Chapter 2

Hyperbolic Discounting as a Factor in Addiction: A Critical Analysis

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Rational choice theory (RCT) is the conventional decision-making model in not only economics and behavioral psychology, but fields ranging from philosophy to law (see Korobkin & Ulen 2000). RCT holds that utility is the selective factor for all choice — all behavior that is not reflexive — and thus that all choice must maximize expected utility. Psychology also looks at the process by which utility is realized, which it refers to as reinforcement or reward. We will talk of RCT as the theory that all choice maximizes expected reward.

There is now an enormous catalog of behavior patterns that violate RCT (Kahneman et al. 1982; Loewenstein & Elster 1992; Thaler 1991). The greatest contradiction to this theory in terms of sheer amount of motivation involved is inconsistent preference, usually manifested as temporary preference for options that are inordinately costly or harmful in the long run. Such options range from the extreme intertemporal ambivalence seen in alcoholism and drug abuse to more ordinary phenomena such as overeating, credit card debt, overconsumption of passive entertainment, and other bad habits too widespread to be diagnosed as pathological (e.g. Offer 1998).

Hyperbolic Discounting Supplies a Mechanism for Temporary Preference

Parametric research has revealed a fundamental property of reward that has some obvious bearing on the phenomenon of temporary preference, and hence on the clinical problems of addiction in particular: It has long been known that the value of an expected reward diminishes with delay. The (relatively) new finding is that this temporal discounting does not occur at a fixed rate per unit of time, but rather in proportion to overall delay; the longer the delay that precedes a reward, the less the reward is further devalued with additional delay. Mathematically, this is represented by temporal discount functions with delay in the denominator (Baum & Rachlin 1969; Grace 1996; Mazur 1984; Myerson & Green 1995).
Mazur's formula is simplest:

\[ V = \frac{A}{1 + kD} \]  

where \( V \) is value, \( A \) is the undiscounted reward value, \( D \) is delay, and \( k \) is a constant describing the individual subject's degree of impatience. Functions in this class are referred to as hyperbolic, as contrasted with exponential functions, which model temporal discounting as occurring at a fixed rate over time.

The implications of hyperbolic discounting clearly bear on phenomenon of temporary preference. A subject who discounts expected rewards hyperbolically is apt to choose imminent but inferior alternatives that she would pass up if she chose at a distance. Choosing $80 to be received in one year over $100 to be received in 13 months would be absurd. But if the choice is between receiving the same $80 immediately versus $100 in one month, the immediate alternative may be attractive. This pattern of preference (which Loewenstein & Prelec [1992] refer to as "the common difference effect") has been demonstrated in humans (Bohm 1994; Kirby & Herrnstein 1995), rats (Deluty 1978), and pigeons (Ainslie & Herrnstein 1981; Mazur 2001). Systematic preference reversals of this type (Figure 1) would not occur for an exponential discounter; given a fixed rate of discounting per unit of time, the more compelling of a set of alternatives does not change based on temporal distance to the option set. Thus, hyperbolic discounting supplies a promising mechanism for temporary preference.

**Temporal Discount Rate Can be Used as an Individual Difference Measure**

Hyperbolic discounting provides a framework for understanding the cycles of resolution, indulgence and regret that are the sin qua non of addiction. However, fruitful application of the temporal discounting perspective to the field of addiction requires moving beyond the generalities of hyperbolic discounting. In particular, practical application requires an individual difference variable that will relate to variability in clinically relevant measures like vulnerability (who becomes addicted), severity (who has the better prognosis), treatment matching (who will benefit from a particular type of treatment), or perhaps efficacy of

![Figure 1: Hyperbolic discount curves from two rewards of different sizes available at different times (vertical dashed lines). The smaller-earlier reward is temporarily valued higher (preferred) for a period just before it's available, as shown by the portion of its curve that projects above that from the later-larger reward.](image)
treatments (which psychotherapy or pharmacotherapy is most effective). The natural place to turn for an individual difference measure is the steepness of individuals' discounting.\(^1\) If problematic drug use is the choice of an immediate but transient reward at the expense of delayed but more substantial reward, then individual differences in the steepness with which the future is discounted ought to relate to the problem of addiction.

**Methodologies for Assessing Rate of Discounting in Humans**

A variety of paradigms have been used to quantify steepness of temporal discounting in humans. The rewards used include, points (Forzano & Logue 1994), health outcomes (Chapman 1996, 2000; Chapman et al. 2001; van der Pol & Cairns 2001), hypothetical drug or alcohol (Bickel et al. 1999; Madden et al. 1997 1999; Petry 2001), hypothetical money with context (e.g. "you just won some amount at a casino") (Bohm 1994; Chapman 1996; Chesson & Viscusi 2000; Thaler 1981), hypothetical money without context (Ainslie & Haendel 1983; Fuchs 1982; Madden et al. 1997), actual money (Ainslie & Haendel 1983; Crean et al. 2000; Kirby & Herrnstein 1995; Richards et al. 1999; Wallace 1979),\(^2\) consumer goods (Kirby & Herrnstein 1995), food (Forzano & Logue 1994; Mischel & Grusec 1967; Mischel et al., 1969); and juice (Forzano & Logue 1992). Less frequently, choices among punishments have been used, including shocks (Cook & Barnes 1964; Hare 1966a; Mischel et al. 1969) and aversive noise (Navarick 1982). In terms of the procedures used, some studies have used choices among a fixed set of alternatives (Ainslie & Haendel 1983; Kirby et al. 1999; Kirby & Marakovic 1996; Monterosso et al. 2001; van der Pol & Cairns 2001), some have used a titration procedure with choice stimuli generated so as to narrow in on the subject’s level of discounting (Crean et al. 2000; Kirby & Herrnstein 1995; Madden et al. 1997; Richards et al. 1999), while others have required subjects to generate indifference amounts rather than to make choices (Cairns, 2000; Chapman 1996).

