manipulated, including magnitude of the rewards, the probability of the rewards, whether rewards occur in the past or future, whether rewards are to be gained or lost, and the social distance between the participant and the reward recipient (Rachlin et al. 1991; Baker et al. 2003; Yi et al. 2006a, b; Rachlin and Jones 2008).

Once indifference points are calculated, they are often fit to a nonlinear regression model. Again, multiple theoretical models are used to fit the indifference points (see Franck et al. 2015; Killeen 2009; Madden and Johnson 2010); however, Mazur's (1987) **hyperbolic model**

$$V = \frac{A}{1 + kD}, \tag{8.1}$$

is most common in the addiction literature (MacKillop et al. 2011). Here, $V$ is the present value of the reward (i.e., indifference point), $A$ represents the amount of the delayed reward, $D$ is the delay, and $k$ is a free parameter which indexes discount rate. Higher values of $k$ indicate a more rapid decline in value of delayed rewards (Odum 2011).

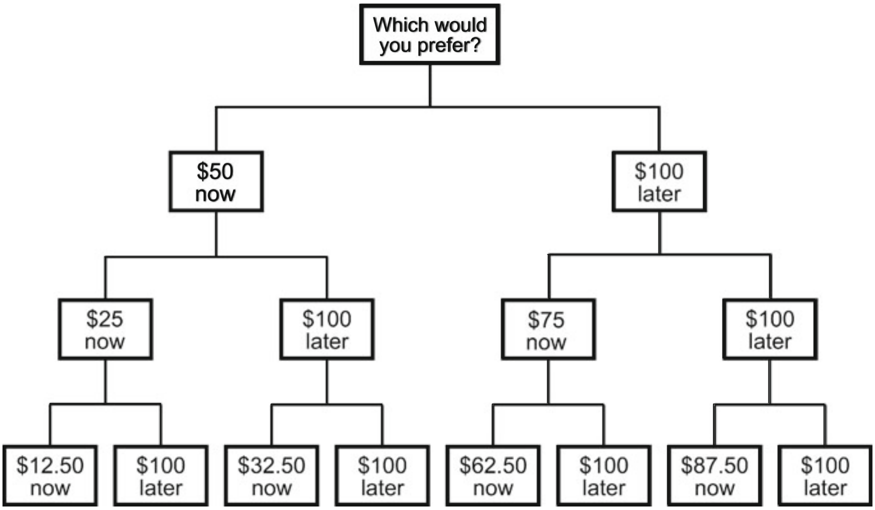


**Fig. 8.1** Three example trials of the adjusting-amount temporal discounting task. With each choice, the smaller, immediate amount increases or decreases by half of the previous amount. The traditional adjusting-amount task titrates a total of five times to determine an estimated indifference point at each delay

## Trans-disease Study of Health Behaviors

Given the state of health in the USA, namely that it lags behind other developed countries in several common metrics of health, identifying ways to prevent poor health and intervene on the behavior that causes it is of utmost importance. The National Research Committee and the Institute of Medicine, in a report titled *US Health in International Perspective*: *Shorter Lives*, *Poorer Health*, examined several metrics of health and in the USA and compared them to other developed countries (Woolf et al. 2013). Key findings from the report include shortcomings in the USA across six health behaviors: smoking, diet, physical inactivity, substance use, sexual practices, and injurious behaviors, implicating these behaviors as contributors to increased morbidity and mortality.

Health disparities in the USA necessitate improvements in how we study health and disease. One challenge to the study of disease is the assumption that diseases have unique etiologies which should be studied and treated as distinct from one another. This perspective is evident in disease-specific scientific societies, in journals, and even in the organization of the National Institutes of Health in which each institute is charged with the study of overlapping disease states (e.g., National Institute on Drug Abuse and National Institute on Alcohol Abuse and Alcoholism). In addition, science largely follows a reductionistic approach; that is, we study smaller and smaller phenomena with the hope that by breaking diseases into their component parts, the solution to the problem will become clear at a lower level of analysis (Skurvydas 2005; Strange 2005). Reductionistic approaches have resulted in remarkable productivity (e.g., DNA sequencing), evidenced by a rapidly increasing body of published research (Evans 2008) that has engrained this approach as the dominant scientific paradigm (Mitchell 2009). This approach, however, may have unintended consequences as scientists are compelled to learn more about progressively finer points related to their specialty. Specifically, the cause of some diseases may not be found by delving deeper, and specialization comes at the cost of less communication across specialty areas, creating "intellectual silos." An emphasis on deep, but narrow, specialization may result in failure to identify similar phenomena across specialties that could otherwise help in the characterization of many disease states.

Adding to this challenge is that a variety of diseases are both complex in cause and presentation. In particular, the symptoms of mental health and substance-use disorders are heterogeneous and diffuse; that is, many symptom profiles may result in the diagnosis of the same disorder. For example, in the current version of the *Diagnostic and Statistical Manual* (American Psychiatric Association 2013), substance-use disorders are comprised of eleven different symptoms; however, to be diagnosed with mild substance-use disorder, an individual must only present with two of those symptoms. Thus, several different individuals diagnosed with substance-use disorder may not share a single common symptom. The heterogeneous presentation of symptoms in diseases necessitates the consideration of possible common factors across diseases to elucidate those that may share similar etiologies or disease trajectories.

Here, we discuss a recent application, summarized by physicist and philosopher Ernst Mach: "Thence is imposed the task of everywhere seeking out in the natural phenomena those elements that are the same, and that amid all multiplicity are ever present" (Mach and McCormack 1907, p. 5). These ever-present phenomena are identified through the study of trans-disease processes, where the goal "is to understand the processes that operate in more than one disease and use that information to better understand, in principle, all the diseases in which they operate" (Bickel and Mueller 2009, p. 2). Trans-disease processes offer a means of dealing with the heterogeneous and diffuse manifestations of disorders and maladaptive behaviors by elucidating underlying characteristics that are present across multiple pathologies and to then use that information to better understand disease (cf. Insel et al. 2010).

Over the past two decades, temporal discounting has emerged as a candidate trans-disease process (see Box 8.2 for illustration of a foundational study). Tables 8.1, 8.2, and 8.3 (adapted from Bickel and Stein, under review) summarize the results of studies providing examinations of the relation between temporal discounting and a wide variety of health behaviors. Table 8.1 focuses on omissions of behavior that improve or maintain health (e.g., medical screening), Table 8.2 focuses on commissions of behavior that worsen health directly (e.g., substance

**Table 8.1** Summary of study findings describing the association between delay discounting and health behavior omissions

| | Finding | Study population | Study |
|---|---|---|---|
| *Medical screening* | | | |
| Blood pressure tests | − | Hypertensive patients, ≥ age 20 | Axon et al. (2009) |
| Cholesterol tests | − | ≥ age 50 | Bradford (2010) |
| Mammograms | − | ≥ age 50 | Bradford (2010) |
| Breast examinations | − | ≥ age 50 | Bradford (2010) |
| Pap smears | − | ≥ age 50 | Bradford (2010) |
| Prostate examinations | − | ≥ age 50 | Bradford (2010) |
| Dental visits | − | ≥ age 50 | Bradford (2010) |
| | | College graduates (mostly) | Chabris et al. (2008); Exp. 3 |
| Doctor/dental visits | | College students | Daugherty and Brase (2010) |
| HSV-2 tests | − | STI clinic patients | Chesson et al. (2006) |
| | | General clinic patients | Chesson et al. (2006) |
| | | Teenage clinic patients | Chesson et al. (2006) |
| | | College students | Chesson et al. (2006) |
| *Prevention and treatment* | | | |
| Exercise frequency | − | Normal weight, overweight, and obese | Chabris et al. (2008); Exp. 1 |
| | − | ≥ age 50 | Bradford (2010) |
| | | College students | Daugherty and Brase (2010) |
| | | College students and community residents | Chabris et al. (2008); Exp. 2 |
| | | College graduates (mostly) | Chabris et al. (2008); Exp. 3 |
| On a diet | | Normal weight, overweight, and obese | Chabris et al. (2008); Exp. 1 |
| Eating healthy food | | College graduates (mostly) | Chabris et al. (2008); Exp. 3 |
| | | Overweight and obese females | Appelhans et al. (2012) |
| Eating breakfast | − | College students | Daugherty and Brase (2010) |
| Flu shots | − | ≥ age 50 | Bradford (2010) |
| | − | Corporate workplace employees | Chapman and Coups (1999) |
| | − | College faculty/staff | Chapman et al. (2001); Exp. 1 |
| Wearing sunscreen | − | College students | Daugherty and Brase (2010) |
| Wearing sunscreen | − | Adults | Bradford et al. (2014) |
| Flossing | − | | Chabris et al. (2008) |

