

The Picoeconomic Approach to Addictions: Analyzing the Conflict of Successive Motivational States

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ABSTRACT

The branch of behavioral economics called “picoeconomics” (Ainslie 1986) models behavior as the competition between successive motivational states within the individual. This approach is particularly well suited for investigating addiction and recovery from addiction. We begin by outlining behavioral findings that provide the foundation for picoeconomics. Next we discuss strategies of self-control available to the individual guarding against her own anticipated preference reversals, and also consider negative side effects of these self-control strategies. These generally overlooked side effects include the tendency for lapses to lead to binges -- the “abstinence violation effect”. Finally, we describe the relative effectiveness of contingency management and 12-step treatments for substance dependence from the perspective of picoeconomics, and discuss other implications of picoeconomics for the field of addiction.

Key words: picoeconomics, behavioral economics, self control, willpower, delay discounting, addiction

TEXT

The substance dependent individual appears to be suffering by her own behavior, in a cycle of resolution, transgression, and regret. Her inability to make her choices consistent over time may compel her to seek treatment. This dynamic inconsistency is captured by the criteria for substance dependence included in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) (“the substance is often taken in larger amounts or over a longer period than intended”, and “there is a persistent desire or unsuccessful efforts to cut down or control substance use.”) By contrast, the mainstream of modern economics, “neoclassical economics”, builds from a set of axiom that entails consistency in preference (Samuelson, 1947). While these axioms have proven acceptable in modeling the behavior of financial markets, and sometimes in modeling individual financial behavior, they are not compatible the core of addictive behaviors. When neoclassical economic models have been applied to addiction (Becker & Murphy, 1988), they have been grossly inadequate (see discussions in Hanson, Forthcoming and Skog, 1999).

In contrast to neoclassical economics, *behavioral economics* does not assume consistent preferences over time. It has relied principally on laboratory studies to inform models of individual decision-making, and initially found evidence for the income-maximizing patterns described by neoclassical economists (e.g., Kagel et al., 1975). However, the experimental method allowed behavioral economists to detect and analyze systematic divergences from the neoclassical economic axioms. Two approaches to subjects’ apparent irrationality developed in parallel in the 1970s: the study of cognitive heuristics and biases in estimating the objective value of outcomes (Tversky & Kahneman, 1974), and the study of how subjects devalue expected outcomes as a function of delay (“delay discounting”) (Ainslie, 1975). Both approaches have now developed extensive literatures. In the area of addiction research, the cognitive approach

has been applied mostly to the mistakes of gamblers (e.g., Rachlin, 1990; Wagenaar, 1988), and has little to say about the most treatment-resistant aspect of addictions: addicts' persistent temptation to relapse despite ample experience with the consequences.

In this article we will provide an introductory account of how a basic property of expected reward predisposes to addictions when the reward is strong or rapid enough, and how this property can be the basis both of spontaneous defenses against addiction and of effective therapies. We use "reward" in the deterministic sense rather than the normative sense: To achieve adequate parsimony, an economic theory must hold that an individual is constrained to choose the option with the greatest expected reward of all those she considers. Because this approach is based on analysis of competing interests within the individual over time it has been called "picoeconomics" (micro-micro-economics; (Ainslie, 1986; Ross, Sharp, Vuchinich, & Spurrett, 2008)).

Delay discounting and addiction

The immediacy of reward associated with drug use clearly has something to do with why quitting can be difficult. If the high from smoking crack didn't arrive till weeks later, but the bad feelings associated with all the personal loss came on as soon as blood carried the drug to the brain-- there would be no problem "just saying no." As Samuel Butler quipped, "If only the headache preceded the intoxication, alcoholism would be a virtue". Thus it has been hypothesized that addicted populations may discount more steeply with delay than non-addicted populations (Ainslie, 1975; Bickel, Odum, & Madden, 1999). Discounting can be studied quantitatively in both human and animal subjects by letting them choose between pairs of smaller, sooner (SS) rewards and larger, later (LL) ones, or alternatively in humans by asking what amount of reward at a particular delay would be equally preferable to a given reward at a different delay. Across a range of addicted populations, the evidence has been consistent with the hypothesized association between steep delay discounting and problem drug use. Using hypothetical money, a heterogeneous group of substance-dependent subjects discounted more steeply than controls (Ainslie & Haendel, 1983); heavy social drinkers and problem drinkers both discounted delayed rewards more steeply than did light drinkers (Vuchinich & Simpson, 1998); smokers discounted delayed rewards more steeply than non-smokers (Bickel et al., 1999; Fuchs, 1982; van der Pol & Cairns, 2001); methamphetamine dependent individuals discounted more steeply than comparison participants (Monterosso et al., 2007) and opioid dependent patients discounted money more steeply than controls (Bickel et al., 1999; Bretteville-Jensen, 1999; Madden, Petry, Badger, & Bickel, 1997). Similar results were obtained using actual monetary rewards: Compared to controls, heroin-dependent subjects chose more immediate nickels over tokens exchangeable for dimes in 10 day (Wallace, 1979), regular smokers discounted money more steeply than did a population who had never smoked (Mitchell, 1999), and heroin-dependent subjects had steeper discount functions than demographically matched controls (Kirby, Petry, & Bickel, 1999). Furthermore, Odum *et al.* (2000) found that heroin addicts who shared needles discounted money more steeply than heroin addicts who did not.

Steeper delay discounting among addicted populations does not necessarily imply that this discounting is a causal factor in addiction. Addicted and non-addicted populations are self-selected, and so are liable to differ in myriad ways other than their drug use; ways that could drive an association between delay discounting and substance

abuse without the two being causally linked (Meehl, 1970). Furthermore, if steep discounting and problem drug use *are* causally linked, it is entirely possible that the directionality is partially or wholly the reverse, with problem drug use leading to steeper discounting (Bickel et al., 1999). Longitudinal studies offer some leverage for distinguishing between these possibilities, but there has been little longitudinal research in this area to date. One exception is a study that looked at the relationship between delay discounting and progression of cigarette smoking in adolescents. Steep discounting was associated with smoking at the study baseline, and indirectly linked to progression over time (Audrain-McGovern et al., 2004). Despite the absence of definitive longitudinal studies, the robust association between steep discounting and problem drug use is encouraging to behavioral scientists interested in applying the discounting construct to addiction.

Hyperbolic delay discounting and preference reversals

More important than steepness of delay discounting is the form that it takes over time. Delay discounting does not violate neoclassical economic axioms provided that discounting occurs at a constant rate per unit of time (“exponential discounting”). The critical feature of exponential discounting from the standpoint of rational maximization is that it preserves consistency. Just as the ratio between two bank balances growing at the same interest rate never changes, given exponential discounting the ratio between the value of two delayed rewards does not change, regardless of how close one gets in time to those rewards. For example, with exponential discounting, if on Monday the value of partying with friends the next Friday night is lower than the value of a ski outing Saturday morning, then the value of the ski outing will remain superior even on Friday evening.

But parametric behavioral assessment of delay discounting suggests that value is *not* discounted by a fixed rate per unit of delay. Experimental evidence from both humans and nonhumans indicates that, like other psychophysical relationships, the relationship between expected delay and value is proportional, that is, *hyperbolic* (Ainslie, 1975; J. Mazur, 1987; Rodriguez & Logue, 1988). The increase in valuation that occurs when moving a fixed unit of time closer to an expected outcome is proportionately greater the closer you are to that outcome. Think of the experience of moving one day closer to an important event that is a year off, versus for one that is imminent; one day makes no noticeable difference in the former case, but a powerful difference in the latter. The spike in value/emotional salience (positive or negative) as you get temporally closer to a particular reward creates systematic reversals of preference over time. From a distance, the prospect of late night partying might not seem worth it if it precludes you from having a good ski outing the following day, but when the opportunity to drink with friends is at hand and the skiing is still some distance away, the option of partying may be temporarily valued above its alternative. Unlike exponential discount functions, hyperbolic discount functions predict dynamic inconsistency (Fig 1a and 1b). Hyperbolic discounting creates windows in which a more immediate but inferior reward is temporarily preferred over its alternative (one operationalization of “impulsivity”). The exponential formula is:

$$\text{Present value} = \text{Value}_0 \times \delta^{\text{Delay}} \qquad \text{Formula 1}$$

where $Value_0$ = value if immediate and $\delta = (1 - \text{discount rate})$. The hyperbolic formula is:

$$\text{Present value} = \text{Value}_0 / [1 + (k \times \text{Delay})] \quad \text{Formula 2}$$

where $Value_0$ = value if immediate and k is degree of impatience.

The fit of Formula 2 to behavioral data can be improved by raising the denominator to a power (Grace, 1996; Green & Myerson, 2004; Kirby, 1997; Mazur, 2001) which results in a hyperboloid function rather than a true hyperbola, but this does not change the major implication that the discount curve has for impulsive choice: SS rewards will be regularly preferred to LL alternatives as the choice gets closer. Not only can impulsive choices be expected in anyone who has not managed to compensate for this curve (which we discuss below) but the nature of intentionality itself may be quite different from the commonsense notion of it. The inherent instability of preference creates separate, temporally-defined agents within the unit that classical economics has always seen as basic, the individual person. *Picoeconomics*, the most microscopic branch of behavioral economics, models the resulting strategic interaction among one person's successive motivational states (Ainslie, 1986; Ross et al., 2008).