Since delay discounting is offered as an operational definition for impulsive choice (Ainslie 1975, 1992; Mowrer & Ullman 1945), it is useful to consider it in relation to more traditional self-report measures of impulsivity. Overall, correlations between temporal discount rate and impulsivity measured by self-report have been modest (Kirby et al. 1999; Madden et al. 1997; Mitchell 1999; Richards et al. 1999; Vuchinich & Simpson 1998). However, it should be noted that dozens of impulsivity scales and sub-scales have been created to measure impulsivity, and the intercorrelations among them are modest as well, suggesting different underlying conceptions of the construct (Corulla 1987; Parker et al. 1993).

**Application of Temporal Discount-Rate Assessment to Addiction**

The most expedient way to make empirical contact between temporal discount rates and the phenomenon of addiction is to compare the discount rates of addicted and non-addicted populations. In particular, it has been hypothesized that addicted populations may be more myopic (have higher \(k\) values) than non-addicted populations (Ainslie 1975; Bickel et al. 1999; Madden et al. 1997; Vuchinich & Tucker 1988). Across a range of addicted populations, the evidence has been consistent with this hypothesis. 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 the future more steeply than non-smokers (Bickel et al. 1999; Cairns & van der Pol 2000; Fuchs 1982); and opioid-dependent patients discounted money more steeply than controls (Bretteville-Jensen 1999; Madden et al. 1997, 1999). 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 days (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 (age, gender and education) controls (Kirby et al. 1999). Also of interest, Odum et al. (2000) found that heroin addicts who shared needles discounted money more steeply than heroin addicts who did not.3

Some Limitations on Drug vs. Non-drug Group Comparisons of Discount Rate

Steeper discounting among addicted populations does not necessarily imply that steep temporal discounting is a causal factor in addiction. First, addicted and non-addicted populations are self-selected, and so are liable to differ in myriad ways other than their drug use. Several studies have taken efforts to match drug and control samples on characteristics such as IQ, age, race, and income (Kirby et al. 1999; Madden et al. 1997). However, even the most conscientious attempts to match samples cannot eliminate the problem of self-selection. Firstly, matching samples on a dimension in which the respective populations differ systematically produces undermatching because of regression to the mean (Kahneman 1965). However, this is only a small problem, and can be compensated for. A more vexing problems is that of systematic unmatching (Meehl 1970). Causal inference requires controlling for nuisance variables — those which may affect both the hypothesized causal antecedent and the explanandum. If we hypothesize that temporal myopia is a causal factor in addiction, then we might want to control for, say, religion (though we know of no such study that did). Rates of drug dependence are lower among people who identify themselves as religious. Furthermore, as one would expect given differing proscriptions, differences in rates of dependence exist across religious affiliations (Anthony et al. 1994). It is entirely possible that religiosity might also be related to choices made on a delay discounting experiment. For instance, more religious people may overall demonstrate shallower (we suspect) temporal discounting. And so, if we wanted to gain support for our hypothesis that steep discounting is a causal factor in addiction, we might want to match our sample on identified religion. This way, if we did see a relationship between group membership (addict vs. control) and discount rate, we could rule out the possibility that it is merely a byproduct of religiosity’s relation to both drug use and delay discounting.

The problem, however, is that Kahneman’s (1965) point regarding undermatching aside, is that while religiosity may be a causal contributor to addiction, it is certainly not the only causal contributor to addiction. And those unconsidered variables (and there is no way to exhaust that list) will have been systematically unmatched as a result of the care taken to match religiosity.
...for any but the most trivial and "unpsychological" examples of input variable X [addiction], the naturalistic self-selection of the organism for treatments or levels of X [addiction] must itself be determined. Hence the result of holding constant an identified nuisance variable Z [religiosity] will, in general, be to systematically unmatch pair members with respect to some unidentified nuisance variable (Meehl 1970: 376-377, brackets added).

As an illustration, suppose low parental love is one of the countless other causal factors in addiction. What can we say, in terms of parental love, about a religious person who, despite religion's protective effects, becomes addicted? Or about a non-religious person who, despite the absence of this protective factor, does not have problems with addiction? On average, the former will be less loved than is typical, and the latter more loved. And so, by artificially matching our groups on religious affiliation, we have unmatched on parental love, and thus have a new variable to worry about as far as a potential basis for a spurious relationship between delay discounting and group membership.

Furthermore, there are demand characteristics to worry about (Orne 1962). From the standpoint of the drug dependent subject, she is very likely participating in a study in which she sees her drug problems as, to the experimenter, her primary identity. Such a subject, aware she is in the lab as an addict, may even conceive the experimenter's hypothesis with respect to the presentation of delay of gratification choices. Indeed, subjects in our experiments have indicated as much. And she may, in general, be inclined to give the experimenter what he wants.

Finally, even if discount rate could be shown to be causally linked to drug use, it is unclear from the cohort-comparisons reported in which direction the causal arrow points. It is possible, for example, that the effects of chronic drug use on the brain (Kosten 1998; London et al. 1990; Volkow et al. 1988, 1991) might affect performance on delay discounting tasks, as has been shown in other decision-making procedures (Grant et al. 2000; Rogers et al. 1999). Or, perhaps the life-style of the addict might dispose her to emphasize immediate attainment of reward. Of course, the possibility that drug use, or being a drug addict, may lead to steeper discounting does not preclude that the causal arrow points in the other direction as well, but it weakens the ability to infer such a connection from group differences.