(continued)

**Table 8.1** (continued)

| | Finding | Study population | Study |
|---|---|---|---|
| | | College graduates (mostly) | |
| Bike/motorcycle helmet use | | College students | Daugherty and Brase (2010) |
| Seatbelt use | − | College students | Daugherty and Brase (2010) |
| Seatbelt use | − | Adults | Bradford et al. (2014) |
| Condom use with alcohol intoxication | − | Problem drinkers | Celio et al. (2016) |
| Condom use, general | | Problem drinkers | Celio et al. (2016) |
| | | General clinic patients | Chesson et al. (2006) |
| | | Teenage clinic patients | Chesson et al. (2006) |
| | | College students | Chesson et al. (2006) |
| Prescription compliance | − | Type 2 diabetes patients | Reach et al. (2011) |
| | − | Type 2 diabetes patients | Lebeau et al. (2016) |
| | − | College graduates (mostly) | Chabris et al. (2008); Exp. 3 |
| | | Elderly | Chapman et al. (2001); Exp. 2 |
| Diet/exercise | − | Hypertensive patients, $\geq$ age 20 | Axon et al. (2009) |
| Treatment compliance, general | | Hypertensive patients, $\geq$ age 20 | Axon et al. (2009) |

*Note* Adapted from Bickel and Stein (under review)
− indicates a significant negative association between the behavior and delay discounting
*Blank cells* in this column indicate no significant relation

**Table 8.2** Summary of study findings describing the association between delay discounting and health behavior commissions

| | Finding | Study population | Study |
|---|---|---|---|
| *Substance abuse* | | | |
| Opioids[a] | + | Opioid-dependent versus controls | Madden et al. (1997) |
| Alcohol[a] | + | Problem drinkers versus controls | Vuchinich and Simpson (1998) |
| Tobacco[a] | + | Smokers versus controls | Mitchell (1999) |
| Other stimulants[a] | + | Cocaine-dependent versus controls | Coffey et al. (2003) |
| Marijuana[a] | | Marijuana-dependent versus controls | Johnson et al. (2010) |
| Needle sharing | + | Opioid users | Odum et al. (2000) |

(continued)

**Table 8.2** (continued)

| | Finding | Study population | Study |
|---|---|---|---|
| *Gambling* | | | |
| Pathological gambling[a] | + | Pathological gamblers versus controls | Petry (2001b) |
| Problem gambling plus substance abuse[a] | + | Problem gambling substance abusers versus controls | Petry and Casarella (1999) |
| *Diet* | | | |
| Binge-eating disorder | + | Females, aged 25–45 | Davis et al. (2010) |
| Fast/convenience food consumption | + | College employees | Garza et al. (2016) |
| | | Overweight and obese females | Appelhans et al. (2012) |
| Snack consumption | + | General sample | Bradford et al. (2014) |
| Overeating | | College graduates (mostly) | Chabris et al. (2008); Exp. 3 |
| *Sexual behavior* | | | |
| Intercourse (ever) | | STI clinic patients | Chesson et al. (2006) |
| | | General clinic patients | Chesson et al. (2006) |
| | | Teenage clinic patients | Chesson et al. (2006) |
| | + | College students | Chesson et al. (2006) |
| Earlier sexual experiences | | STI clinic patients | Chesson et al. (2006) |
| | + | General clinic patients | Chesson et al. (2006) |
| | | Teenage clinic patients | Chesson et al. (2006) |
| | | College students | Chesson et al. (2006) |
| | + | General sample | Reimers et al. (2009) |
| Multiple partners | | Problem drinkers | Celio et al. (2016) |
| | | STI clinic patients | Chesson et al. (2006) |
| | | General clinic patients | Chesson et al. (2006) |
| | | Teenage clinic patients | Chesson et al. (2006) |
| | + | College students | Chesson et al. (2006) |
| Sexual infidelity | + | General sample | Reimers et al. (2009) |
| Pornography use | + | College students | Negash et al. (2016) |
| *Other risky behavior* | | | |
| Texting while driving | + | College students | Hayashi et al. (2015) |
| | | College students | Hayashi et al. (2016) |

*Note* Adapted from Bickel and Stein (under review)
+ indicates a significant positive association between the behavior and delay discounting
− indicates significant negative association
*Blank cells* in this column indicate no significant relation
[a]Indicates seminal finding; more detailed reviews and meta-analyses of this robust finding may be found elsewhere (MacKillop et al. 2011; Amlung et al. 2016b)

**Table 8.3** Summary of study findings describing the association between delay discounting and health outcomes and other disorders

| | Finding | Study population | Study |
|---|---|---|---|
| *Outcome* | | | |
| Obesity[a] | + | Female college students | Weller et al. (2008) |
| High body fat | | College students | Rasmussen et al. (2010) |
| | | Adolescent boys | Lu et al. (2014) |
| | + | Adolescent girls | Lu et al. (2014) |
| | | College students | Daly et al. (2009) |
| Poor response to weight-loss treatment | + | Adolescents | Best et al. (2012) |
| High blood pressure | | Elderly | Chapman et al. (2001); Exp. 2 |
| | + | College students | Daly et al. (2009) |
| Heart rate | | College students | Daly et al. (2009) |
| Heart rate invariance | + | College students | Daly et al. (2009) |
| Poor glycemic control | + | Type 2 diabetes patients | Reach et al. (2011) |
| | + | Type 2 diabetes patients | Lebeau et al. (2016) |
| | | College students | Daly et al. (2009) |
| Pregnancy (ever) | | STI clinic patients | Chesson et al. (2006) |
| | + | General clinic patients | Chesson et al. (2006) |
| | | Teenage clinic patients | Chesson et al. (2006) |
| | | College students | Chesson et al. (2006) |
| *Disorder* | | | |
| Attention deficit/hyperactivity disorder | + | Adolescent boys | Paloyelis et al. (2010) |
| | +[b] | Children, aged 7–9 | Wilson et al. (2011) |
| | | Children and adolescents, ages 6–17 | Scheres et al. (2006) |
| | | College students | Scheres et al. (2008); hypothetical rewards |
| | + | College students | Scheres et al. (2008); real rewards |
| | + | College students | Hurst et al. (2011) |
| Anorexia | − | Anorexia patients versus controls | Steinglass et al. (2012) |
| | − | Anorexia patients versus controls | Decker et al. (2015) |
| | | Anorexia patients versus controls | King et al. (2016) |
| | | Anorexia patients versus controls | Ritschel et al. (2015) |

(continued)

**Table 8.3** (continued)

| | Finding | Study population | Study |
|---|---|---|---|
| | | Weight-recovered anorexia patients versus controls | Decker et al. (2015) |
| | | Weight-recovered anorexia patients versus controls | Ritschel et al. (2015) |
| Bulimia | + | Bulimia patients versus controls | Kekic et al. (2016) |
| Obsessive–compulsive personality disorder | − | OCPD patients versus controls | Pinto et al. (2014) |
| Schizophrenia | + | Schizophrenia patients versus controls | Heerey et al. (2007) |
| | | Schizophrenia patients versus controls | Wing et al. (2012) |
| | | Schizophrenia patients who smoke versus controls who smoke | Wing et al. (2012) |
| | | Schizophrenia patients who smoke versus controls who smoke | MacKillop and Tidey (2011) |

*Note* Adapted from Bickel and Stein (under review)
+ indicates a significant positive association between the behavior/disorder and delay discounting
Blank cells in this column indicate no significant relation
[a]Indicates seminal finding; a more detailed review and meta-analysis of this robust finding may be found elsewhere (Amlung et al. 2016a)
[b]Indicates an effect of delay discounting was no longer observed when controlling for intelligence

abuse), and Table 8.3 focuses on behavioral outcomes (e.g., obesity) and psychiatric disorders. As these findings show, elevated rates of discounting are associated with virtually every form of addictive substance (for meta-analysis, see MacKillop et al. 2011; Amlung et al. 2016b), including cigarettes (Bickel et al. 1999; Baker et al. 2003; Reynolds et al. 2004), cocaine (Coffey et al. 2003; Bickel et al. 2011; Moody et al. 2016), opioids (Madden et al. 1997; Stoltman et al. 2015), and alcohol (Petry 2001a; Moallem and Ray 2012; Moody et al. 2016).