Figure 1A

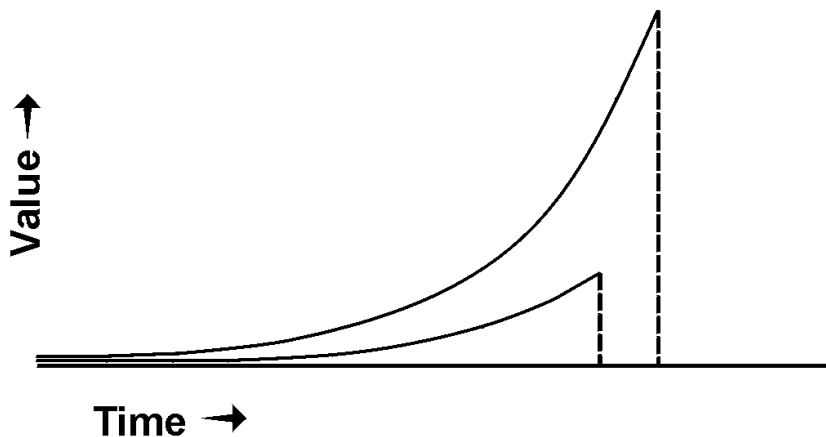


Figure 1B

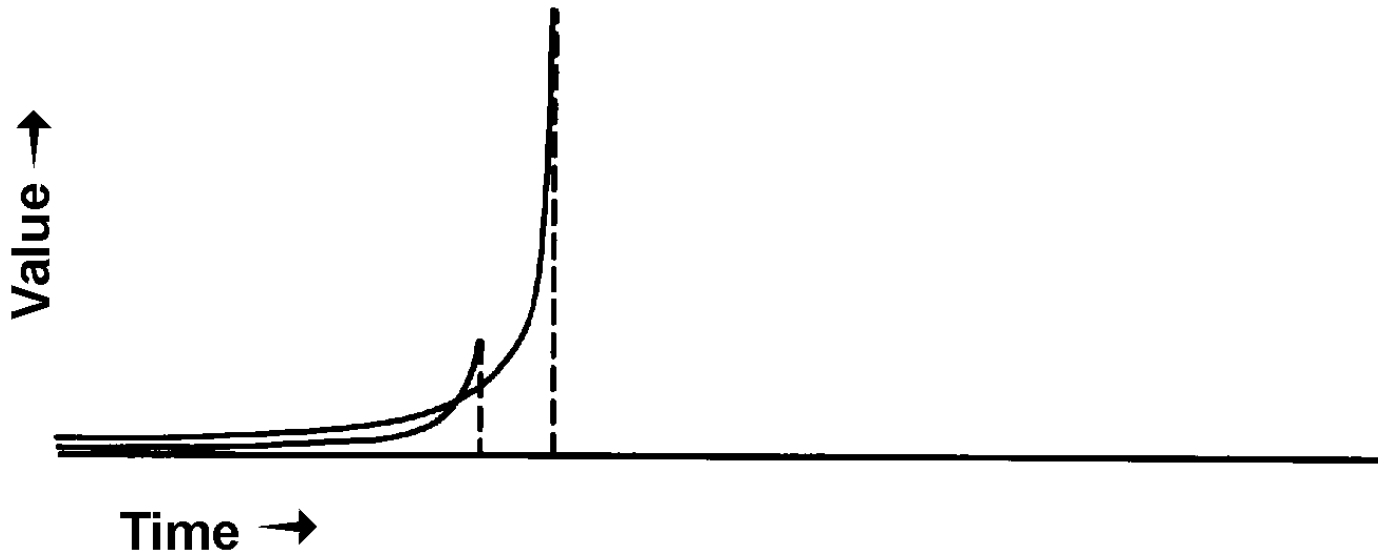


Figure 1 Exponential discount curves from two rewards of different sizes available at different times (a), and hyperbolic discount curves from two rewards of different sizes available at different times (b). For exponentially discounted rewards there is no delay at which preference switches. For the hyperbolically discounted rewards, the smaller reward is more valued just in the period when its availability is relatively immediate.

The hyperbolic shape appears to be elementary, having been observed in humans and various animal species, with both rewards and punishments (Deluty, 1978), and both when the SS is literally immediate and when it is weeks away (Green, Myerson, & Macaux, 2005). However, two alternative or additional factors have been proposed to account for the apparent hyperbolic shape of people's discount curves: visceral reward and cognitive framing. Visceral reward theory holds that particular kinds of rewards become disproportionately motivating when they are imminently available, or when they have been classically conditioned to a current stimulus:

Visceral factors include drive states such as hunger, thirst, and sexual desire, moods and emotions, physical pain, and, most importantly for addiction, craving for a drug... At intermediate levels, most visceral factors, including drug craving, produce similar patterns of impulsivity, remorse, and self-binding. At high levels, drug craving and other visceral factors overwhelm decision making altogether, superseding volitional control of behavior (Loewenstein, 1999, p. 235; see also (Laibson, 2001; McClure, Ericson, Laibson, Loewenstein, & Cohen, 2007; McClure, Laibson, Loewenstein, & Cohen, 2004).

The visceral reward phenomenon is widely experienced, both in addictions and in everyday life. But the fact that the value of rewards change as a function of state (e.g., food becomes more rewarding as time since last meal increases) does not itself imply preference reversal. After a good breakfast you may have no appetite for food, but at that moment, the prospect of eating again at lunchtime still has value because a return of

appetite is predictable. For visceral factors to explain preference reversals, they must entail unanticipated changes in appetite, and since preference reversals are still observed in domains in which changes in appetite are highly predictable, visceral factors alone is not an adequate explanation of the phenomenon (Ainslie, in press).

Several cognitive framing hypotheses have proposed that the apparently hyperbolic shape of discount curves has been an artifact of various ways of framing choices: Human subjects have been reported to discount future payoffs more steeply when delays are broken into shorter periods, and when smaller amounts are at stake (Read, 2001; Read & Roelofsma, 2003). Subjects' heuristics, such as grouping outcomes into the categories of similar vs. dissimilar (Rubinstein, 2003), or treating outcomes abstractly vs. concretely (Trope & Liberman, 2000, 2003), have also been identified as possible causes of inconsistent choice. These suggestions are discussed in more detail elsewhere (Ainslie, in press), but they share the fundamental limitation that none of them predict the key property of hyperbolic curves, temporary preference for SS over LL rewards. However, these framing effects may sometimes add to this preference pattern.

Picoeconomics and recovery from addiction

Despite the fact the pleasures available through drug use are relatively immediate and the costs generally paid further down the line, most people who use drugs do not become dependent, and among those who do, most successfully quit (Robins, 1993). Recovery from addiction can be extraordinarily abrupt without any obvious changes in contingencies (Miller & C'de Baca, 2001; Premack, 1970), and is commonly described in spiritual terms (Bien & Bien, 2002). Thus it may seem that although behavioral economic and other deterministic approaches are productively applied to the urge driving addiction, they are not applicable to studying *recovery from* addiction (for example, see Miller, 2003). However, we argue that behavioral economics sheds new light on recovery from addiction (Ainslie, 1975, 1992, 2001.)

Because preference among a fixed set of alternatives can vary predictably as a function of the passage of time (delay dependence), it follows that in some cases, one of the obstacles faced in trying to attain current preferences are your own expected preferences at some point in the future; thus, in the analysis of impulsive choice and defenses against it, it may be more productive to model the individual as a series of successive selves in partial conflict, rather than as a single self moving consistently through time. Consider an addict trying to quit, who currently has a clear preference for abstaining in the future, but an equally clear awareness that her own future self poses a threat to this current preference. She may be expected to behave strategically towards the competitive interests of her future self, that is, to precommit herself to her current preferences. The strategies that have been observed can be summarized as extrapsychic commitment, attention control, emotion control, and willpower (Ainslie, 1975, 1992, 2001).

External precommitment

The most direct method of precommitment is to arrange for some external control or influence (e.g., Ulysses binding himself to the mast, or the chronic overeater's gastric bypass surgery). While truly binding precommitment is often not available, partial precommitments are often possible, in which the current self increases the likelihood of

attaining its preference by altering the contingencies future selves will face. For instance, if an alcoholic checks into a detoxification facility far away from the available drug or takes disulfiram (Antabuse) or acamprosate (Campral), then the alcoholic is partially precommitting in accordance with current preferences by making it more costly or less pleasurable to drink. Precommitment by choosing external constraints has been demonstrated even in pigeons (Ainslie, 1974; Leonard Green & Rachlin, 1996), though only in a situation where the commitment method was highly salient. Precommitment itself does not require cognitive sophistication; it follows mechanistically from hyperbolic discounting. The LL reward discounted for its associated delay is simply greater at the time of precommitment than is the discounted SS reward (to the right of the intersection of the curves in Fig 1b).