All said, the existence of consistent steeper discounting among addicted populations supports but does not prove the hypothesis that individual differences in temporal discount rate, as measured by existing procedures, have anything to do with addictive behavior.

Hyperbolic Discounting Alone is Not Enough

There is considerable doubt whether the psychological processes underlying [intertemporal choice] actually draw on a personal discount function... Decision makers appear to have as many discount rates as choice situations into which they can be placed. Moreover, different measures of discount rates are either uncorrelated, or are correlated weakly or idiosyncratically (Roelofsma & Read 2000: 171–172).
While hyperbolic discounting has consistently provided a better account of intertemporal choice than has exponential discounting, the story has been far from simple. Over the past fifteen years, researchers have demonstrated patterns of choice that seem anomalous even from the framework of hyperbolic discounting (for reviews, see Loewenstein & Prelec 1992; Loewenstein & Thaler 1989; Roelofsma 1996). Some of these patterns are of particular interest to behavioral economic researchers in the field of addiction. We will address the following problems with the hyperbolic discounting hypothesis, and suggest how they might be solved within the hyperbolic discounting framework:

1. Discount slopes in humans are variable and unstable;
   a. Steepness of discounting varies enormously across qualitatively different rewards;
   b. Steepness of discounting is not even well correlated across modalities of reward within an individual;
   c. Discounting measures have only modest reliability.

2. Humans' discounting is shallower for larger rewards;

3. Addictive behaviors often do not depend on the proximity of temptation;

4. People may come to feel imprisoned by their self-control, while a hyperbolic shape seems to predict that avoiding temporary preferences will always increase long-range reward;

5. Some discount rates in humans appear to be negative — that is, delayed rewards may be valued more than immediate ones;

6. The most prudent rewards often lose their rewarding power, even after periods of non-occurrence when appetite should be fresh.

Discount Slopes in Humans Are Variable and Unstable

**Steepness of Discounting Varies Enormously across Qualitatively Different Rewards**

Some rewards are regularly discounted more steeply than other rewards. Indeed, Navarick suggested the possibility that different rewards might be ranked “according to their potential for producing effects of delay of reinforcement” (Navarick 1986: 354). In general, when points or money are used, discounting is relatively modest. In fact, with points or money, researchers have sometimes failed to show any discounting on the time-scale of minutes — the duration of a typical experiment (Logue et al. 1986, 1990). Plotting the discount function with money (at least large quantities of money) requires a more extended time scale, and thus favors a procedure where subjects do not respond to contingencies experienced during an experiment, but only to questions they are presented with (e.g. Would you rather $500 tomorrow, or $1,000 in 1 year?). In an experiment in which subjects expressed preferences for hypothetical amounts of money to be received in the future, adults discounted $10,000 by only about half over 10 years (Green et al. 1997).

In contrast, studies using other rewards have found steep discounting. Navarick (1982) found subjects on average preferred five seconds of silence followed by 75 seconds of aversive noise over 75 seconds of aversive noise followed by 20 seconds of silence (Navarick 2001). Similarly, with a positive reward — access to slides of famous people — subjects...
chose ten seconds of reward followed by 70 seconds of time-out over 40 seconds of time-out followed by 40 seconds of reward slightly more than half the time (Navarick 1986). With juice as reward, Forzano & Logue (1992) found subjects to be, on average, indifferent between an immediate three seconds access to juice and six seconds access delayed by 39 seconds. In each of these cases, the value of a reinforcer was diminished by half or more in an amount of time on the order of a minute. This represents a difference of six to seven orders of magnitude when compared to discounting of large hypothetical monetary quantities.

While the above discrepancies are based on comparisons across studies, variability in steepness of discounting across qualitatively different rewards has also been demonstrated within the same study. Of special interest to the field of addiction, recent studies have reported that heroin-dependent subjects discounted hypothetical heroin more steeply than hypothetical money (the median $k$ parameter was 19 times as high in one study and 15 times as high in the second, better controlled study) (Madden et al. 1997, 1999). Comparison between smokers discounting for cigarettes vs. money yielded a qualitatively similar result, though the magnitude of the difference was much smaller; discounting for cigarettes, again in terms of median $k$, was approximately 17% higher than for money (Bickel et al. 1999).

Results of a fourth study suggest that active alcoholics, abstinent alcoholics, and controls all discounted alcohol more steeply than money (Petry 2001). However, this study did not control for magnitude of the qualitatively different rewards, and so is difficult to interpret (see next section). It is worth noting that money, the most common reward in discounting experiments – may be ill suited for them since the consummatory period is unspecified. An immediate windfall, particularly for a well-to-do subject, may not change near, or even distant, future consumption.

Steepness of Discounting Is Not Well Correlated across Modalities of Reward Even within an Individual

All the studies of which we are aware that sought to relate steepness of discounting to drug use have used monetary rewards, or else monetary rewards and a second reward (hypothetical drug). Implicit in this design is the expectation that discounting is not modality specific — that a steep discounter of monetary rewards will be a steep discounter also when different rewards (such as those most relevant to their addiction) are at stake. However, research assessing the generality of individual discount rates across modalities has been rather discouraging. In a careful comparison of outcomes related to health outcomes and outcomes related to monetary outcomes, Chapman (1996) found little relation between subjects’ discounting in one domain and the other ($r = 0.11$). Furthermore, a principal component factor analysis of the monetary and health items she used suggested a clear two-factor solution which neatly separated monetary and health dimensions. A more recent study again found only a modest relationship between discount rates in the modalities of money and health ($r = 0.24$) (Chapman et al. 2001). Furthermore, discount rates in this study were virtually unrelated to subsequent real-life choices hypothesized to relate to delay discounting — getting a flu vaccination and contributing to a retirement fund. More encouragingly, the data reported in Madden et al. (1999) allow the correlation to be computed between discounting of hypothetical heroin and hypothetical money. By our calculation,
after logarithmic transformation, the correlation is 0.69. Nevertheless, there appears to be, at least in some instances, considerable modality specificity to temporal discount rates.