**Box 8.2: Temporal Discounting and Addiction**
In a foundational study, Madden et al. (1997) compared temporal discounting in **opioid users** to **demographically matched, non-drug-using controls** (see Fig. 8.2). Opioid users showed dramatically higher rates of discounting of a $1000 reward that is depicted by the curves, fit using Eq. 8.1, where the more closely the curves hug the axes, the steeper the discounting. The effective delay 50 ($ED_{50}$), or delay at which the commodity (in this case $1000) loses half of its value, is calculated as the inverse of the *k* parameter from Eq. 8.1

(Yoon and Higgins 2008). In this case, the $ED_{50}$ of the control group was more than a month ($ED_{50}$ = 37.04 months), while the $ED_{50}$ of the opioid-dependent group was less than a week ($ED_{50}$ = 4.55 months)—more than an eightfold difference. The strikingly high rate of discounting observed in opioid-dependent individuals depicts the restricted perspective from which these individuals view the future and makes evident how future negative consequences of poor health behaviors may carry little value for these individuals.

Excessive temporal discounting has also been reported in problem gambling (Dixon et al. 2003; Miedl et al. 2012), obesity (Weller et al. 2008; Epstein et al. 2010), and binge-eating disorder (Davis et al. 2010), as well as frequent consumption of fast food (Garza et al. 2016), earlier sexual encounters (Chesson et al. 2006; Reimers et al. 2009), and texting while driving (Hayashi et al. 2015). Likewise, excessive discounting has been observed in those who less frequently engage in health-promoting behaviors such as eating breakfast (Daugherty and Brase 2010), receiving flu shots (Bradford 2010), wearing sunscreen (Daugherty and Brase 2010), flossing (Chabris et al. 2008), wearing a helmet when biking or motorcycling (Daugherty and Brase 2010), wearing seatbelts (Chesson et al. 2006), using condoms (Chesson et al. 2006), and complying with prescribed medical advice (Chabris et al. 2008; Reach et al. 2011; Lebeau et al. 2016). In sum, the pervasiveness of excessive temporal discounting in this wide range of diseases, disorders, and health behaviors (see Tables 8.1, 8.2 and 8.3) supports temporal discounting as a trans-disease process and occasions investigation of its underlying mechanisms.

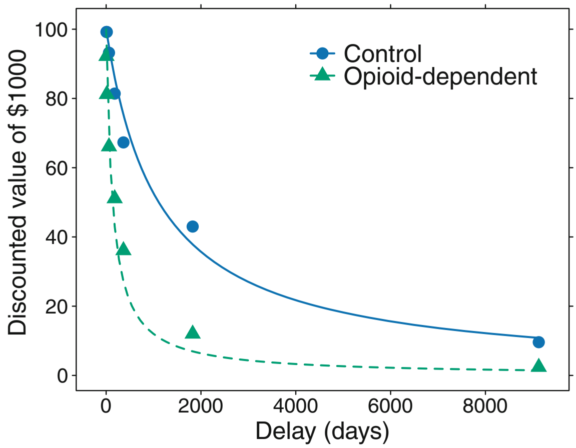


**Fig. 8.2** Evidence of greater discounting in opioid users compared to controls. Data replotted from Madden et al. (1997)

**Table 8.4** Dual-systems theories of decision making

| System | Researchers |
|---|---|
| *Controlled versus automatic*: A theory of information processing in which two systems are required to parse categorical and individual information from the environment | Schneider and Shiffrin (1977) |
| *Planner versus doer*: A farsighted planner and a myopic doer are fundamental to the agency conflict of economic systems | Shefrin and Thaler (1977) |
| *Verbatim versus gist*: Fuzzy trace theory is a dual-process theory of judgment and decision making focusing on verbatim (literal surface form) and gist (bottom-line meaning) representations of stimuli | Reyna and Brainerd (1995), Rahimi-Golkhandan et al. (2017) |
| *Conscious versus unconscious*: Emotional states that are not consciously experienced can still impact behavior, implying a distinct conscious center and emotional center | Damasio et al. (1996) |
| *Cool versus hot*: A two-system framework for the underpinnings of self-control, in which a "cool, cognitive 'know'" system and a "hot, emotional 'go'" system strategically self-regulate | Metcalfe and Mischel (1999) |
| *System 2 versus System 1 (also deliberative versus impulsive and slow versus fast)*: A dual-process model of thought and decision where system 2 (the slower, rule-based system) assesses associative and deductive components of information and system 1 (the fast, associative system) provides heuristics | Frederick (2002), Kahneman (2011), Kahneman and Frederick (2002) |
| *Abstract versus visceral*: An ideal, diffuse, abstract goal and a more immediate and environmentally cued visceral goal compete in self-controlled decisions | Bernheim and Rangel (2002) |
| *PFC versus mesolimbic*: The PFC has relatively greater involvement while making delayed decisions that favor larger, later rewards. The mesolimbic system has relatively greater involvement while making immediate decisions that favor smaller, sooner rewards | McClure et al. (2004) |
| *Reflective versus impulsive*: The prefrontal cortex is the seat of reward for future prospects, and an impulsive and amygdala-centered system signals reward for current prospects | Bechara (2005) |
| *Patient versus myopic*: A dual-self model that describes why reinforcers in the future are less valued and why cognitive load disrupts self-control | Fudenberg and Levine (2006) |
| *Executive versus impulsive*: The CNDS described here distinguishes between the executive and impulsive decision systems | Bickel et al. (2007) |

## Competing Neurobehavioral Decision Systems Theory

The maladaptive decision making that characterizes the various diseases, disorders, and health behaviors presented in Tables 8.1–8.3 can be modeled as the product of two distinct systems which form the basis of the *competing neurobehavioral decision systems* (CNDS) theory: (1) the reward-driven, present-oriented system and (2) the controlled, future-oriented system. The two systems, termed the "impulsive" and "executive" systems (Bickel et al. 2007), provide an engine of reward and an engineer of future plans to direct it. However, the CNDS theory is not the only dual-systems model applied to decision making. Displayed in Table 8.4 are other dual systems relevant to the study of choice previously described in the literature (see also Rahimi-Golkhandan et al. 2017).

The biologic substrates of dual systems have been described both in isolation and as interacting systems that produce the neurophenotypes associated with disease (see also Robbins and Dalley, this volume). For example, McClure et al. (2004) identified two distinct categories of neural activation during completion of a temporal discounting task in a functional magnetic resonance imaging (fMRI) scanner. Individual choices between the smaller, immediate rewards and larger, delayed rewards reflect relatively greater activation in distinct regions associated with different components of decision making. For example, when participants made choices that reflected their preference for smaller, immediate rewards, they showed relatively greater activation of impulsive reward centers (i.e., the paralimbic cortex). In contrast, when individuals made more self-controlled decisions to select larger, later rewards, they demonstrated relatively greater activity in executive control centers (i.e., lateral prefrontal cortex and parietal prefrontal cortex). Extrapolating from these observations, one might predict diminished activity in the prefrontal cortex (i.e., the executive decision system) would be associated with the various disease states reviewed previously.

So long as these impulsive and executive systems of the CNDS are in balance, individuals will be both sensitive to reinforcement and also able to delay reward in order to consider how their decisions may interact with long-term consequences. Specifically, both systems must be capable of influence and sensitive to context for an individual to engage in healthy behavior. For example, during periods of immediate threat or other conditions in which proximal events are of primary concern, relative control by the impulsive system is desirable. In contrast, relative control by the executive system is desirable in decisions regarding retirement savings or other long-term outcomes. With disease states, however, comes a persistent imbalance in relative control of these systems. Insensitivity to reward is associated with distinct pathologies of anhedonia (i.e., inability to experience pleasure) and depression (Liu et al. 2016). Hyperactivation of the left ventromedial prefrontal cortex in response to putatively rewarding cues (pictures of food) is associated with anorexia nervosa (Uher et al. 2004), a condition of excessive self-control (Steinglass et al. 2012; Decker et al. 2015; Ritschel et al. 2015). Conversely, diminished executive control compared to impulsive control has been identified in addiction (Goldstein and Volkow 2011). Thus, relative dominance of either the executive or impulsive decisions appears to produce disorder. Only regulatory balance between systems is likely to produce consistently adaptive decision making.

Although individual drug classes have different acute actions on prefrontal cortex activity (Goldstein and Volkow 2011), pathological states of addiction are associated with decreased activity in the lateral prefrontal cortex during working-memory tasks (Wang et al. 2010), decreased performance on executive function tasks (Chanraud et al. 2007), and decreased gray matter density in the broader prefrontal cortex (Fein et al. 2002). These structural changes may be the result of, rather than the cause of, substance use at least in the case of alcohol and marijuana in adolescence (Medina et al. 2008, 2009); however, executive dysfunction may also precede excessive drug taking (Heitzeg et al. 2008). This suggests a cycle in which disrupted executive control (as demonstrated by increased discounting of future rewards) predisposes an individual to addiction; in turn, this drug use associated with addiction then further disrupts function executive control and compounds the decision-making dysfunction.