Whereas it is unusual for someone to arrange for physical restraints, many social institutions serve the purpose of precommitment. People often accept lower interest on savings in return for protection from spending them, as in Christmas clubs, “banking with Uncle Sam” for income tax refunds, and many forms of otherwise puzzling illiquid investments (Laibson, 1997). Even more powerful are selective friendships—staying open to the influence of some people and not others, and even making public declarations of intention to those people so as to make a lapse embarrassing (Becker, 1960). Before the vogue of individual willpower in seventeenth century Europe, social influence was by far the greatest factor in self-control (Stone, 1977). However, reliance on social pressure as a form of precommitment has several drawbacks: A whole society may succumb to an impulse, as often happened in the middle ages (Huizinga, 1924) and still happens with addictions such as smoking and certain eating habits; other people may not have the person’s best interests at heart—not only the out-and-out exploiters who thrive in a cosmopolitan society, but also self-gratifying friends, as in Jane Austen’s *Persuasion*; most self-defeating behaviors can be concealed up to a point; and social supervision sets up short-term incentives for getting away with evasions, often a rewarding game in its own right, as many parents discover.

Internal precommitment: Control of attention and emotion

Precommitment can be accomplished by purely mental behaviors. Individuals’ responses to tempting stimuli depend on their attention to those stimuli. Control of attention can be used to guard against preference reversal; for example, someone struggling to maintain fidelity to a spouse may not allow herself to notice the flirtations of an attractive other. Attending to such information may foreseeably increase the likelihood of creating preferences in opposition to current preferences. Attention control can occur as either deliberate avoidance of information or as an avoidance that is itself not reportable. The latter case is the repression that Freud at one time held to be the cornerstone of all defensive processes (Freud, 1956). The repressing individual avoids unwanted thoughts, feelings or behaviors by not attending to the psychically loaded information.

It often feels as though the direction of attention is the essence of willpower. Philosopher Michael Bratman considers the mechanism of willpower to be an avoidance of reconsidering one’s resolutions (Bratman, 1999), and this idea dates back to at least William James: “The effort by which [a drunkard] succeeds in keeping the right *name* unwaveringly present to his mind proves to be his saving moral act” (1890, p. 565). But

it is hard to stay unaware of tempting alternatives over periods of time longer than minutes. Hypnosis, the most thorough form of attention control in susceptible subjects, can overcome urges to emit mannerisms or attend to pain (Hilgard & Hilgard, 1994), but has proven useless for treating addictions (Abbot, Stead, White, Barnes, & Ernst, 2000; McConkey, 1984). There is a more complex mechanism implicit in Bratman's, and James', concept of willpower, which we will get to presently. As for attention control itself, it is a short-term manipulation that can be used either to prevent impulses or to further them, by protecting them from interference, and is not stable over even moderate lengths of time.

Aroused appetites and emotions clearly change the motivation for relevant activities. This is the "viscerality" that is often experienced in addictive losses of control, and that has been proposed as the core phenomenon of impulsiveness (Loewenstein, 1999). The factors that govern it are controversial (Ainslie, in press). But if a person expects an appetite or emotion to make currently unpreferred reward dominant, she may commit herself not to choose the reward through early inhibition of that appetite/emotion. In a classic experimental demonstration of emotional control. Walter Mischel and colleagues found that while children below around 6 years were poor at self-control, many older children were often able to resist the temptation of an immediately available marshmallow in favor of a more preferred reward. Those that succeeded in avoiding the impulsive preference reversal often used emotion control in the form of thinking about the immediately available marshmallow in a "cool" way, or by imagining it to be undesirable (Mischel & Mischel, 1983; Mischel & Moore, 1980). Psychoanalysts early identified this manipulation of appetite/emotion under the names "isolation of affect," "reversal of affect," and "reaction formation" (Freud, 1956). Significantly, they described mainly its harmful side-effects: a reduced openness to emotional experience and the domination of important decisions by a few crude attitudes.

Beyond Precommitment: Intertemporal bargaining as the mechanism of willpower

Tactics that commit choice in advance are sometimes evident in addicts' efforts to avoid temptation. However, precommitment behaviors (whether by internal or external means) are not the only mechanism by which we guard against preference reversal. We sometimes do not need to bind ourselves by the devices described above. It is certainly good advice for an addict to avoid the haunts where her substance is readily available; but most people who have given up a bad habit do not depend on keeping temptation at a distance or out of mind. People who have given up smoking, for instance, often say that they "just did it" one day (Premack, 1970). They are said to have used willpower. If they relapse, they are more apt to attribute it to an exceptional circumstance - the pressure of an exam, depression over a failed relationship - than to the imminent availability of a cigarette. Rationalization, not proximity, is the most notorious threat to willpower.

Writers since antiquity have related willpower to choosing according to principle; that is, choosing in categories containing a number of expectable choices rather than just the choice at hand. Aristotle said that impulsive choice ("akrasia") was the result of choosing according to "particulars" instead of "universals" (Aristotle, 1984; 1147a24-28); Kant said that the highest kind of decision-making involved making all choices as if they defined universal rules (the "categorical imperative,"; Kant, 1793/1960: 15-49); the Victorian psychologist Sully said that will consists of uniting "particular actions... under a

common rule" so that "they are viewed as members of a class of actions subserving one comprehensive end" (Sully, 1884pg 663). The fundamental insight is that you increase your self-control by choosing according to category rather than on a case-by-case basis (e.g. a preference for being a non-smoker, even as you prefer this particular cigarette). The philosophical terms in which this topic has usually been discussed may sound too academic to fit mundane choices by ordinary people, and may readily lead to dismal conclusions about categorical choice as a self-control tool (Wolf, 1982). Better to start with the situation that the will is needed to solve: The mere fact of your having "made" a decision, for instance about consuming a tempting good, does not prevent your preference from changing as the opportunity gets closer. At a given moment you share some values with your expectable selves at future moments, but when some outcomes are closer than others you may have particular differences with these selves, a relationship that has been called limited warfare (Schelling, 1960, pp. 20-80). In the apparent absence of a faculty that can make your current decision stick, how can you expect to influence your future motivational states by any means other than the precommitting devices we have just covered?

Among individuals in limited warfare relationships, conflict can often be avoided by bargaining. An analogous solution among successive motivational states, *intrapersonal bargaining* (Ainslie, 1975, 1992, 2001) can be expected to let an individual unite "particular actions... under a common rule"(Sully, 1884). First notice how intuitively clear it is that a current choice in a self-control situation effects future choices: Consider a smoker who is preparing to initiate abstinence, but currently strongly craves a cigarette that is offered to her. Suppose that at the moment her resolve is uncertain, time stops long enough for an angel whispers in her ear that it is a forgone conclusion that she is destined to smoke a pack a day from tomorrow on. What effect would this have? Given the certainty that she would be a pack a day smoker, we think she would have no incentive to turn down the desired cigarette - it would seem pointless. What if the destiny revealed by the angel was instead that she would never smoke again from tomorrow on? Here, too, there seems to be little incentive left to turn down the desired cigarette - it would be harmless. Fixing future smoking choices in either direction evidently makes smoking the dominant current choice. Only if future smoking is in doubt does a current abstention seem worth the effort. But why should fixing future smoking behavior make a difference to the choice at hand? There is no physical connection between current and future choices. You literally make one choice at a time. However, willpower is in some important way related to the conception that more than 'just one' episode is in the balance with a given choice. Remove this connection between present and future behavior, and you will remove the lift from under your willpower's wings.

While the above example provides intuitive evidence that a perceived connection between current choices and future choices is relevant to self- control, it leaves the question of why this should be so. Our answer proceeds from the observation that delay discounting is less steep when future choices are bundled with current choices. While value declines dramatically when a relatively small delay is added to an immediate reward, the effect of adding a similar additional delay to a reward that is already much delayed is very small. A hundred dollars now may be far better than \$100 in 3 months, but what is the difference between \$100 in 6 years and the same in 6 years and 3 months? The relatively flat discounting of rewards when delay is already large implies a potential

for great increases in value if series of expected future rewards are added together - and there is good evidence that the discounted values of series of rewards are additive (Mazur, 1997). Unlike exponential curves, hyperbolic curves level off with longer delays. As such, the added value from series of alternative rewards, if *bundled* together, will favor the larger-later rewards increasingly as the series lengthens (Figure 2).