**Discounting Measures Have Only Modest Reliability**

The value of any individual difference measure is subject first to the limits of its reliability. Are measures of individual temporal discounting reliable? Is a steep discounter on Monday a steep discounter on Friday? Given that methods for assessing individual discounting vary widely, there is no single answer to the question. One study that presented cocaine-dependent subjects with a fixed set of questions about hypothetical money reported split-half reliability (that is, within session) of 0.79 (Monterosso et al. 2001). Also using hypothetical money, another study found the test-retest reliability (after one week) to be an encouraging 0.84 (Simpson & Vuchinich 2000). Less encouragingly, using vignettes in the domains of health and money, test-retest reliability after a one year interval was only 0.26 in the domain of health and 0.39 in the domain of money (Chapman et al. 2001). The higher rate of test-retest reliability in the domain of money as opposed to health is consistent with other studies reported by Chapman and colleagues (Chapman 1996; Chapman & Elstein 1995). Unpublished data reported by Chapman and colleagues suggest that the low rates of reliability they found were likely to be due to the long test-related interval rather than the type of measurement procedure used; with similar health and financial vignettes but only a two-week interval, test-retest reliability was a more respectable 0.73.

**Suggestion: Human Subjects’ Responses Have Been Modified by Impulse Controls**

Apparent discounting in human subjects is much more variable than in non-human animals. In human experiments in which the standard delay discounting procedure is used, subjects at the 10th percentile in discount rate may differ from those at the 90th percentile by a factor variously found to be 200 (Monterosso et al. 2001), 250 (Richards et al. 1999) and 600 (Madden et al. 1999). In animal experiments this factor has been just seven for both pigeons (Mazur 2000) and rats (Ainslie & Monterosso 2003). Much of this difference is probably attributable to differences in the modalities of reward commonly used in humans and animals. Most human studies have used amounts of money over long time delays, arguably apt to be judged by some subjects as calling for prudence. The rewards in the animal studies were food. When Forzano & Logue (1992) studied students’ preferences for juice, the 90th percentile was only 13 times the tenth. This suggests that when rewards call for a gut reaction, discounting is relatively similar among subjects; when rewards lend themselves to higher order process like planning and calculation, differences in subjects’ backgrounds come much more into play.

Dependence on such higher order processes may also account for the variability of discounting within subjects. We know of no comparisons between modalities of reward in individual animals, but we have measured the test-retest reliability of discount rate in rats to be 0.81 over ten weeks, a very long time for these animals (Ainslie & Monterosso 2003).
Humans’ Discounting Is Shallower for Larger Rewards

Within the same class of rewards, human subjects discount less steeply when the rewards are larger or more valued. Given the choice of $5 today or $10 in one year, many people would be inclined to take the immediate $5. If, however, a sufficient number of 0s are added to each of those amounts, the number of people willing to wait for the “later-larger” money rises dramatically. Far fewer people would choose $50,000 today over $100,000 in one year. Thus, the devaluation that occurs appears to be inversely related to the magnitude of the reward. This intuition has been confirmed in lab experiments with monetary outcomes (Benzion et al. 1989; Green et al. 1997; Thaler 1981), as well as for outcomes in the domain of health (Chapman 1996; Chapman & Elstein 1995). By the same token, in experiments using primary rewards (food and juice), both children (Mischel & Ebbesen 1970) and adults (Forzano & Logue 1992) made more self-controlled choices when the reward was especially valued.

Thus, human subjects discount less when more is at stake. Significantly, shallower discounting with larger amounts occurs only in humans. In animal experiments the reverse has been found. Wogar et al. (1993) found that the amount of additional time hungry rats were willing to wait in order to double their pay-off of food was greater when the choice was between one and two pellets than it was when the choice was between three and six pellets. This contrast suggests that the shallower discounting seen with large amounts in humans does not reflect a basic property of the discounting process. People’s greater patience when larger rewards are at stake must have a more complex cause; as with the great variability in human discount rates the elicitation of self-control is a leading possibility.

Hyperbolic Discounting Motivates Self-Control

There have been many opinions about how people achieve self-control. The simplest would be that people learn to modify the steepness of their discount curves directly. Certainly reductions in apparent impatience are observed, but the hypothesis that the basic discount curve changes faces one probably fatal difficulty: If organisms can directly change the steepness of their discount functions, they will always be motivated to discount the future as little as possible, since the current effectiveness of a given delayed reward is greatest when there is least discounting. Given a choice, they should always choose to make delayed rewards be worth as much as possible. To learn to discount the future less, that is, to value the future more, would be to learn to coin reward.

The literature of cognitive psychology often implies that people can learn to ignore reward, or at least to distance themselves from its effect, and make decisions according to reason instead. However, this approach treats reason as a force separate from motivation, an imponderable factor that makes a systematic analysis of choice virtually impossible (see critique in Ainslie 1996). Hyperbolic curves suggest a less mysterious possibility: foresight provides leverage that the attenuated motives at a distance from expected outcomes, “the still voice of reason,” can manipulate to constrain future passions. These curves predict several self-control mechanisms.
Since a person's preference among a fixed set of alternatives can vary predictably as a function of the passage of time, it follows that one of the obstacles she may face in trying to attain her current preferences is the expected preferences of her future selves. The dieter who has just finished bingeing has both a current clear preference for moderate consumption in the future, and an equally clear expectation that her own future self may pose a threat to this current preference. She may thus be expected to behave strategically towards the competitive interests of her future self — that is, to try to commit to her current interests. Ainslie (1975, 1992, 2001) has identified four several distinct commitment tactics, three that must be chosen in advance and one that can be invoked concurrently with temptation. To the extent that a subject in an experiment has learned such mechanisms, they might influence her valuation of delayed outcomes. Thus, variability of individual discount rates might relate less to differences in basic discounting than to differences in self-control style or sophistication. Furthermore, the different ways that a subject applies such tactics across modalities of reward could well cause differences in her apparent discounting of these modalities.