Again, the CNDS theory of addiction relies on the interplay between both the executive and impulsive decision systems. For example, diminished functional connectivity between executive control centers of the prefrontal cortex and dopaminergic reward centers of the midbrain and paralimbic cortex is associated with longer duration of drug use in heroin-dependent individuals (Yuan et al. 2010). In addition, smokers who experience greater craving while abstinent from nicotine show altered functional connectivity between executive and reward centers compared to smokers who report less craving (Cole et al. 2010). Thus, in addiction and other health behaviors described here, an imbalance between activity of the executive and impulsive decision systems is apparent.

## Reinforcer Pathology

The dysregulation between the two decision systems of the CNDS may result in a process that undergirds the various diseases and maladaptive health behaviors described above. This process, which we have called *reinforcer pathology* (Bickel et al. 2014a), is the interaction between (1) excessive temporal discounting (see Box 8.2) and (2) overvaluation of specific commodities that may damage health (see Box 8.3). Substance-use disorders, obesity, and other maladaptive health behaviors (see Tables 8.1–8.3) are associated with a history of health decisions that offer short-term rewards despite negative, long-term consequences. Moreover, commodities that are chronically overconsumed in reinforcer pathology, such as drugs of abuse and food, share a common reinforcement timeline in that they offer their greatest rewards in the immediate period after consumption (e.g., alcohol intoxication or the taste of a snack food; see Fig. 8.3) and their greatest costs at some point in the future (e.g., liver disease or type 2 diabetes).

**Box 8.3: Measuring Commodity Valuation through Behavioral Economic Demand**

**Demand** for reinforcers in humans can be understood by investigating the variance in purchasing of a commodity as a function of price. Price can be manipulated by either increasing or decreasing the amount of a commodity available for purchase at a set price, or by increasing or decreasing the monetary price of a commodity available for purchase at a set quantity. Altering either of these two price components results in a functionally equivalent change in the **unit price** of the commodity (DeGrandpre et al. 1993). Purchasing behavior can then be understood over different commodity unit prices, with demand for a commodity typically decreasing as the price of the commodity increases. This sensitivity to price is termed **elasticity of demand** and varies in degree of responsiveness of purchasing to price changes. Relative insensitivity to price increases represents a higher valuation of the commodity, where an individual will defend purchasing behavior despite increasing costs. Individual valuation of a commodity can also be understood using **intensity of demand**, that is demand for a commodity at marginally low prices.

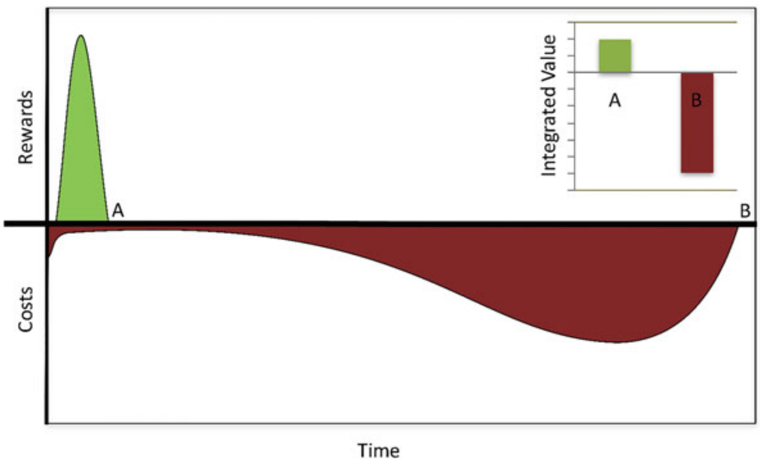


**Fig. 8.3** The temporal window of valuation. The commodities overconsumed in reinforcer pathology deliver their rewards and costs over a common timeline. That is, they may come with some marginal, initial monetary or search costs, but they also offer their greatest rewards soon after consumption. If the overall value of the reward is subjectively calculated as the benefits minus the costs up to point A, consumption of the commodity is rational and highly reinforcing. However, if the temporal window is extended to point B, the long-term costs may be of a greater magnitude than the immediate rewards. Comparing the total benefits minus costs of the commodity at the two points (see *inset graph*) demonstrates how an abbreviated temporal window can lead to reinforcer pathology

These components of demand can be assessed through many laboratory procedures and naturalistic observations (for a detailed discussion of these historical and contemporary procedures, see Bickel et al. 2016a). One assay to measure demand is a **self-administration** task, during which an individual is given the opportunity to work for a single unit of a commodity. For example, individuals may be given access to a preferred food at costs which vary in number of lever presses or duration of work at a task, with the opportunity to consume that food within an experimental setting. Demand assessment may also involve **purchase tasks**, where a participant is given the choice to purchase units of the commodity at varying prices. These purchases can be real (where choices are actualized at the end of the experiment), potentially real (where some subset of purchasing choices are actualized), or purely hypothetical. Thus far, evidence suggests that data obtained from each type of task are functionally equivalent (Amlung et al. 2012; Amlung and MacKillop 2015; Wilson et al. 2016).

Recent innovations in methods of demand assessment have allowed for observation of purchasing behavior in complex marketplaces filled not just with single commodities, but also economic **substitutes** and **complements** (other commodities which either replace, or are used in conjunction with, a primary commodity). One novel example is the **experimental tobacco marketplace** (Quisenberry et al. 2015b), which simulates an online storefront featuring both cigarettes and alternative tobacco

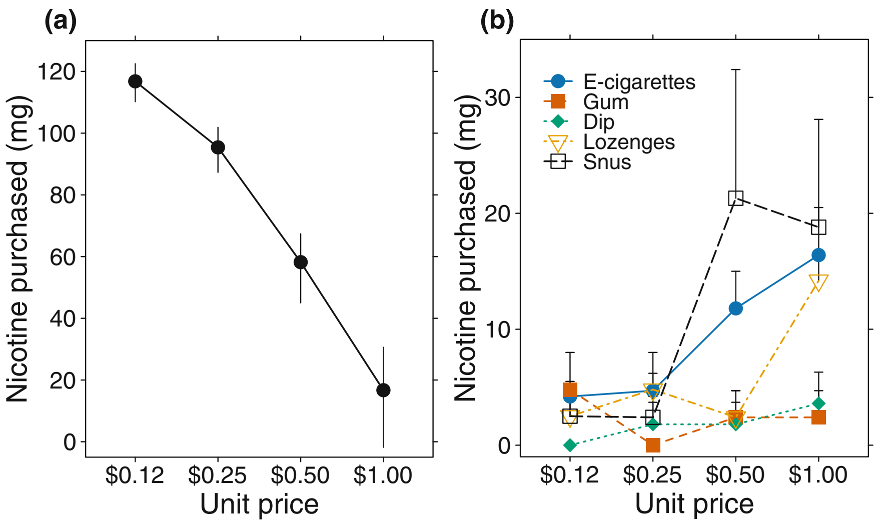


**Fig. 8.4** Demand and substitution curves for tobacco products. **a** The elasticity of demand for cigarettes decreases as they increase in price. **b** The cigarette price effects purchasing of other commodities, demonstrating that consumption of other products increases as the price of cigarettes increases (i.e., a substitution effect). Data shown were obtained from the experimental tobacco marketplace (Quisenberry et al. 2015b)

products (e.g., snus, e-cigarettes, dip, cigarillos, lozenges, and gum). Participants can navigate this store and select commodities to purchase during experimentally determined conditions, with varying prices, incomes, and product labeling.

The end result of many of the assays described above is the generation of a **demand curve**, or representation of how demand for a commodity decreases over increasing price (see Fig. 8.4), which can be modeled exponentially (Hursh and Silberberg 2008; see also Koffarnus et al. 2015).

Individuals suffering from addiction demonstrate the two components of reinforcer pathology: increased discounting of the future (MacKillop et al. 2011; Bickel et al. 2016a, c) and increased demand for drugs of abuse (Wilson et al. 2016). They may seek out drugs at great personal costs, not only in terms of the monetary price or search costs, but also in terms of alternative reinforcers that are sacrificed in favor of drug-seeking or drug-taking behavior (e.g., loss of health, employment, or family time). However, to the individual, the rewards of drug use are still worth the immediate costs of drug seeking and purchasing. The valuation of these drugs can be observed through the investigation of *behavioral economic demand* (see Box 8.3), which measures sensitivity of consumption of a given commodity to increases in its price (Bickel et al. 2017).