Figure 2a

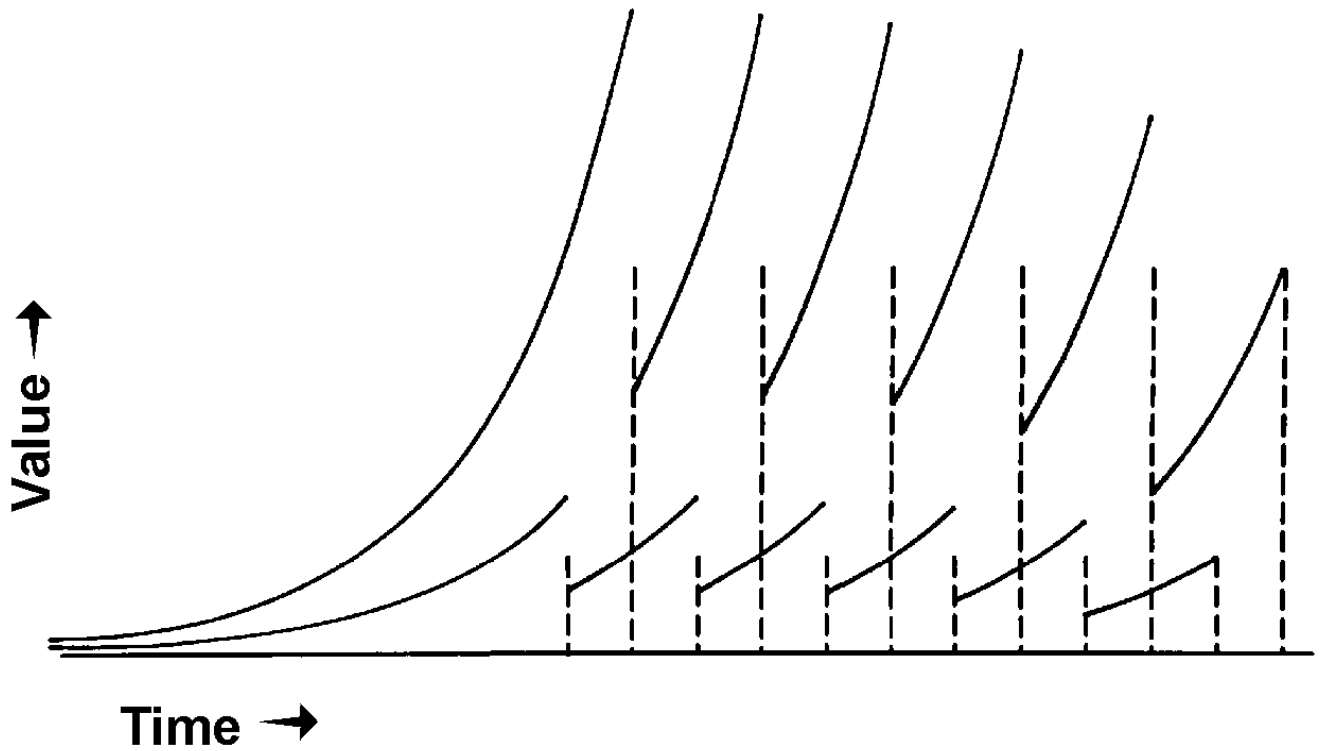


FIGURE 2b

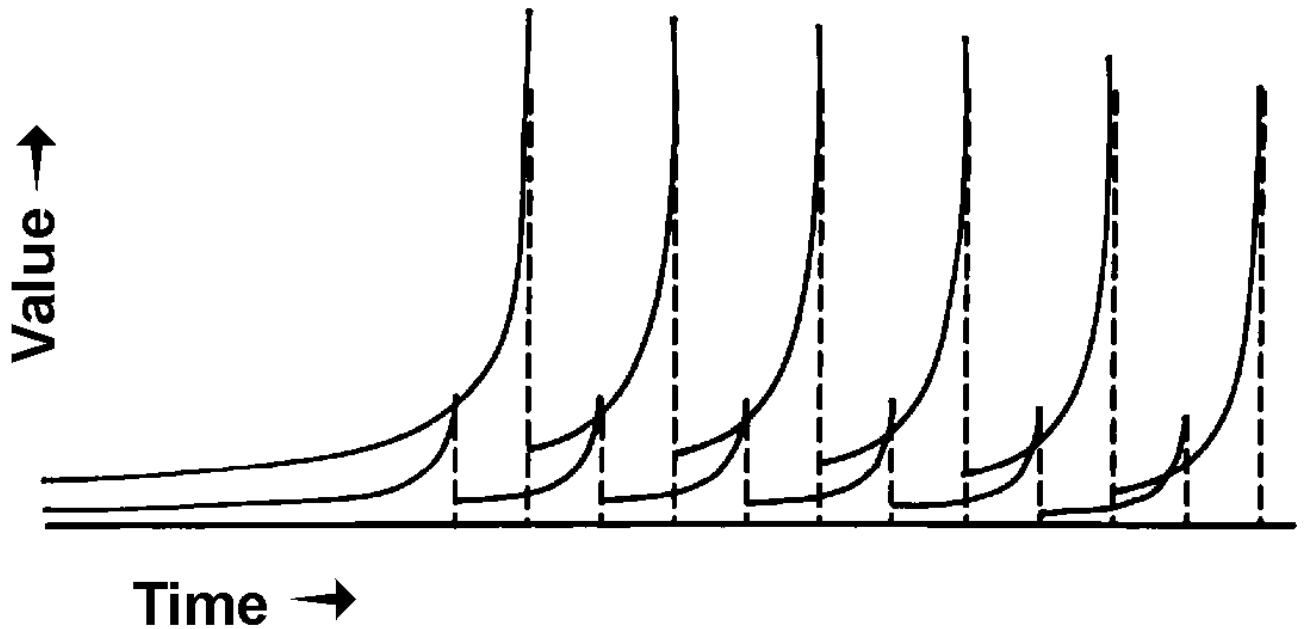


Figure 2 Summed hyperbolic curves from a series of larger-later rewards and a series of smaller-earlier alternatives (vertical dashed lines). Each curve depicts the summed discounted values of all future (rightward) rewards in the series. Thus, the curves depicted at choice pair 1 are the sum of discounted value of the corresponding alternative in pairs 1 through 6, and the curves of choice pair 2 are the sum of 2 through 6, etc. For the hyperbolic (b) but not the exponential (a) discount curve, as the series gets longer and the summed curves peak higher above the current rewards, the initial period of temporary preference (the period in which the SS curve is higher than its LL alternative) shrinks to zero.

Experiments with both human and rodent subjects confirm a greater tolerance for delay with bundled rewards. Kirby and Guastello (2001) gave college students choices between SS rewards and LL alternatives, both with money and food. In one condition the choice was made five times, each time separated by a week. In another condition, the choice was made between the two alternatives up front and for all five weeks at once. As predicted from the summation of hyperbolically discounted rewards, preference for the LL alternative was increased in the condition in which a series of choices was bundled together. Indeed, when Kirby and Guastello merely suggested to student subjects that the subjects' current choices might serve as predictions of their future choices, preference for larger-later alternatives increased, although not as much as when the experimenters bundled the choices directly (Kirby & Guastello, 2001).

We demonstrated the same phenomenon of decreased impulsive choice with bundling in rats (Ainslie & Monterosso, 2003). Eight rats were run through two conditions of a procedure designed to determine how much immediate sugar water was

equal in value to a delayed standard reward of 150 ml after a three second interval. In one condition of the procedure, choices were made on a trial-by-trial basis while in another condition every choice determined the reward that would be delivered for three consecutive trials. As predicted by hyperbolic discounting, but not exponential discounting, preference for the LL alternative was greater for all subjects in the bundled condition.

Of course, unlike the experimental cases, willpower in daily life requires the individual to spontaneously bundle future choices with current choices. What mechanism underlies spontaneous bundling? Consider a smoker whose preference for cigarettes is roughly described by Fig 1b. That is, while she prefers smoking in the immediate future, she also prefers nonsmoking in the more distant future. If she is deciding today on a plan for her entire smoking future, the dominant option is to choose to smoke in the near future, but plan to abstain thereafter. To make it concrete, consider the near future “January”, and thereafter “February” on. So our smoker decides she will smoke in January and not smoke from February on. But what happens in February? Without bundling, in February she will simply change her mind, since now the dominant plan in terms of discounted pay-offs is to smoke in February and quit from March on. But of course, the same reversal left unchecked would occur when March becomes the present.

By April she may see the pattern of unrealized plans. She may notice her preference to stop smoking in May looks just like last month’s preference to stop smoking in April and ultimately, the plan may lose credibility. She may think something like “If I break last month’s plan not to smoke in April, I am going to do the same next month with my current plan not to smoke in May”. The credibility of attaining abstinence from May and beyond may thus depend upon not smoking in April. If, for simplicity, we consider her credibility to herself to be all or none, then our smoker who sees her situation in this way is left with the *de facto* options of smoking from the present on, versus not smoking from the present on. If the lifetime of not smoking is preferred given such a conception, the product is a *personal rule* (Ainslie, 1992, 2001) – such as “I cannot smoke any cigarettes”. The expectation of smoking future is therein tied to her own current adherence, or more accurately, her current perception of her adherence, to her rule. Her current choice may thus function as a test case.