**Extrapsychic devices** The most direct method of commitment is to arrange for some external control or influence. A current preference for eating in moderation can be secured by undergoing gastric bypass surgery or, less permanently, by checking into a “fat farm.” Buying only healthy food at the supermarket does not guarantee that you will not go on a late-night junk food binge, but it adds the disincentive of having to go to a store when the urge strikes. David Laibson (1997) has suggested that a need for this kind of commitment accounts for people’s otherwise unaccountable preference for relatively illiquid investments. Extrapsychic commitment has been demonstrated even in pigeons (Ainslie 1974; Green & Rachlin 1996), though only in a situation where the commitment method was highly salient; presumably people are far more creative at finding external factors that may have a committing effect. For instance, proclaiming to your friends that you will never eat meat again does not eliminate it as an option, but it adds a new cost — that of losing face. Reputation may be a major vehicle of commitment (Becker 1960).

**Control of attention** Another method to guard against future changes of preference is by the control of attention. Someone struggling to maintain fidelity to a spouse may not allow herself to notice the flirtations of an attractive third party. Attending to such information may foreseeably lead to the likelihood of creating preferences in opposition to current preferences. Attention control can occur as either deliberate avoidance of information or an avoidance that is not itself acknowledged. The latter case is the repression that Freud at one time held to be the cornerstone of all defensive processes (Freud 1814/1956: 16). The repressing individual avoids unwanted thoughts, feelings or behaviors by not attending to the psychically loaded information. Aside from the distortions that Freud noted, its disadvantage is a loss of information that may be needed for other decisions.

**Control of emotions** Emotions such as fear, anger and sexual arousal can, up to a point, be vicious circles. After the emotion has gotten underway, there is a lower threshold for further emotional activity of the same kind, until some satiation point is reached. If a person expects an emotion to make currently unpreferred reward dominant, she may commit herself not to
choose the reward through early inhibition of that emotion. There have been some experimental demonstrations of this tactic. For instance, Walter Mischel and colleagues found that, while children below around six were poor at self-control, many older children were 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 & Moore 1980; Mischel & Mischel 1983). However, emotion-forestalling devices tend to distort rather than normalize motivation, and may make people emotionally unresponsive, as in alexithymia (Nemiah 1977). At the moment, there seems to be no way to analyze them using animal models.

Prior Commitment Is Not Enough

Tactics that commit choice in advance are admittedly not conspicuous in subjects’ evaluations of experimental rewards. They are sometimes evident in addicts’ efforts to avoid temptation, so we have summarized them briefly. However, although these commitment devices are recognizable, they are also marginal. We mostly do not need to bind ourselves by some physical device, or contract, or even reputation, to keep our intentions steady. 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 sight. People who have given up smoking, for instance, often say that they “just did it” one day. 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, a resentment of meddlesome advice givers — than to the imminent availability of a cigarette. Rationalization, not proximity, is the most notorious threat to willpower.

Western culture has long been familiar with commitment that does not entail keeping a distance from temptation. Writers since antiquity have related self-control 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 incontinence (akrasia) was the result of choosing according to “particulars” instead of “universals” (Aristotle 1984: *Nichomachean Ethics* Chapter 1147a pp. 24–28); 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 1884: 663). This strategy lets people resist temptation “with both alternatives steadily held in view” (James 1890: 534). In recent years behavioral psychologists have followed this approach to decrease pigeons’ preference for smaller-earlier rewards — Heyman & Tanz (1995) by giving them extra reward for choosing according to “overall” rather than “local” maxima, Siegel & Rachlin (1996) by making choice depend on only every 31st peck, thus arguably creating a “molar” rather than “molecular” choice pattern.

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). But just such an effect is predicted by hyperbolic
discount curves. Although hyperbolae spike up sharply in the period just before a reward is due and are thus exquisitely sensitive to short delays, their tails become not only more level, but also higher than the tails of exponential curves at long delays. The relatively high tails of hyperbolic curves imply 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). Exponential curves keep declining relentlessly at a constant proportion of their remaining height for every unit of time that passes. Hyperbolic curves level off more. The greater height of their tails means that curves from series of alternative rewards, if bundled together, will favor the larger-later rewards increasingly as the series lengthens (Figure 2a). Exponential curves do not predict increased tolerance for delay with summation of series of choices (Figure 2b).

Experiments with both human and rodent subjects confirm a greater tolerance for delay with bundled rewards. Kirby & Guastello (2001) gave college students choices between

![Figure 2](image_url)

**Figure 2:** (a) 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 (more to the right) rewards in the series. As the series gets longer and the summed curves peak higher above the current rewards, the initial period of temporary preference for the series of smaller rewards shrinks to zero. (Compare the top of the first short vertical dashed line with that of the last vertical dashed lines). The curves from the final (right-hand) pair of rewards are the same as in Figure 1. (b) Summed exponential curves from the same series of paired alternative rewards (vertical dashed lines). Summing increases their heights as the series get longer (more to the left), but does not change their relative heights. (This would also be true if the curves were so steep that the smaller, earlier rewards were preferred; but in that case summing would add little to their total height, anyway, because the tails of exponential curves are so low.)
smaller and earlier rewards and larger but more delayed 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 later larger alternative was increased in the condition in which a series of choices was bundled together (Kirby & Guastello 2001). We recently demonstrated the same phenomenon in rats. 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, tolerance for delay was greater for all subjects in the bundled condition (Ainslie & Monterosso 2003).