Addiction is not the only disorder that follows the reinforcer pathology model of excessive discounting and commodity overvaluation. Individuals who are overweight or obese demonstrate both excessive temporal discounting and high demand for food (Epstein et al. 2010). First, like addiction, high rates of temporal discounting are robustly associated with obesity (Weller et al. 2008; Amlung et al. 2016a). Second, individuals with high body mass index (BMI) will expend a greater amount of effort to earn a single unit of preferred food than their lower BMI counterparts (Giesen et al. 2010). Moreover, the interaction of both demand and discounting is a better predictor of BMI (Best et al. 2012) and energy intake (Rollins et al. 2010) than either measure alone.

A trans-disease understanding of fundamental pathologies may also lead us to treatment options for addiction and obesity, as well as other maladaptive health behaviors which may fit within the reinforcer pathology model (e.g., indoor tanning, Reed 2015). These interventions may come from novel applications of treatments currently found effective in other disease states; alternatively, novel treatments may be developed to specifically correct the underlying imbalances of the CNDS that may contribute to reinforcer pathology (Bickel et al. 2016a, c).

## Narrative Theory and Methods

The CNDS theory suggests that reinforcer pathology results from an imbalance between dual decision systems such that the executive decision system is relatively weaker than the impulsive decision system. One way to treat reinforcer pathology is to strengthen the components of the executive system and, as a result, approximate regulatory balance between impulsive and executive decision systems. Several methods along these lines have been explored and discussed elsewhere (Bickel et al. 2016a, c). Here, however, we address a new approach to such interventions that we explicate for the first time, namely narrative theory and methods.

To understand the rationale for this approach, consider the important evolutionary reason for our highly developed prefrontal cortex and associated executive function. Robin Dunbar (Dunbar 1992; Dunbar and Shultz 2007) sought to identify correlates of the size of the neocortex among human and non-human primates proportional to the rest of the brain. Although he considered many factors, such as diet and foraging patterns, among others, the only variables that showed a strong relationship with proportional neocortex size were social factors such as group size, social play, and grooming. Thus, Dunbar's (1998) social brain hypothesis suggests that the relative size of the neocortex and therefore the executive decision system is not the result of the contingencies of survival, but rather the contingencies of social interactions.

Apes and monkeys form social alliances with conspecifics through grooming or other forms of direct physical contact. However, humans can interact with a much larger number of conspecifics with the use of language. Interestingly, most human conversations are about gossip. Indeed, gossip accounts for approximately 65% of conversations (Dunbar 2004). When humans communicate with each other, they use distinct storylike structures (Mar 2004) and humans learn more information when it is presented as a story than when given as factual information (Baumeister et al. 2004). Moreover, the centrality of narratives to our species is evident in that we see narratives where none exist (Gazzaniga 1998; Gottschall 2012). For example, Heider and Simmel (1944) showed 144 undergraduates a film that depicted a big stationary square with a flap that opens and closes and two triangles and a circle that move around the screen. When asked what they saw, only three students said that they saw geometric shapes move about on the screen. The remainder provided narratives of various types that suggested motives and a storyline. Consider a brief portion of what one participant said about the film: "Triangle number-one shuts his door (or should we say line) and the two innocent young things walk in. Lovers in the two-dimensional world no doubt; little triangle-two and sweet circle. Triangle one (here-after known as the villain) spies the young love…." (p. 247). This and other examples suggest that narratives are a key feature of human behavior and that narratives may provide more than mere information. They convey story and emotion in a way that is uniquely salient in human society.

Importantly, Huth et al. (2016) asked participants to listen to two hours of narratives while in an fMRI scanner. Subsequent principal component analysis of language content and brain regions found four distinct components involved in processing these narratives: social, emotional, communal, and violent components. Results showed intricate patterns of activation in numerous brain regions that were consistent across participants, including portions of the prefrontal cortex and the

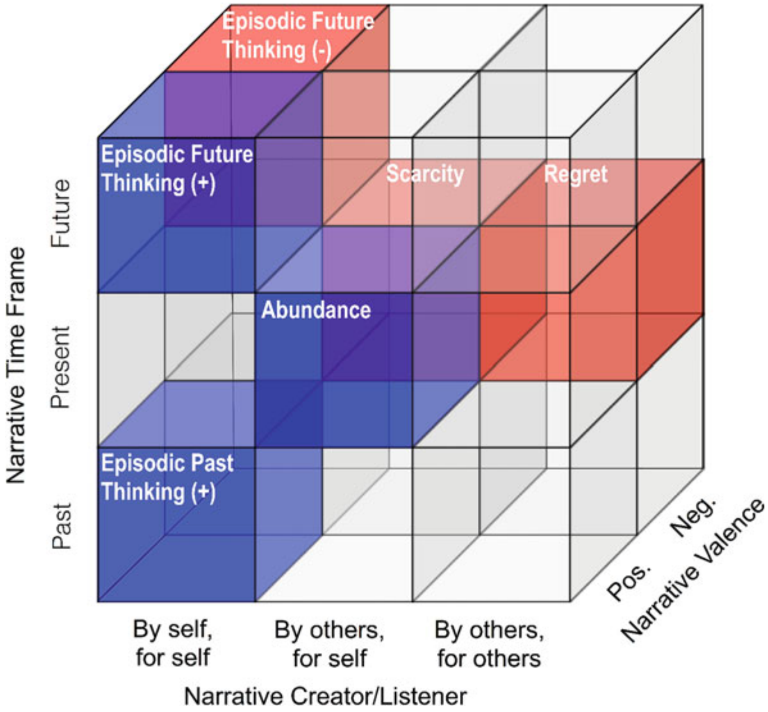


**Fig. 8.5** A narrative theory framework depicting the three-dimensional space in which narratives may be manipulated: narrative creator/listener ($x$-axis), time frame ($y$-axis), and valence ($z$-axis). *Shaded cells* depict areas we and others have investigated in prior research (see Table 8.5 for results). Narratives describing mortality cues (Griskevicius et al. 2011) are not pictured due to space limitations, as the diffuse nature of these narratives could be considered to span multiple cells on two separate axes (time frame and narrative creator/listener)

limbic system. Thus, listening to narratives may result in greater utilization and perhaps interaction than information without such stories (see also Nummenmaa et al. 2014).

If narratives engage multiple neural structures from both the impulsive and executive decision systems, then perhaps narratives can be used to rebalance the dysregulation between these systems seen in addiction. Narratives can vary in at least three dimensions (see Fig. 8.5). The first dimension refers to the narrative creator/listener; that is, narratives can be created by the research participant for the research participant, by the experimenter for the research participant, or by the experimenter about someone else for the research participant. The second dimension is time; that is, narratives can occur in the past, the present, or the future. The third dimension is valence; that is, narratives can address negative or positive outcomes. Collectively, these dimensions describe in broad outline how narratives can be manipulated. In the following sections, we review data from the field and our laboratory to examine whether narratives and narrative structure can alter the distinct components of reinforcer pathology.

## *Episodic Future Thinking*

One component intervention of narrative theory is episodic future thinking (EFT), which can be used to expand the temporal window over which individuals value rewards. Also called "mental time travel," EFT is a form of mental prospection in which individuals generate their own narratives about the future (Atance and O'Neill 2001). These narratives then allow individuals to pre-experience the future by invoking vivid imagery and details surrounding specific events (e.g., starting a new job or attending a loved one's wedding). To some extent, most individuals spontaneously engage in EFT in the absence of intervention. In turn, such naturally occurring EFT appears to modulate temporal discounting, allowing possible future outcomes to guide present behavior. For example, greater vividness of naturally occurring EFT in adolescents is associated with lower rates of temporal discounting (Bromberg et al. 2015), suggesting that EFT is integral to decisions involving valuation of the future.

Additional data, however, suggest that episodic prospection is not the only variable that influences temporal discounting, as rates of discounting are undifferentiated between healthy controls and amnesic patients unable to engage in EFT (Kwan et al. 2013, 2015). Moreover, quality of EFT is undifferentiated between healthy controls and pathological gamblers (Wiehler et al. 2015), despite pathological gambling otherwise being associated with excessive temporal discounting (Petry 2001b; Dixon et al. 2003; Miedl et al. 2012). Thus, a clearer understanding of the role of EFT in temporal discounting awaits further investigation. Nonetheless, explicit intervention designed to evoke highly vivid narratives involving EFT robustly reduces temporal discounting. A summary of the methods used in these studies may be found in Box 8.4. These effects have been demonstrated in a range of populations, including obese participants (Daniel et al. 2013a, b), cigarette smokers (Stein et al. 2016), and healthy volunteers (Peters and Büchel 2010), an effect likely mediated in part by enhanced activation of brain areas associated with the executive decision system (e.g., medial rostral prefrontal cortex; Peters and Büchel 2010).