As with *interpersonal* bargaining, the *intrapersonal* bargaining situation is usually not perceived in explicit terms, and the personal rule that provides a truce line is intuited rather than stated. The result is that an individual looks as if she is following principles, but except in the most deliberate cases usually cannot put the principle into words. She completes a chore and feels virtuous, or fails to get out of bed at the usual point in the program on her clock radio and feels a vague sense of loss, but in neither case consciously thinks she is testing a principle. Her successive selves are engaged in a situation similar to a repeated prisoner's dilemma, differing from the *interpersonal* kind mainly in that the threat of losing her expectation of a bundle of future rewards replaces the threat of deliberate retaliation for defections. The person in her successive motivational states solves the dilemma in the same way as tacit *interpersonal* bargainers: Each expects future ones to perceive the current choice as a precedent for cooperation or defection, and this expectation adds to those incentives that depend on that choice alone (see Ainslie and Monterosso 2002). In this regard, repeated prisoners’ dilemmas between

individuals have been used experimentally to model phenomena related to impulse control (Monterosso, Ainslie, Toppi-Mullen, & Gault, 2002).

In principle, personal rules make it possible for a person never to prefer small early alternatives at the expense of the series of larger later ones. She may successfully keep temptations nearby without succumbing to them; however, although she may always prefer a series of larger later rewards to the small early one at hand, she must even more strongly prefer to have both. The danger is no longer one of the poorer reward coming so close that she will suddenly choose it. To the extent that her abstinence is based on a bundling effect, the primary danger comes from factors that reduce her differential expectation of future abstinence as a function of current abstinence. Such a reduction can result from increased confidence that she can abstain in future similar situations, even if she indulges presently (overconfidence), reduced confidence that future abstinence will be achieved even if she presently abstains (underconfidence), or from the perception that a current opportunity to indulge is sufficiently dissimilar to ordinary situations so as to not inform her expectations about her future behavior (rationalization). Proximity is still a contributor to her temptation, of course, but the deciding factor is no longer whether a prior commitment is too weak. The person will not experience this situation as the voyage past some Siren or other, but as a simultaneous struggle between two ways of conceiving a choice. Her rules have enabled her to live in close proximity to her temptations, but while she is there the struggle will be continuous rather than episodic. Lapses will occur through attempts to claim loopholes, variously clever and inept, rather than through a global shift of preference in favor of the forbidden activity. A person is apt to express preference for the course of action required by her rule even as she is evading it, as Sjöberg and Johnson (1978) found in their study of smoking lapses (Sjöberg & Johnson, 1978).

A personal rule may be eroded gradually, through perceiving incremental numbers of occasions as exceptions, or it may collapse suddenly through a particularly significant lapse. For instance, recovering alcoholics often report that a single drink of alcohol has a devastating, physical effect on their willpower, but an experiment with placebo drinks demonstrated that it is the perception of having taken a drink, not the alcohol itself, that causes the upward spike of craving (Maisto, Lauerman, & Adesso, 1977). Recursive self-perception may govern traits and states of widely varying volatility. The “self-signaling” (Bodner & Prelec, 2001) that deters people from giving themselves evidence of a shameful character trait arguably had its most extreme form in the Calvinist belief in predestination, which created a strong incentive never to behave inconsistently with being a member of the elect (Weber, 1904/1958; see Ainslie, 2001, pp. 134-139; Ainslie, 2005). Over a much shorter time scale, a recovering addict or controlled eater may experience the perception of any upward variation in appetite as a vulnerable moment, and even a slight reduction in her expectation of keeping her resolve may lead to further increase in appetite and a chain reaction that produces an explosion in craving, often the occasion for seemingly random lapses (Ainslie, in press). Over an intermediate time scale, such lapses may in turn be experienced as evidence that a personal rule is weak, leading to its collapse by an analogous but slower chain reaction.

The behavioral psychologist Howard Rachlin offers a slightly different concept of the tension between impulsivity and self-control that is also grounded in hyperbolic discounting. Rachlin argues that the foundation self-control is the perception of the act as

part of a larger and attractive pattern rather than as a particular and isolated act. For instance, "not smoking" might be a more satisfying pattern than "smoking this once." In support of this idea, Rachlin and colleagues report that self-control during behavioral experiments is enhanced by establishing contingencies that generate cohesive patterns, such as requiring that choices be made in groups (Kudadjie-Gyamfi & Rachlin, 1996 see also Gene Heyman's concept of choosing in an "overall" instead of a "local" context-- (Heyman, 1996)). Ross et al., 2008 argue that Rachlin's account is less an alternative to the bundling concept than it is a redescription of the same phenomenon. Both make contact with Aristotle's notion that the conflict of self-control relates to a tension between particulars and universals. But what differentiates the models is that bundling emerges as a bargaining ploy against impulses that remain attractive, while Rachlin (consonant with Aristotle) sees both the defect and its remedy in cognitive terms: Failure of self-control results from failure to see acts as part of larger patterns, and success emerges for the very reason that this more global level of analysis is realized. While the two perspectives make similar predictions regarding many of the factors that lead to self-control and loss of self-control, they differ dramatically with regard to predicted negative side-effects of self-control. Only the intrapersonal bargaining account predicts costly side-effects to self-control, to which we now turn our attention.

The limitations of willpower as a solution to addictive preferences

It might seem that the best treatment for addictions would be to encourage addicts to use more willpower. There are some therapies that advocate this (Glasser, 1965). Rehearsing particular choice contingencies in advance and specifying "implementation intentions" in response to them has been reported to increase impulse control in people with poor control, including opium addicts (Brandstätter, Lengfelder, & Gollwitzer, 2001). However, willpower is not the unqualified good imagined by Victorian optimists. Even before Sully prepared his analysis of willpower, Kierkegaard had begun the line of philosophical thought that became existentialism, warning of the inauthenticity that comes from a too-planful life (May, 1958). In accordance with this warning, the intertemporal bargaining mechanism of willpower that we have just described predicts major limitations.

Willpower is the most flexible and potentially the most powerful of the choice-stabilizing devices, but the intertemporal bargaining model predicts that it will also have serious side effects, side effects that have in fact been observed by clinicians. Such bargaining doesn't let us estimate our best prospects from moment to moment as true exponential discounting would. Rather it formalizes internal conflict, making some self-control problems better, but some worse. We briefly consider three downsides to willpower below. For a more complete treatment of this topic, see Ainslie, 2001.

1. Rules overshadow goods-in-themselves. The perception of a choice as a precedent often makes it much more important for its effect on future expectations than for the rewards that intrinsically depend on it. When this is true, choices become detached from their immediate outcomes and take on an aloof, legalistic quality, the extreme of which is obsessive-compulsive personality disorder.
2. Rules magnify lapses. When you violate a personal rule, the cost is a fall in your prospect of getting the long range rewards on which it was based. But this prospect is what you've been using to stake against the relevant impulses; a lapse suggests that your

will is weak, a diagnosis that may act recursively to weaken your will. The consequence may be that a small lapse is likely to lead to a total collapse of restraint, sometimes referred to as the "abstinence violation effect" (Marlatt & Gordon, 1980). This effect has been documented in such disparate areas as drinking among alcoholics in treatment (Collins & Lapp, 1991), smoking among individuals attempting to quit (Shiffman et al., 1997; Spanier, Shiffman, Maurer, Reynolds, & Quick, 1996), eating among dieters (Grilo & Shiffman, 1994; Johnson, Schlundt, Barclay, Carr-Nangle, & et al., 1995), and fantasies among pedophiles (Hudson, Ward, & France, 1992; Ward, Hudson, & Marshall, 1994).

3. Rules motivate misperception. Personal rules depend heavily on perception-- noticing and remembering your choices, the circumstances in which you made them, and their similarity to the circumstances of other choices. And since personal rules organize great amounts of motivation, they naturally create temptations for you to suborn the perception process. When a lapse is occurring or has occurred, it will often be in both your long and short range interests not to recognize that fact: Your short range interest is to keep the lapse from being detected so as not to invite attempts to stop it. Your long range interest is also at least partially to keep the lapse from being detected, because acknowledging that a lapse has occurred would lower the expectation of self-control that you need to stake against future impulses.

After a lapse, the long range interest is in the awkward position of a country which has threatened to go to war in a particular circumstance that has then occurred. The country wants to avoid war without destroying the credibility of its threat, and may therefore look for ways to be seen as not having detected the circumstance. Your long range interest will suffer if you catch yourself ignoring a lapse, but perhaps not if you can arrange to ignore it without catching yourself. This arrangement, too, must go undetected, which means that a successful process of ignoring must be among the many mental expedients that arise by trial and error-- the ones you keep simply because they make you feel better without your realizing why. As a result, money disappears despite a strict budget, and people who "eat like a bird" mysteriously gain weight.

These considerations suggest why a simplistic policy of "the more willpower, the better" contradicts the experience of many addicts. To them, more willpower may mean less of the human qualities they value most in themselves. They're able to listen to reason only when reason, represented by personal rules, stops starving their own longest range prospects for emotional satisfaction. Intertemporal bargaining may nevertheless suggest refinements in therapies for addictions, at least by clarifying their motivational rationales; but improvements from simply attacking some shortage of willpower will be unlikely.