But a piece of the puzzle is still missing: if a person is a population of reward-seeking processes, what could make this throng choose according to principle? We suggest that it is the same thing that determines trust among nations, or among business people in areas not regulated by law: hard experience of the relevant bargaining contingencies. If a person has no awareness of a relationship among her decisions, then the life of any long-range plan will be short. Before it reaches its goal an incompatible plan will become more attractive at some point. A child who wants friends may have too many urges to be selfish. Someone who wants to lose weight may encounter too many tempting foods. An imminent payoff for an individual act of selfishness or particular snack is apt to be worth the little damage it does to friendships or the minor weight gain. It would probably not be worth losing all expectation of friendship or slimness, but such huge outcomes are rarely at stake in individual choices. As long as she attends only to the contingencies of each individual decision, a person stays riddled with impulses. There is no incentive to plan, because plans are usually rendered idle by the experience of reversing preferences.

However, an astute person — or someone who borrows the astuteness of her culture — is aware that her preferences are volatile. The best way she has to predict what she will do in the face of a future temptation is to see what she does with a similar temptation in the present. The act of selfishness predicts further selfishness and the eventual loss of friendship with all but the most long-suffering people. The snack predicts future snacks and inevitable weight gain. However, insofar as she is responsive to this rough insight about self-prediction, she will move toward choosing according to principle. Her current choices will become test cases, choices about selfishness and eating which this elementary insight will bundle together in her expectations to form series. When she chooses to be selfish, she chooses an expectation of future selfishness as well, and when she overeats the act bodes more overeating. She looks principled, but what literally happens is that her successive selves form a repeated prisoner's dilemma relationship, which they come to solve in the same way as tacit interpersonal bargainers do; each expects future selves 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.4

Our hypothesis is that the will is an intertemporal bargaining situation, dependent for its force on a person's recursive evaluations of the prospects for her own behavior. Such an internally fed back process is probably impossible to study with controlled experiments.
However, given its formal similarity to the repeated prisoner's dilemma, we have tried to use an interpersonal prisoner's dilemma as a model (Monterosso et al. 2002). Subjects played long strings of sequential prisoners dilemmas. When stable cooperation or stable defection spontaneously occurred, false feedback was given to subjects indicating to them that their counterpart had broken the trend. A large asymmetry was observed, with false defection doing far more damage to mutual cooperation than false cooperation repaired mutual defection. While original levels of mutual defection were restored after a single "recovery" move, cooperation rates were incompletely restored after even eight rounds of recovery moves following a single defection. While this may not confirm the usefulness of the interpersonal analog to intrapsychic bargaining, it is certainly consistent with the lore on self-control (e.g. "every gain on the wrong side undoes the effect of many conquests on the right; Bain 1886: 440).

It is also instructive that an intertemporal bargaining model fits descriptions of will over the centuries better than other published theories of will, and solves thought experiments that have otherwise seemed paradoxical in the philosophy of mind (see Ainslie 2001: 117–140 for discussion of Kavka's problem and Newcomb's problem, as well as the venerable argument over freedom of will). Thought experiments may prove to be a particularly useful way of isolating the active ingredient of subtle incentives like the value of precedents. Consider a smoker who is trying to quit, but who craves a cigarette. Suppose that the choice at hand — to smoke the cigarette or not — is explicitly disconnected from future similar choices by specifying what those choices were destined to be. For example, suppose a trustworthy angel tells her that she is destined to smoke a pack a day from tomorrow on. Given this certainty, she would have no incentive to turn down the desired cigarette — it would seem pointless. What if the destiny revealed was instead that she was never to smoke again after today? Here, too, there seems to be little incentive to turn down the 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 its importance cannot come from any physical consequences for future choices; hence the conclusion that it matters as a precedent. Indeed when Kirby & Guastello (2001) 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.

Thus, subjects in amount-versus-delay experiments who seems to have markedly shallower discount curves for a particular reward, as compared with other kinds of reward or other subjects, may actually have been evaluating this reward as a member of a broader category. Such evaluation will have made her choice predict, and thus depend on, future rewards that may overshadow the reward literally at stake. She will then seem more patient with this reward than with other kinds, and more patient than younger or otherwise less skilled subjects for whom the reward at hand dominates the choice.

Addictive Choices Do Not Depend on the Proximity of Temptation

As hyperbolic mechanisms for addictive choices get proposed, they are often criticized for seeming to force the choice into a Ulysses-and-\textquoteright 12-Sirens mold. Clinicians are well aware
that the precipitant for a relapse is not always, or even usually, a sudden coming into close proximity with a tempting opportunity. Rather lapses are apt to follow a significant event, good or bad, in the person's day, and be explained by the person herself with a more-or-less plausible rationalization.

But although this pattern would not be seen in a naive subject trying to control temptation by prior commitment, it is exactly what we would expect in someone struggling to use the willpower mechanism we have just described. 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 be able to keep temptations close at hand without succumbing to them. However, although she may always prefer a series of larger later rewards to the series of small early ones, she would most rather have a small reward now and expect the larger ones later. The danger is no longer one of the poorer reward coming so close that she will suddenly choose it, but of her finding a credible distinction between this choice and the other members of the series that form the stake of her private side bet. Proximity is still a contributor to her temptation, of course, but the deciding factor is no longer whether a prior commitment is too weak but whether a tentative loophole currently looks to her like she could get away with it. The person will not experience this situation as the exotic 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 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 Sjoberg & Johnson (1978) found in their study of smoking lapses.