Additional data indicate that EFT narratives produce therapeutic effects on the second component of reinforcer pathology: commodity overvaluation. Specifically, EFT has been shown to reduce behavioral economic demand for highly palatable food in obese populations (Sze et al. under review), alcohol in alcohol-dependent populations (Snider et al. 2016a), and cigarettes in cigarette smokers (Stein and Bickel, unpublished data). Importantly, data from both the laboratory and naturalistic contexts indicate that EFT also reduces direct measures of consumption, including cigarette smoking (Stein et al. 2016) and food intake (Daniel et al. 2013b, 2015; Sze et al. 2015; O'Neill et al. 2016).

**Table 8.5** Summary of narrative studies to date and their effects on delay discounting and food or drug consumption

| Narrative type | | | Temporal discounting | | Food/drug consumption | |
|---|---|---|---|---|---|---|
| | Reference | Study sample | Effect | Commodity | Effect | Commodity |
| *Positive EFT* | | | | | | |
| | Peters and Büchel (2010) | Young adults | ↓ | Hypothetical money | | |
| | Benoit et al. (2011) | Adults | ↓ | Hypothetical money | | |
| | Daniel et al. (2013b) | Overweight/obese adult females | ↓ | Hypothetical money | ↓ | Real food |
| | Daniel et al. (2013a) | Overweight/obese adult females | ↓ | Hypothetical money | | |
| | | Lean adult females | ↓ | Hypothetical money | | |
| | Liu et al. (2013) | Young adults | ↓ | Hypothetical money | | |
| | Lin and Epstein (2014) | Adults | ↓ | Hypothetical money | | |
| | Daniel et al. (2015) | Overweight/obese children | ↓ | Hypothetical money | ↓ | Real food |
| | Sze et al. (2015) | Overweight/obese parent–child dyads | | | ↓ | Real food |
| | Dassen et al. (2016) | Young adult females | ↓ | Hypothetical money | ↓[b] | Real food |
| | O'Neill et al. (2016) | Overweight/obese adult females | | | ↓ | Real food |
| | Snider et al. (2016a) | Alcohol-dependent adults | ↓ | Hypothetical money | ↓[a] | Hypothetical alcohol |
| | Stein et al. (2016) | Cigarette-smoking adults | ↓ | Hypothetical money | ↓ | Real cigarettes |
| | Stein and Bickel (unpublished data) | Cigarette-smoking adults | | | ↓[a] | Hypothetical cigarettes |

(continued)

**Table 8.5** (continued)

| Narrative type | Reference | Study sample | Temporal discounting | | Food/drug consumption | |
|---|---|---|---|---|---|---|
| | | | Effect | Commodity | Effect | Commodity |
| | Sze et al. (under review) | Overweight/obese adults | ↓ | Hypothetical money | ↓[a] | Hypothetical food |
| | Daniel et al. (2016) | Adults | ↓ | Hypothetical money | | |
| *Neutral EFT* | | | | | | |
| | Liu et al. (2013) | Young adults | – | Hypothetical money | | |
| | Lin and Epstein (2014) | Adults | ↓ | Hypothetical money | | |
| *Negative EFT* | | | | | | |
| | Liu et al. (2013) | Young adults | ↑ | Hypothetical money | | |
| *Positive episodic past thinking (EPT) EFT* | | | | | | |
| | Daniel et al. (2016) | Adults | –[c] | Hypothetical money | | |
| *Abundance* | | | | | | |
| | Bickel et al. (2016d) | Adults | – | Hypothetical money | | |
| | Dixon et al. (2016) | Pathological gamblers | ↓ | Hypothetical money | | |
| *Scarcity* | | | | | | |
| | Bickel et al. (2016d) | Adults | ↑ | Hypothetical money | | |
| | Sze et al. (under review) | Overweight/obese adults | ↑ | Hypothetical money | ↑ | Hypothetical food[a] |
| | Dixon et al. (2016) | Pathological gamblers | – | Hypothetical money | | |
| *Mortality cues* | | | | | | |
| | Griskevicius et al. (2011) | Adults from low childhood SES | ↑ | Hypothetical money | | |
| | | Adult from high childhood SES | ↓ | Hypothetical money | | |

(continued)

**Table 8.5** (continued)

| Narrative type | | | Temporal discounting | | Food/drug consumption | |
|---|---|---|---|---|---|---|
| | Reference | Study sample | Effect | Commodity | Effect | Commodity |
| *Sexual regret expression* | | | | | | |
| | Quisenberry et al. (2015a) | Adults | ↓ | Hypothetical condom-protected sex | | |
| | Quisenberry et al. (2015a) | Adults | – | Hypothetical money | | |

*Note* Effects on specified measures are summarized as follows: ↓ = reduced; – = no change; ↑ = increased; blank = not investigated
[a]Indicates consumption investigated in a demand context
[b]Indicates EFT only reduced consumption when using food-based cues
[c]Did not affect discounting of future monetary rewards, but did reduce discounting of past monetary rewards

Table 8.5 provides a summary of studies examining the effects of EFT narratives on temporal discounting and either drug or food consumption. Collectively, these data support the use of EFT as an intervention for the reinforcer pathology associated with addiction and other maladaptive health behaviors.

**Box 8.4: Narrative Methods Used in EFT, Scarcity, Abundance, and Regret Studies**

Some procedures are common to many narrative theory studies, regardless of whether those narratives involve EFT, scarcity, abundance, or other manipulations. Namely, a participant is asked to read and consider a narrative, whether that narrative is self- or experimenter-generated or varies along any other dimension depicted in Fig. 8.5. Participants then complete behavioral tasks, often while text or audio reminders of the narratives are presented.

Below, we outline the specific procedures used in each narrative theory method. See the main text for additional details.

**Episodic Future Thinking**

Participants first complete a guided task designed to generate narratives about events that could occur at multiple time points in the future (EFT) or occurred in the recent past (ERT). Care is taken to elicit as much vivid detail as possible (e.g., "Who were you with?" and "What were you doing?"). This narrative generation task is most often administered by research staff (e.g., Daniel et al. 2013a, b); however, an effective self-guided task has recently been developed for use online and other instances in which availability of research staff is limited (Sze et al. under review).

During the completion of one or more behavioral tasks, participants are asked to vividly think about their events. A short textual cue reminding participants of their narrative appears on the computer monitor. Occasionally, participants record themselves reading a written description of the events to use as subsequent audio cues (e.g., Stein et al. 2016), especially in instances in which behavioral tasks do not require continuous attention to the computer monitor.

**Scarcity and Abundance**

Participants read a short narrative describing an abrupt change in income and related lifestyle, consider it for a period of time (e.g., 15 s; Sze et al. under review), and assume they are experiencing the conditions described. Narratives remain on the screen for a predetermined period of time to allow careful reading and consideration (Bickel et al. 2016d). Participants then complete one or more behavioral tasks. Although other narratives have been used (Dixon et al. 2016), below we present the scarcity and abundance narratives, as well as the neutral control narrative, used by Bickel et al. (2016d).

> *Scarcity*. You have just been fired from your job. You will now have to move in with a relative who lives in a part of the country you dislike, and you will have to

spend all of your savings to move there. You do not qualify for unemployment, so you will not be making any income until you find another job.

*Neutral.* At your job, you have just been transferred to a different department in a location across town. It is a similar distance from where you live so you will not have to move. You will be making 2% more than you previously were.

*Abundance.* At your job you have just been promoted. You will have the opportunity to move to a part of the country you always wanted to live in OR you may choose to stay where you are. Either way, the company gives you a large amount of money to cover moving expenses, and tells you to keep what you don't spend. You will be making 100% more than you previously were.

**Regret**

Like scarcity and abundance, participants are asked to read short narratives, consider them for some period of time, and then complete one or behavioral tasks. However, specific details of the narrative are individualized to the participants to make the details more salient and relatable. Below are the narratives used by Quisenberry et al. (2015a) in an examination of the effects of regret on discounting of delayed sexual gratification.

*Negative narrative, with regret expression.* Taylor, your best friend who is also [*male/female*], [*X*] years old, and engages in sexual behavior similar to yours, just called to tell you about a social gathering [*s/he*] attended where [*s/he*] met someone [*s/he*] was interested in. They ended up having sex without using protection and Taylor expressed extreme regret. [*S/he*] said, "I knew I should have used protection that night. What was I thinking?!" Soon after the experience, Taylor experienced a sore throat, fever, rash, fatigue, headache, and muscle pain and described it as "the worst flu ever". Taylor went to the doctor for these symptoms and tested positive for the HIV virus that causes AIDS. Taylor is profoundly devastated, afraid [*his/her*] whole life is over, and wishes [*s/he*] never made the mistake.