Implications for Therapy

It is not usually the case that the individual seeking treatment for substance dependence has simply failed to discover willpower as the solution to her problem. She typically has called on willpower repeatedly, making resolutions that may have lasted only hours or days before failing. Significantly, the various schools of psychotherapy rarely try to make the will maneuver more forceful, but rather target people's overzealous use of it—the "punitive superego" and its synonyms (Ainslie, 2001, pp. 143-155). An approach to addictions that does seem to use the properties of intertemporal bargaining, while deftly avoiding its pitfalls, is not seen in professional therapies at all, but in grass

root “twelve-step” programs. We first discuss the professional approach that draws directly on behavioral economic principles, contingency management, and then discuss the twelve-step approach.

Contingency management

In contingency management treatments (CM) for addiction, participants are rewarded according to a specified schedule for favorable outcomes such as drug-free urines (Petry, 2000). In conjunction with counseling, CM provides a substantial boost to treatment outcomes (Higgins, Stitzer, Bigelow, & Liebson, 1986). And this in itself is puzzling; individuals that come to treatment are generally suffering – they may have no money, no job, their children may have been taken from them. That they seek treatment suggests that they both believe their drug use is causing their suffering, and that they are unable to stop on their own. So how does adding a few dollars reward for a clean urine make a difference where far more substantial consequences were insufficient?

At least part of the answer relates to delay discounting. At first, abstinence is all pain, no gain – none of the bad things in the addict’s life turn good overnight. So, particularly in light of the addict’s steep discounting, the relative immediacy of the reward for a drug-free urine may make an important difference. The efficacy of CM may also be explained by *certainty*, which is conceptually distinguishable from *immediacy* (though the two are often hard to tease apart in practice since delayed outcomes tend to be less certain). With respect to the benefits of drug use, the typical addict has failed so often in her efforts to moderate use that benefits that require prolonged abstinence may seem unobtainable. Having some small reward for one or two clean days will be more effective than the more meaningful benefits of recovery when only the former seem possible.

The success of CM would be far less exciting if the benefits of the regimen always stopped when the extrinsic rewards stopped. Indeed we could worry that the introduction of an extrinsic reward for abstinence would undermine the value of the intrinsic rewards of abstinence, such that the latter are less potent than they would have otherwise been (Lepper & Greene, 1978). However, there is no evidence of this, and some reason for optimism regarding the persistent effect of CM (Dultra et al., 2008). We find particularly intriguing a recent study in which smokers whom were not interested in quitting were paid large sums of money (\$40 per day for a month) to not smoke. This was a large enough amount of money that virtually all participants stopped smoking. When the monetary incentive was removed and the participants were given opportunities to smoke, the majority refused, at least for that first day (Yoon et al, submitted). In behavioral economic terms, somehow the experience changed the operative contingencies. But the nature of the change remains to be determined, as does how best to capitalize on the change in order to promote long-term abstinence.

12-Step recovery

In one large multi-site trial for cocaine addiction, 12-step treatment for was more effective than an equivalent amount of either cognitive behavioral therapy or supportive expressive therapy (Crits-Christoph et al., 1999). Interestingly, the advantage of 12-Step treatment (in terms of abstinence rates) over other therapies was most apparent during periods in which high craving is experienced (Weiss et al., 2003). In other words,

individuals in 12-step seemed to do relatively well maintaining abstinence in the face of craving, ordinarily the job of willpower; but 12-step programs proclaim that willpower is not only unnecessary, but ineffective. We hold that the strategies of these programs nevertheless depend on properties of intertemporal bargaining and thus invoke a variant of willpower. In particular, we propose that aspects of the 12-step approach are responses to how overconfidence, underconfidence, and rationalization, as we have just defined them, pose primary threats to the maintenance of abstinence.

The declaration of powerlessness (Step 1: “We admitted we were powerless over our addiction - that our lives had become unmanageable”) may seem an unpromising starting point for a program designed to buttress self-control. However, among other things, this declaration of powerless effectively wards against overconfidence by dismissing the often evidence-resistant notion that the individual can say “yes” now to the first drink, and say “no” later to the second, or tenth. It deters attempts to use rationalization and other hedges on willpower. “One drink is a thousand drinks” shores up one side of the critical perceived differential in conditional probabilities, by asserting that the probability of saying “no” later if you say “yes” now is zero. The threat of overconfidence that may develop later in recovery is also appreciated in the otherwise inexplicably dismal saying “every day brings you one day closer to your next relapse” as well as through the principle that addiction is a permanent condition, regardless of how long abstinence is maintained.

If self-control depends on present behavior informing expectation about future behavior within the whole category, then self-control should be inoperative when a temptation is not seen as belonging to the larger category. If the person who has vowed to stop smoking cigarettes does not perceive an opportunity to smoke a cigarillo as belonging to the same category, then there is nothing larger at stake in her response to the possibility. The problem is, of course, that since the payoff of smoke today and not smoke from tomorrow on is, *ex hypothesi*, higher than “abstain always,” she has incentive to rationalize individual cases as exceptions. As William James (James, 1890 pg 565) famously put it:

How many excuses does the drunkard find when each new temptation comes! It is a new brand of liquor which the interests of intellectual culture in such matter obliges him to test; moreover, it is poured out and it is a sin to waste it; or others are drinking and it would be churlishness to refuse; or it is but to enable him to sleep, or just to get through this job of work; or it isn't drinking, it is because he feels so cold; or it is Christmas day; or it is a means of stimulating him to make a more powerful resolution in favor of abstinence than any he has hitherto made; or it is just this once, and once doesn't count, etc., etc., ad libitum – it is, in fact, anything you like except being a drunkard.

Minimizing such rationalization is a major focus of 12-step recovery, as typified in the prayer for “freedom from self-will, rationalization and wishful thinking”. Twelve-step proponents adhere to the idea that total abstinence is the only possibility; there can be no exceptions or holidays from abstinence. If the alcoholic is helpless against alcohol, any lapse becomes a sign that the disease is going to take over. Instead of being nullified, the will is given the largest possible stake—all remaining hope of sobriety—but

at the cost of no longer having any scope to redefine its terms. Max Weber proposed that a similar perception of helplessness was the key to the Calvinists' increase in self-control, as we have described above (1904/1958, p. 115). This would be another example of making the will not actually helpless but, rather, resistant to rationalizing (Ainslie, 1992, pp 203-204).

While perceived helplessness might seem to promote under-confidence that future abstinence can be maintained, the 12-step method fuels expectation that abstinence can be maintained. The ambitious resolutions that have ceased to be credible ("I'll never drink again") are replaced by believable building blocks: "one day at a time." The believable expectation of one day's sobriety becomes worth more than devalued long-range expectations—and yet the effect of a series of successful single days builds that very credibility that was lost, and this rebuilding is concretized in the practice of keeping a running total of how many days abstinent the participant "has." The question of how this initially small stake is enough to motivate abstinence might be answered by the second step, "Come to believe that a Power greater than ourselves could restore us to sanity." One of us has argued that putting at stake one's good relationship with a felt other—guardian angel, god, observing ancestor, etc.—may provide much of the power of a personal rule with less risk of the legalistic rigidity that can seriously limit the effectiveness of intertemporal bargains (Ainslie, 2004).

Abstinence versus moderation approaches

Most contemporary treatment for addiction in the United States is "abstinence-oriented", meaning that abstinence is the sole outcome that constitutes a treatment success. Why should this be when the majority of people that use recreational drugs (both legal and illegal) do so without major adverse consequences? Why can't the alcohol dependent person be taught whatever skills the casual drinker has? The disease model long dominant in the United States (Jelinek, 1960) argues that addiction simply makes moderation *impossible*. But this claim has not held up to empirical scrutiny (Marlatt & Witkiewitz, 2002; Sobell, Cunningham, & Sobell, 1996) and the disease model of addiction is, in general, problematic (Heyman, 1996). But the picoeconomic perspective clarifies why moderation-oriented approaches are so controversial. Establishing abstinence as the only successful outcome puts up the maximum stake (maximally large bundle) against any individual temptation. Perhaps more critically, it provides the clearest "bright line" to guard against rationalization. Belief that moderation is possible, it is feared by some in the field, opens the door to the seductive idea that one can indulge today and be moderate tomorrow, thereby inviting relapse (Cadogan, 1999). The downsides, on the other hand, to abstinence only orientation may be those discussed in the context of the downsides of willpower efforts generally (such as extreme rigidity and the tendency to make any lapse an unmitigated binge—as Marlatt & Marlatt warned). The balance in this trade-off is likely to depend on the skills and disposition of the therapist and client.

Final remarks: the future of picoeconomics in addiction research

The eminent behavioral psychologist Frank Logan once wrote "Principles of animal behavior can provide a basis for a theory of human drug use and abuse, but voluntary control of addictive behavior requires uniquely human cognitive processes"

(Logan, 1993; pg 291). We believe the outlined approach is the most promising theory regarding the nature of the uniquely human processes to which Logan referred. Picoeconomics provides a reductionist behavioral foundation from which to investigate the complex struggles with self-control that have traditionally eluded reductionist psychology. But the mechanisms suggested present unique challenges. The positive feedback loop relating future expectations to current preferences makes the proposed system chaotic in the technical sense of the word (Devaney, 2003). The empirical work we and others have carried out to test this model has so far done little more than test some foundational ideas (e.g., that bundling is associated increased tolerance for delay (Ainslie & Monterosso, 2003; Kirby & Guastello, 2001)). The critical next step will be to find better ways to empirically assess the model using methods that bring the phenomena of will and its failure into the laboratory.