Among other things, intertemporal bargaining allows people to establish personal rules for valuation of money and other important goods. A person who works in finance will surely be forced to rule that she will calculate value according to exponential curves, for instance, or she will lose out to competitors who do. However, the shallower she makes this artificial curve, the more she risks that at some point her expected reward from obeying this curve will not be enough to overcome spikes of temptation, which are still governed by her underlying hyperbola. Ruling that she should not discount future goods at all would be still harder, and thus riskier.

It seems to be possible to shield rules against imminent temptation by defining them so that investment decisions are not weighed against your strongest temptations. As Shefrin & Thaler (1988) have pointed out, people assign their wealth to different "mental accounts" such as current income, current assets, and future income. These accounts seem to represent personal rules for how readily the money they govern may be used to satisfy immediate wants. In effect, the person draws boundaries where she thinks they will never demand so great an act of abstention that she will prefer to abandon them by spending money from the asset account ("breaking into capital"), or borrowing against future income. We believe that people are apt to have a fourth account to the left of Shefrin and Thaler's three: a category for comparatively small windfalls like gifts or prizes, or money earned under exceptional circumstances like the pay as experimental subjects. Money in this category is beyond the protection of rules, as Thaler (1990) reports noticing personally when it was suggested to him that he spend $300 in football winnings evenly over his expected lifetime. Only in this account are the
person's valuations of single choices apt to be governed by the hyperbolic formula for single cases.

People May Come to Feel Imprisoned by Their Self-Control, While a Hyperbolic Shape Seems to Predict that Avoiding Temporary Preferences Will Always Increase Long-Range Reward

Intertemporal bargaining is still not a complete solution. Until Victorian times philosophers regarded willpower as an unmixed blessing. It was Kierkegaard who first pointed out that it could become a prison (May 1958). His heirs, the existentialists, continue to identify an "idealistic orientation" which, although it inhibits the pursuit of transient pleasure, makes a person "inauthentic" (Kobasa & Maddi 1983). The most obvious side-effect of an iron will is compulsiveness, arguably also a plague that grows proportionally as a society gets more sophisticated at self-control. Most psychotherapy deals with problems concerning overcontrol, described for instance by psychoanalysts as a punitive superego, by cognitive therapists as overgeneralization and magnification, and by gestalt therapists as dependence on cognitive maps (many summarized in Corsini 1984), rather than the simple inability to give up an impulse.

The intertemporal bargaining hypothesis predicts just such a potential for personal rules to grow pathologically. Reliance on this bargaining causes a decision to be worth as much or more as a precedent than it is in its own right. This does not necessarily imply that it is the wrong decision. On the contrary, you would think from the logic of summing discount curves that judging choices in whole categories rather than by themselves would have to improve your overall rate of reward (Figure 2a). Cooperation in a repetitive prisoner's dilemma would have to serve the players' long range interests, or else they would abandon it. How, then, can this cooperation ever become a prison?

The likeliest answer is that in everyday life a person can discern many possible principles in a given situation; and the way of grouping choices that finally inspires intertemporal cooperation need not be the most productive, because of the selective effect of distinctness: personal rules operate most effectively on distinct, countable goals. Thus, to a person who is afraid of her spontaneous wishes, a rule to maximize foreseeable wealth or to never spend money unnecessarily will be more reassuring than the assortment of softer rules and social incentives by which people usually arrange to control their spending. Likewise, a person who is chronically afraid that she will get too angry, will make or adopt narrow rules for conduct rather than relying on vague rules like putting herself in the other person's shoes. In such cases the person often knows that she is impairing her long range effectiveness, but cannot give up the guarantee that explicit rules supply.

So cooperation among successive motivational states does not necessarily bring the most reward in the long run. The mechanics of policing this cooperation may produce the intrapsychic equivalent of regimentation, which will increase your efficiency at reward-getting in the categories you have defined, but reduce your sensitivity to less well-marked kinds of reward. Even short of frank compulsiveness, the systemization that lets rules recruit motivation most effectively may undermine our longest range interests.
The attempt to optimize our prospects with personal rules confronts us with the paradox of definition — that to define a concept is to alter it, in this case toward something more formalized. If you conclude that you should maximize money, you become a miser; if you rule that you should minimize your vulnerability to emotional influence, you will develop the numbing insensitivity that clinicians have named alexithymia (Nemiah 1977); if you conclude that you should minimize risk, you become obsessively careful; and so forth. The logic of rules may come to so overshadow your responsiveness to current experience that your behavior becomes formal and inefficient. A miser's strict rules for thrift make her too rigid to optimize her chances in a competitive market, and even a daring financier undermines the productiveness of her capital if she rules that she must maximize each year's profit (Malekzadeh & Nahavandi 1987). Similarly, strict autonomy means shielding yourself against exploitation by others' ability to invoke your passions; but alexithymics cannot use the richest strategy available for maximizing emotional reward, the cultivation of human relationships (Ainslie 1995). Likewise, avoidance of danger at any cost is poor risk management.

In this way people who depend on willpower for impulse control are in danger of being coerced by logic that does not serve what they themselves regard as their best interests. Concrete rules dominate subtle intuitions; and even though you have a sense that you will regret having sold out to them, you face the immediate danger of succumbing to short-range urges like addictions if you do not. If you have not learned ways of categorizing long-range rewards that permit them to dominate systematic series of mid-range rewards, your mid-range interests will make you compulsive.