*Negative narrative*. Taylor, your best friend who is also [*male/female*], [*X*] years old, and engages in sexual behavior similar to yours, just called to tell you about a social gathering [*s/he*] attended where [*s/he*] met someone [*s/he*] was interested in. They ended up having sex without using protection and Taylor expressed extreme excitement. said, "I had a great time and my partner was very attractive. I'm excited to see them again!" Soon after the experience, Taylor experienced a sore throat, fever, rash, fatigue, headache, and muscle pain and described it as "the worst flu ever". Taylor went to the doctor for these symptoms and tested positive for the HIV virus that causes AIDS. Taylor is profoundly devastated, afraid [*his/her*] whole life is over, and crying uncontrollably.

*Positive narrative*. Taylor, your best friend who is also [*male/female*], [*X*] years old, and engages in sexual behavior similar to yours, just called to tell you about a social gathering [*s/he*] attended where [*s/he*] met someone [*s/he*] was interested in. They ended up having sex without using protection and Taylor expressed extreme excitement. [*S/he*] said, "I had such a good time and my partner was very attractive. I can't wait to see them again!" Soon after the experience, Taylor experienced a sore throat, fever, rash, fatigue, headache, and muscle pain and described it as "the worst flu ever". Taylor went to the doctor for these symptoms and tested negative for the HIV virus that causes AIDS. Taylor is extremely happy and called you jumping for joy.

### Control Conditions

Historically, several comparison conditions have been implemented to isolate the effects of prospection involved in EFT. These include the completion of behavioral tasks in the absence of any episodic thinking (Liu et al. 2013) and non-autobiographical episodic thinking, such as imagining details from a third-party narrative (Daniel et al. 2013b). However, perhaps the most appropriate control condition (and the most frequently used in the study of temporal discounting) is episodic recent thinking (ERT), in which participants imagine real events that occurred over the past several hours or days (Daniel et al. 2015; O'Neill et al. 2016; Snider et al. 2016a; Stein et al. 2016). Like EFT, the ERT condition invokes episodic memory and vivid imagery, but isolates the prospective component of EFT in its effects on temporal discounting and commodity valuation.

### Episodic Future Versus Past Thinking

Recent data suggest that discounting in response to the ERT control condition is undifferentiated from an additional control condition in which discounting was measured under typical circumstances (i.e., featuring no episodic thinking; Sze et al. under review). However, by definition, the absolute temporal distances typically used in ERT and EFT differ in magnitude, with ERT evoking imagery from the last several hours or days and EFT evoking imagery from up to a year in the future (e.g., Stein et al. 2016). Possible effects of episodic thinking of the more distant past on temporal discounting have, until recently, not been examined. Daniel et al. (2016), however, recently reported that such *episodic past thinking* over time frames comparable to traditional EFT did not affect discounting of future rewards; rather, episodic thinking of the distant past reduced only the discounting of past rewards, in which participants report preference between having received smaller rewards in the recent past or larger rewards in the more distant past (Yi et al. 2006b). Conversely, EFT reduced only discounting of future rewards and did not affect discounting of past rewards. Thus, the effects of episodic thinking on discounting appear specific to the time frame (past or future) of episodic imagery and rewards being evaluated.

### Episodic Future Thinking Valence

To date, most studies investigating the effects of EFT on reinforcer pathology have used EFT featuring positive future events (see Table 8.5). However, the effects of EFT featuring neutral, or even negative, content have not been well explored. Some data suggest that valence is not critical in determining EFT's effects on temporal discounting. For example, effects of positive EFT content on discounting remain even when controlling for effects of EFT on affect (Sze et al. under review), as well as ratings of enjoyment, excitement, and other dimensions of episodic content

(Snider et al. 2016a). In addition, neutral EFT content has been shown to produce similar reductions in temporal discounting as positive EFT content in healthy volunteers (Lin and Epstein 2014). In contrast, however, additional data from one study suggest that EFT featuring *negative* content increases temporal discounting in healthy volunteers (Liu et al. 2013), an effect opposite to that observed with positive content in the same and other studies. These preliminary data on EFT featuring negative content outline a clear course for future research before firm conclusions can be reached regarding the role of EFT valence (positive, negative, and neutral) on measures of reinforcer pathology.

#### Effects of Episodic Future Thinking on Alternative Forms of Discounting

As discussed in Box 8.1, the discounting framework has also been used to study the effects of variables other than delay on valuation of rewards. These include probability discounting, defined as valuation of a reward as a function of the odds against its receipt (Rachlin et al. 1991), and social discounting, defined as valuation of a reward as a function of the social distance between the participant and the reward recipient. The former may be considered a measure of risk aversion, while the latter may be considered a measure of altruism.

Importantly, emerging data (not summarized in Table 8.5) suggest that EFT reduces these varied forms of discounting in a manner similar to that observed in a typical temporal discounting framework. Specifically, Kaplan et al. (2015) reported that EFT reduced discounting in a task that combined probability and temporal discounting. Likewise, some evidence suggests that episodic thinking of both the self and others, and in both the present and the future, reduces social discounting (Yi et al. 2016). These extensions of the foundational findings on EFT and discounting demonstrate the flexibility and robustness of the methods and their ability to address a wide variety of psychological phenomena.

Although some unresolved questions remain regarding EFT, its robust therapeutic effects on both components of reinforcer pathology served as a progenitor to narrative theory, leading us, in part, to systematically explore the various narrative dimensions depicted in Fig. 8.5. In the remainder of this chapter, we review evidence from this ongoing line of inquiry.

### *Scarcity and Abundance*

Effects of both economic scarcity and abundance on reinforcer pathology can be modeled using narrative manipulations. A long-standing association between poverty and psychological distress, including impaired decision making, has been previously documented (Shah et al. 2012; Mani et al. 2013; Haushofer and Fehr 2014). Moreover, momentary or enduring executive dysfunction has been observed in individuals under conditions of poverty, resulting in suboptimal decision making, including steep temporal discounting (Haushofer et al. 2013; Bickel et al. 2014c). These established relations serve as the foundation on which scarcity narrative manipulations are based.

Exposure to hypothetical scarcity conditions in the laboratory has modified racial perception (Krosch and Amodio 2014), cognitive performance (Mani et al. 2013), and the effect of contextual cues (Shah et al. 2012). More germane to this chapter, direct investigations of the effects of scarcity on monetary decision making have demonstrated a relation with scarcity conditions in both the laboratory and real world. For example, a within-subjects investigation of farmers pre- and postharvest found that cognitive control measures were more impaired in a preharvest period in which the farmers were poorer compared to a postharvest period in which they had recently been paid (Mani et al. 2013). In addition, in an investigation of the effects of a narrative invoking mortality cues on discounting, socioeconomic status in childhood predicted discounting outcomes (Griskevicius et al. 2011). That is, mortality narratives increased and decreased discounting in adults with low and high childhood socioeconomic status, respectively. Generally, the data reviewed above are consistent with the conclusion that scarce resources refocus attention toward immediate choices (Shah et al. 2012); that is, scarcity constricts the temporal window of reward valuation.

In our exploration of scarcity and temporal discounting using narrative theory methods, the effect of varying economic conditions on a modified temporal discounting task was investigated in Amazon Mechanical Turk control participants (Bickel et al. 2016d). The 5-trial adjusting temporal discounting task is a rapid version of the adjusting-amount task typically used (see Box 8.1), and it returns the traditional fitted discount rate parameter, *k* (see Koffarnus and Bickel 2014 for details). In this experiment, participants were asked to read narratives describing either conditions of economic scarcity, abundance, or neutrality and assume that these narratives were true (see Box 8.4 for the specific narratives used). Figure 8.6

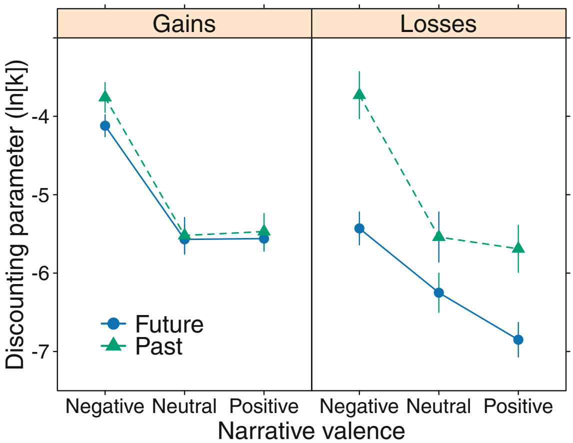


**Fig. 8.6** The scarcity narrative significantly increased discount rate, compared to the neutral and abundance income narratives, in all four discounting conditions spanning the future and the past and with both monetary gains and losses. Data regraphed from Bickel et al. (2016d)

depicts the results of this experiment. Exposure to the scarcity narrative, compared to the neutral and abundance narratives, increased discount rate for both future gains and losses, and past gains and losses (see Box 8.1 for further explanation of these task variations). In contrast, no effects of the abundance narrative compared to the neutral narrative were observed in any condition.