REFERENCES

- Abbot, N. C., Stead, L. F., White, A. R., Barnes, J., & Ernst, E. (2000). Hypnotherapy for smoking cessation. *Cochrane Database Syst Rev*(2), CD001008.
- Ainslie, G. (1974). Impulse control in pigeons. *Journal of the Experimental Analysis of Behavior*, 21(3), 485-489.
- Ainslie, G. (1975). Specious reward: a behavioral theory of impulsiveness and impulse control. *Psychological Bulletin*, 82, 463-496.
- Ainslie, G. (1986). Beyond microeconomics: conflict among interest in a multiple self as a determinant of value. In J. Elster (Ed.), *The Multiple Self* (pp. 133-175). Cambridge: Cambridge University Press.
- Ainslie, G. (1992). *Picoeconomics: The strategic interaction of successive motivational states within the person*. New York, NY, USA: Cambridge University Press.
- Ainslie, G. (2001). *Breakdown of Will*: Cambridge University Press.
- Ainslie, G. (2004). Gods are more flexible than resolutions. *Behavioral and Brain Sciences*, 27, 18-19.
- Ainslie, G. (in press). Hyperbolic Discounting versus Conditioning and Framing as the Core Process in Addictions and Other Impulses. In D. Ross, H. Kincaid, D. Spurrett & P. Collins (Eds.), *What Is Addiction?* . Cambridge: MIT Press.
- Ainslie, G., & Haendel, V. (1983). The motives of the will. In E. Gottheil, K. Druley, T. Skodola & H. Waxman (Eds.), *Etiology Aspects of Alcohol and Drug Abuse*. Springfield, Illinois: Charles C Thomas.
- Ainslie, G., & Monterosso, J. R. (2003). Building blocks of self-control: increased tolerance for delay with bundled rewards. *J Exp Anal Behav*, 79(1), 37-48.
- Aristotle. (1984). *The Complete Works of Aristotle*. Princeton: Princeton University Press.
- Audrain-McGovern, J., Rodriguez, D., Tercyak, K. P., Epstein, L. H., Goldman, P., & Wileyto, E. P. (2004). Applying a behavioral economic framework to understanding adolescent smoking. *Psychol Addict Behav*, 18(1), 64-73.
- Becker, G., & Murphy, K. (1988). A Theory of Rational Addiction. *The Journal of Political Economy*, 96, 675-700.
- Becker, H. S. (1960). Notes on the concept of commitment. *American Journal of Sociology*, 66, 32-40.

- Bickel, W. K., Odum, A. L., & Madden, G. J. (1999). Impulsivity and cigarette smoking: delay discounting in current, never, and ex-smokers. *Psychopharmacology (Berl)*, 146(4), 447-454.
- Bien, T., & Bien, B. (2002). *Mindful Recovery: A Spiritual Path to Healing from Addiction*. New York: Wiley and Sons.
- Bodner, R., & Prelec, D. (2001). The diagnostic value of actions in a self-signaling model. In I. Brocas & J. D. Carillo (Eds.), *Collected Essays in Psychology and Economics*. Oxford.
- Brandstätter, V., Lengfelder, A., & Gollwitzer, P. M. (2001). Implementation intentions and efficient action initiation. *Journal of Personality and Social Psychology*, 81, 946-960.
- Bratman, M. E. (1999). *Faces of Intention: Selected Essays on Intention and Agency*. Cambridge: Cambridge U.
- Bretteville-Jensen, A. L. (1999). Addiction and Discounting. *Journal of Health Economics*, 18(4), 393-407.
- Cadogan, D. A. (1999). Drug use harm. *American Psychologist* 54, 841-842.
- Collins, R. L., & Lapp, W. M. (1991). Restraint and attributions: Evidence of the abstinence violation effect in alcohol consumption. *Cognitive Therapy & Research*, 15(1), 69-84.
- Crits-Christoph, P., Siqueland, L., Blaine, J., Frank, A., Luborsky, L., Onken, L., et al. (1999). Psychosocial treatments for cocaine dependence: National Institute on Drug Abuse Collaborative Cocaine Treatment Study. *Archives of General Psychiatry*, 56(6), 493-502.
- Deluty, M. (1978). Self-control and impulsiveness involving aversive events. *Behaviour Analysis Letters*, 3, 213-219.
- Devaney, R. L. (2003). *Introduction to Chaotic Dynamical Systems*. Westview Press.
- Dutra, L., Stathopoulou, G., Basden, S. L., Leyro, T. M., Powers, M. B., & Otto, M. W. (2008). A meta-analytic review of psychosocial interventions for substance use disorders. *Am J Psychiatry*, 165(2), 179-187.
- Freud, S. (Ed.). (1956). *On the History of the Psychoanalytic Movement* (Vol. 14). London: Hogarth.
- Fuchs, V. R. (1982). Time preferences and health: An exploratory study. In E. A. o. Health (Ed.).
- Glasser, W. (1965). *Reality Therapy*. NY: Harper & Row.
- Grace, R. (1996). Choice between fixed and variable delays to reinforcement in the adjusting-delay procedure and concurrent chains. *Journal of Experimental Psychology: Animal Processes*, 22, 362-383.
- Green, L., & Myerson, J. (2004). A discounting framework for choice with delayed and probabilistic rewards. *Psychological Bulletin*, 130(5), 769-792.
- Green, L., Myerson, J., & Macaux, E. W. (2005). Temporal discounting when the choice is between two delayed rewards. *J Exp Psychol Learn Mem Cogn*, 31(5), 1121-1133.
- Green, L., & Rachlin, H. (1996). Commitment using punishment. *Journal of the Experimental Analysis of Behavior*, 65(3), 593-601.

- Grilo, C. M., & Shiffman, S. (1994). Longitudinal investigation of the abstinence violation effect in binge eaters. *Journal of Consulting & Clinical Psychology*, 62(3), 611-619.
- Hanson, C. (Forthcoming). *Addiction: A philosophical exploration of hyperbolic discounting models of human behavior*. Kenilworth: Rodopi Press.
- Heyman, G. (1996). Resolving the contradictions of addiction. *Behavioral and Brain Sciences*, 19, 561-610.
- Higgins, S., Stitzer, M., Bigelow, G., & Liebson, G. (1986). Contingent methadone delivery: effects on illicit-opiate use. *Drug Alcohol Depend*, 17, 311-322.
- Hilgard, E. R., & Hilgard, J. R. (1994). *Hypnosis in the Relief of Pain, Revised Edition*. New York: Burnner/Mazel.
- Hudson, S. M., Ward, T., & France, K. G. (1992). The abstinence violation effect in regressed and fixated child molesters. *Annals of Sex Research*, 5(4), 199-213.
- Huizinga, J. (1924). *The waning of the middle ages, a study of the forms of life, thought and art in France and the Netherlands in the XIVth and XVth centuries*. London: Arnold & Co.
- James, W. (1890). *The Principles of Psychology* (Vol. 2). New York.
- Jelinek, E. M. (1960). *The Disease Concept of Alcoholism*. New Haven: Hill House Press.
- Johnson, W. G., Schlundt, D. G., Barclay, D. R., Carr-Nangle, R. E., & et al. (1995). A naturalistic functional analysis of binge eating. *Behavior Therapy*, 26(1), 101-118.
- Kagel, J. H., Battalio, R. C., Rachlin, H., Green, L., Basmann, R. L., & Klemm, W. R. (1975). Experimental studies of consumer demand behavior using laboratory animals. *Economic Inquiry*, 13, 22-38.
- Kant, I. (1793/1960). *Religion Within the Limits of Reason Alone* (T. Green & H. Hucken, Trans.). New York: Harper and Row.
- Kirby, K. N. (1997). Bidding on the future: Evidence against normative discounting of delayed rewards. *Journal of Experimental Psychology: General*, 126(1), 54-70.
- Kirby, K. N., & Guastello, B. (2001). Making choices in anticipation of similar future choices can increase self-control. *Journal of Experimental Psychology: Applied*, 7(2), 154-164.
- Kirby, K. N., Petry, N. M., & Bickel, W. K. (1999). Heroin addicts have higher discount rates for delayed rewards than non-drug-using controls. *Journal of Experimental Psychology: General*, 128(1), 78-87.
- Kudadjie-Gyamfi, E., & Rachlin, H. (1996). Temporal patterning in choice among delayed outcomes. *Organizational Behavior and Human Decision Processes*, 65(1), 61-67.
- Laibson, D. (1997). Golden eggs and hyperbolic discounting. *Quarterly Journal of Economics*, 62, 443-479.
- Laibson, D. (2001). A cue-theory of consumption. *Quarterly Journal of Economics*, 66, 81-120.
- Lepper, M., & Greene, D. (1978). *The Hidden Costs of Rewards*. Hillsdale, NJ: Lawrence Erlbaum Associates.
- Loewenstein, G. (1999). A visceral account of addiction. In J. Elster & O. J. Skog (Eds.), *Getting Hooked: Rationality and Addiction*. Cambridge: Cambridge University Press.