However, different effects of scarcity and abundance narratives were observed in pathological gamblers in a recent study (Dixon et al. 2016). In this sample, exposure to a brief narrative about reducing income by half (i.e., scarcity) had no effect on temporal discounting, whereas exposure to a narrative about doubling income (i.e., abundance) reduced temporal discounting. Perhaps, the particular scarcity narrative used in this study did not reflect a change sizable enough to evoke an effect. Alternatively, a more likely explanation for these discrepant effects across studies involves rate dependence, a phenomenon in which response to intervention depends on baseline values of the dependent measure (Bickel et al. 2014b, 2016b; Snider et al. 2016b). Because pathological gamblers show high baseline discount rates compared to healthy controls (Dixon et al. 2003; Petry 2001b), the scarcity narrative in the study by Dixon et al. (2016) may have had little room to further increase discount rate, thereby producing no effect. Conversely, these same baseline discount rates would have provided ample opportunity to show a rate-decreasing effect of the abundance scenario. Indeed, visual inspection of the figure presented in this study corroborates this hypothesis. Nonetheless, this possibility should be systematically explored in future experiments.

### Combined Effects of Economic Scarcity and Episodic Future Thinking

In a recent study, we sought to examine the combined effects of economic scarcity and EFT in overweight/obese participants on Amazon Mechanical Turk (Sze et al. under review). Because these narrative interventions affect components of reinforcer pathology in opposing directions, the effects of combining them might reveal their relative strengths and suggest treatment options for reinforcer pathology associated with economic poverty. Participants were randomly assigned to one of four possible two-way combinations of episodic thinking conditions (EFT or ERT) and income narrative conditions (the scarcity or neutral narratives described earlier).

Data revealed that compared to ERT, EFT reduced temporal discounting and behavioral economic demand for highly palatable food; conversely, compared to the neutral narrative, scarcity increased temporal discounting and demand for food regardless of episodic thinking condition. Moreover, little interaction was observed between episodic thinking and income conditions, suggesting that these interventions affect measures of reinforcer pathology independently of one another. Perhaps more importantly, these data suggest that EFT can be used clinically to partially attenuate the harmful effects of economic scarcity.

## *Regret*

Regret aversion is among the biases that influence human decision making and is defined as the propensity to make decisions in order to minimize future regret (Zeelenberg and Pieters 2004). As such, the anticipation of future regret affects our current choices (Bell 1982; Loomes and Sugden 1982). Two distinct varieties of regret have been described in the decision-making literature, that is, regret resulting from short-term actions (i.e., errors of commission) that cause negative, more immediate consequences and regret following long-term inaction (i.e., errors of omission; Gilovich 1994; Gilovich and Medvec 1995). Both types of regret may be used to inform narrative theory; however, here, we refer to the first variety of regret, resulting from errors of commission.

To our knowledge, the first study of regret and discounting using narrative theory methods investigated delay to sexual gratification following exposure to researcher-generated narratives about individuals who are close to the participant (Quisenberry et al. 2015a). Delay to condom-protected sexual gratification was measured by the sexual discounting task, a behavioral task modeled from traditional temporal discounting (Johnson and Bruner 2012, 2013). Responses represent the choice to engage in risky unprotected sex now or wait some delay for condom-protected sex. To complete the task, participants first chose, from an array of 60 picture options, the individuals with whom they would have casual sex. Afterward, participants chose from this subset the most and least attractive potential partners and the most and least likely to have a sexually transmitted infection (STI). For each of the four chosen images, participants used a visual analog scale to answer questions such as, "Would you rather have sex now without a condom or *at some delay* with a condom?" (0 indicates engaging in immediate unprotected sex, and 100 indicates waiting the specified delay for condom-protected sex). This process is repeated at multiple delays to condom-protected sex, including now (no delay), 1 h, 3 h, 6 h, 1 day, 1 week, 1 month, and 3 months.

In this study, Amazon Mechanical Turk users were presented with a textual and auditory narrative about a best friend's recent sexual encounter that highlighted either a positive outcome, a negative outcome, or a negative outcome with the friend expressing regret (see Box 8.4), all containing an identical number of characters and information (Quisenberry et al. 2015a). After reading and listening to the narrative, participants completed the sexual discounting task and a monetary temporal discounting task. Figure 8.7 depicts the effects of these narratives on delay to sexual gratification. Panels a–d represent the distribution of answers across each condition. In the conditions with the most attractive partners (i.e., panel b) and partners least likely to have an STI (i.e., a safety signal; panel c), sexual discounting was decreased after hearing the narrative that involved a negative health outcome with regret expression. In the condition for the least attractive partner (i.e., panel a), discounting was decreased in both of the negative health outcome narratives with no effect of regret. Finally, in the condition with the partner most likely to have an STI (i.e., a warning signal, panel d), sexual discounting was similar across all

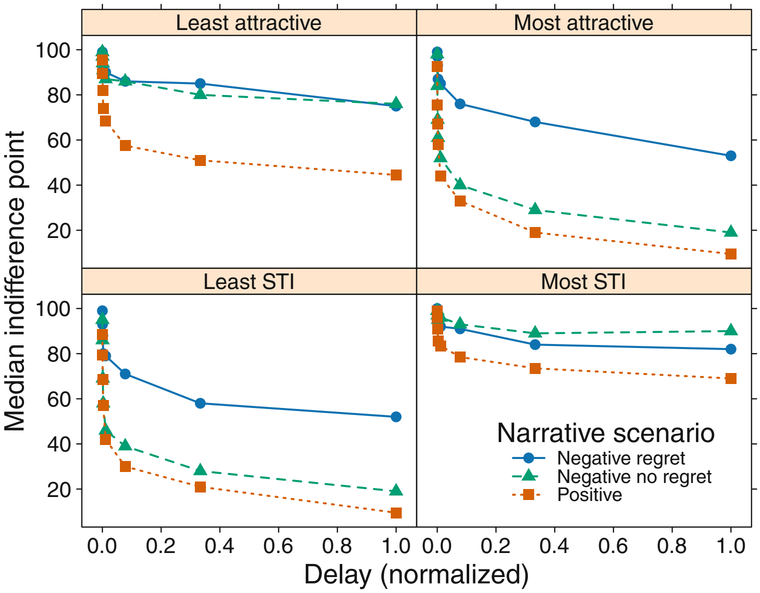


**Fig. 8.7** Discounting curves by narrative scenario for each of the sexual discounting task partner conditions. In the most attractive and least STI conditions, experiencing a narrative regarding a friend expressing regret after undergoing a negative health consequence increased delay to sexual gratification. Data reprinted from Quisenberry et al. (2015a)

narratives. Importantly, no significant differences in monetary temporal discounting were observed between narratives demonstrating that these narratives produce change specific to behavioral tasks associated with risky sexual behavior.

Our results suggest that this laboratory measure could be used to prospectively study the effects of public health initiatives concerning risky sexual behavior. Moreover, evidence that a well-documented bias can change measures of risky behavior supports future research on other human biases integrated into narratives.

## Conclusions

In this chapter, we summarized the extant evidence on temporal discounting as a measure of self-control. The failure of self-control is evident in a wide variety of disorders, providing evidence that it is a trans-disease process. Excessive discounting of future rewards results from regulatory imbalance of CNDS, a dual-decision process, in which the impulsive decision system exerts greater control relative to the executive decision system. Temporal discounting also interacts with reinforcer valuation to produce reinforcer pathology. Evidence suggests that reinforcer pathology is relevant to several disorders, including drug abuse and obesity.

Here, we provide the most recent information on these topics, although we have previously reviewed them elsewhere (Bickel et al. 2014a; e.g., Bickel and Mueller 2009). Most importantly, in this chapter, we introduce for the first time the methods of narrative theory, which harness humans' unique sensitivity to language and storytelling to influence decision making. As such, information embedded in a narrative structure may more effectively impact behavior than provision of information alone. We show in the data reviewed above that the use of narratives can shift preference either to the immediate or to the delayed outcomes in a discounting context and produce corresponding increases and decreases in commodity valuation. Collectively, these data suggest that we are at the vanguard of a new understanding of not only the determinants of disease processes that undergird excess morbidity and mortality, but also to a new approach to intervention. If the observations and speculations regarding narrative theory are replicated and confirmed by further empirical experiment, we may be able to make a meaningful difference in the lives of many people suffering from reinforcer pathology.

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