- Logan, F. A. (1993). Animal learning and motivation and addictive drugs. *Psychol Rep*, 73(1), 291-306.
- Madden, G. J., Petry, N. M., Badger, G. J., & Bickel, W. K. (1997). Impulsive and self-control choices in opioid-dependent patients and non-drug-using control participants: drug and monetary rewards. *Experimental & Clinical Psychopharmacology*, 5(3), 256-262.
- Maisto, S. A., Lauerma, R., & Adesso, V. J. (1977). A comparison of two experimental studies of the role of cognitive factors in alcoholics' drinking. *J Stud Alcohol*, 38(1), 145-149.
- Marlatt, G., & Gordon, J. (1980). Determinants of relapse: Implications for the maintenance of behavior change. In P. O. Davidson & S. M. Davidson (Eds.), *Behavioral Medicine: Changing Health Lifestyles* (pp. 410-452). Elmsford: Pergamon.
- Marlatt, G. A., & Witkiewitz, K. (2002). Harm reduction approaches to alcohol use: health promotion, prevention, and treatment. *Addict Behav*, 27(6), 867-886.
- May, R. (1958). The origins and existential movement in psychology. In R. May, E. Angel & H. F. Ellenberger (Eds.), *Existence: A New Dimension in Psychiatry and Psychology* (pp. 3-36). New York: Basic Books.
- Mazur, J. (1987). An adjusting procedure for studying delayed reinforcement. In M. Commons, J. Mazur, J. Nevin & H. Rachlin (Eds.), *The Effect of Delay and of Intervening Events on Reinforcement Value* (Vol. 5, pp. 55-73). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Mazur, J. E. (1997). Choice, delay, probability, and conditioned reinforcement. *Animal Learning & Behavior*, 25(2), 131-147.
- Mazur, J. E. (2001). Hyperbolic value addition and general models of animal choice. *Psychological Review*, 108, 96-112.
- McClure, S. M., Ericson, K. M., Laibson, D. I., Loewenstein, G., & Cohen, J. D. (2007). Time discounting for primary rewards. *J Neurosci*, 27(21), 5796-5804.
- McClure, S. M., Laibson, D. I., Loewenstein, G., & Cohen, J. D. (2004). Separate neural systems value immediate and delayed monetary rewards. *Science*, 306(5695), 503-507.
- McConkey, K. (1984). Clinical hypnosis: Differential impact on volitional and nonvolitional disorders. *Canadian Psychology*, 25, 79-83.
- Meehl, P. E. (1970). Nuisance variables and the ex post facto design. In M. Radner & S. Winokur (Eds.), *Analysis of Theories and Methods of Physics and Psychology* (Vol. 4, pp. 373-402). Minneapolis: University of Minnesota Press.
- Miller, W. (2003). Comments on Ainslie and Monterosso. In R. Vuchinich & N. Heather (Eds.), *Choice Behavioral Economics and Addiction*. Oxford: Pergamon.
- Miller, W. R., & C'de Baca, J. (2001). *Quantum change: When epiphanies and sudden insights transform ordinary lives*. New York: Guilford Press.
- Mischel, H., & Mischel, W. (1983). The development of children's knowledge of self-control strategies. *Child Development*, 54, 603-619.
- Mischel, W., & Moore, B. (1980). The role of ideation in voluntary delay for symbolically-presented rewards. *Cognitive Therapy and Research*, 4, 211-221.
- Mitchell, S. (1999). Measures of impulsivity in cigarette smokers and non-smokers. *Psychopharmacology, Special issue on impulsivity*.

- Monterosso, J., Ainslie, G., Toppi-Mullen, P., & Gault, B. (2002). The fragility of cooperation: A false feedback study of a sequential iterated prisoner's dilemma. *Journal of Economic Psychology*, 23(4), 437-448.
- Monterosso, J., Ainslie, G., Xu, J., Cordova, X., Domier, C. P., & London, E. D. (2007). Frontoparietal cortical activity of methamphetamine-dependent and comparison subjects performing a delay discounting task. *Hum Brain Mapp*, 28(5), 383-393.
- Petry, N. (2000). A comprehensive guide to the application of contingency management procedures in general clinic settings. *Drug Alcohol Depend*, 58, 9-25.
- Premack, D. (1970). Mechanisms of self-control. In W. A. Hunt (Ed.), *Learning mechanisms in smoking* (pp. 107-123). Chicago: Aldine
- Rachlin, H. (1990). Why do people gamble and keep gambling despite heavy losses? *Psychological Science*, 1(15), 294-297.
- Read, D. (2001). Is Time-discounting Hyperbolic or Subadditive? *Journal of Risk and Uncertainty*, 23(1), 5-32.
- Read, D., & Roelofsma, P. H. M. P. (2003). Subadditive versus hyperbolic discounting : a comparison of choice and matching. *Organizational behavior and human decision processes*, 91(2), 140-153.
- Robins, L. (1993). Vietnam veterans' rapid recovery from heroin addiction: a fluke or normal experience? *Addiction*, 88, 1041-1054.
- Rodriguez, M. L., & Logue, A. W. (1988). Adjusting delay to reinforcement: comparing choice in pigeons and humans. *J Exp Psychol Anim Behav Process*, 14(1), 105-117.
- Ross, D., Sharp, C., Vuchinich, R. E., & Spurrett, D. (2008). *Midbrain Mutiny: The Picoeconomics and Neuroeconomics of Disordered Gambling: Economic Theory and Cognitive Science*. Cambridge: MIT Press.
- Rubinstein, A. (2003). "Economics and psychology"? The case of hyperbolic discounting. *International Economic Review*, 44, 1207-1216.
- Samuelson, P. (1947). *Foundations of Economic Analysis*: Harvard University Press.
- Schelling, T. C. (1960). *The Strategy of Conflict*. Cambridge: Harvard University Press.
- Shiffman, S., Hickcox, M., Paty, J. A., Gnys, M., Kassel, J. D., & Richards, T. J. (1997). The abstinence violation effect following smoking lapses and temptations. *Cognitive Therapy & Research*, 21(5), 497-523.
- Sjöberg, L., & Johnson, T. (1978). Trying to give up smoking: A study of volitional breakdowns. *Addictive Behaviors*, 3(3-4), 149-164.
- Skog, O.-J. (1999). Rationality, irrationality, and addiction. In J. Elster & O.-J. Skog (Eds.), *Getting Hooked: Rationality and Addiction*. Cambridge: Cambridge U.
- Sobell, L. C., Cunningham, J. A., & Sobell, M. B. (1996). Recovery from alcohol problems with and without treatment: prevalence in two population surveys. *Am J Public Health*, 86(7), 966-972.
- Spanier, C. A., Shiffman, S., Maurer, A., Reynolds, W., & Quick, D. (1996). Rebound following failure to quit smoking: The effects of attributions and self-efficacy. *Experimental & Clinical Psychopharmacology*, 4(2), 191-197.
- Sully, J. (1884). *Outlines of Psychology*. New York: Appleton.
- Trope, Y., & Liberman, N. (2000). Temporal construal and time-dependent changes in preference. *J Pers Soc Psychol*, 79(6), 876-889.

- Trope, Y., & Liberman, N. (2003). Temporal construal. *Psychol Rev*, 110(3), 403-421.
- Tversky, A., & Kahneman, D. (1974). Judgment under Uncertainty: Heuristics and Biases
Science, 185, 1124-1131.
- van der Pol, M., & Cairns, J. (2001). Estimating time preferences for health using discrete choice experiments. *Social Science & Medicine*, 52(9), 1459-1470.
- Vuchinich, R. E., & Simpson, C. A. (1998). Hyperbolic temporal discounting in social drinkers and problem drinkers. *Experimental & Clinical Psychopharmacology*, 6(3), 292-305.
- Wagenaar, W. (1988). Paradoxes of gambling behaviour. In S. England (Ed.), *Essays in cognitive psychology* (Vol. 7, pp. 126-152). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Wallace, C. (1979). The effects of delayed rewards, social pressure, and frustration on the response of opiate addicts. *NIDA Monograph Series*, 25, 6-25.
- Ward, T., Hudson, S. M., & Marshall, W. L. (1994). The abstinence violation effect in child molesters. *Behaviour Research & Therapy*, 32(4), 431-437.
- Weber, M. (1904/1958). *The Protestant Ethic and the Spirit of Capitalism*. New York: Charles Scribners Sons.
- Weiss, R., Griffin, M., Mazurick, C., Berkman, B., Gastfriend, D., Frank, A., et al. (2003). The Relationship Between Cocaine Craving, Psychosocial Treatment, and Subsequent Cocaine Use. *American Journal of Psychiatry*, 160(7), 1320-1325.
- Wolf, S. (1982). Moral saints. *The Journal of Philosophy*, 79, 419-439.