The proneness of intertemporal bargainers to fall into compulsions may explain some hitherto perplexing characteristics of addictive behavior. The robustness of suboptimal rules may sometimes let addictions serve long range interests. Better to be fat, you might think, than anorectic. Your will may become so confining that a pattern of regular lapses actually makes you better off in the long run. The lore of addictionology often attributes binging to a patient's inhibitedness in the rest of her life; her general overcontrol is said to set up periodic episodes of breaking loose. The model of intertemporal bargaining predicted by hyperbolic discount curves provides a specific rationale for this pattern: Rules that eliminate any large source of emotional reward will create a proportional motive for you to bypass or break those rules. If those rules have, in William James' phrase, "grown too narrow for the actual case" (James 1990/1896), even your long range interest will lie in partially escaping from them. Thus, personal rules that serve compulsion range interests can create alliances between long and short range interests. The person's occasional binge comes to serve as a corrective to the comparative sterility of such rules, a means of providing richer experiences than these rules allow while its transient nature still limits the damage it does. The longest range interest of an alcoholic who is too rigid when sober may be to tacitly foster the cycle of drunkenness and sobriety, rather than be continuously imprisoned by her rules.

Alcoholics are sometimes described who become nicer, or more genuinely creative, or more fully human when drunk. Furthermore, some addicts plan binges in advance. Such people may believe that their binges are undesirable — indeed, "rationality" will almost certainly dictate such a belief — but the therapists they hire find them mysteriously unresponsive to treatment. The patient who arranges for drinking several days in
advance — who goes off the disulfiram that commits her to sickness if she drinks, for instance, or who brings bottles to her rehabilitation program for later use — cannot simply be yielding to a short range impulse. This is behavioral evidence that she experiences a rational plan like giving up drinking as a compulsion which, even at a distance, appears to need hedging, although she may be unable to report any such thing.

This phenomenon suggests why a simplistic policy of “the more willpower, the better” contradicts the experience of many addicts. To them, more willpower means less of the human qualities they value most in themselves. They are able to listen to reason only when reason, represented by personal rules, stops starving their own longest range prospects for emotional reward.

Some Discount Rates in Humans Appear to Be Negative — That is, Delayed Rewards May Be Valued More than Immediate Ones

A finding that might seem to strike at the heart of an internal marketplace model of choice is a preference for more delayed goods and less delayed punishments. It is not difficult to find human self-reports of preferences that seem to reflect such negative discounting in people. Subjects say that they would rather have $1,000,000 tomorrow, rather than immediately (Rachlin et al. 2000), and most individuals would prefer that a kiss with the movie star they find most attractive be delayed rather than immediate (Loewenstein 1987). Elster and Loewenstein call such reverse discounting “savoring”: the process of “deriving positive utility from anticipation of desirable events” (Elster & Loewenstein 1992: 224). A related observation is that, when deciding on a sequence of rewards of various magnitudes, subjects generally prefer ascending order rather than the descending order predicted by a positive temporal discounting. One study had subjects imagine that they had won a prize of three free meals at three different restaurants: one mediocre, one quite good, and one world-class. The dinners were to be scheduled to occur on the first of the month over each of the next three months, with the only choice being their order. The modal response is to choose the sequence of ascending value (Loewenstein & Prelec 1993). Except in cases where there is a strong expectation that outcomes will generally descend (such as health across one’s lifetime; Chapman 2000), people typically prefer to save the best for last.

As the Victorian economist Jevons said, “There is little doubt that, in minds of much intelligence and foresight, the greatest force of feeling and motive is what arises from the anticipation of the future” (Jevons 1871: 40, quoted by Elster & Loewenstein 1992: 223). The reason for savoring is clearly to increase pleasure. Utility theory has had little to say about the relationships of external events to the experience of pleasure, but there is at least some popular recognition that managing pleasure can be a matter of managing appetite. Our culture warns us not to eat dessert first or read ahead in a novel; indeed it often recommends “working up” an appetite. It has not told us why such practices should make a difference. However, the phenomenon of hyperbolic discounting suggests a hypothesis not only about savoring but about appetite generally. This is the a broader problem of premature satiation, discussion of which will suggest a rationale for savoring.
The Most Constant Rewards Often Lose their Rewarding Power, Even After Periods of Non-Occurrence when Appetite should Be Fresh

Rationality turns out to be less a matter of comparing the sizes of goods than of avoiding seductive derailments. The will, looked at as an intertemporal bargaining strategy, has costs of its own that detract from its value in achieving rationality. It is also limited in scope; purely mental processes options like paying attention and recalling memories, for instance, are probably chosen too quickly to be evaluated as precedents, and thus cannot be well controlled by will. This is a particularly serious limitation in a wealthy society, where physical needs are satisfied readily and most effort goes into pursuing various kinds of emotional satisfaction. The problem that hyperbolic discounting creates here is premature satiation; the solutions people find are apt to be even more costly, and seemingly irrational, than the compulsiveness that comes with willpower.

Hyperbolic discounting can be expected to attenuate many kinds of emotional satisfaction, according to the following logic:

- Rewards that are freely available will be limited by how much appetite you have for them, which often depends on deferring consumption of them;
- Hyperbolic discounting makes you innately impatient to increase your rate of consuming a reward, which often moves you to satiate your appetite for it prematurely (Figure 3a and b);
- You can pace your consumption of physical rewards through personal rules, but this will not work for rewards, like the emotions, that depend only on attention.
- To the extent that you cannot keep your attention from anticipating a familiar sequence of events, this familiarity alone will dissipate your appetite. The only protection from anticipation is for the events to be surprising;
- Premature satiation therefore weeds out emotions not cued by events that are adequately surprising.

The impatience for knowledge that is so adaptive in hostile environments spoils the enjoyment of sustained success, as emotion researcher Sylvan Tomkins noted:

\begin{quote}
The paradox is that it is just those achievements which are most solid, which work best, and which continue to work that excite and reward us least. The price of skill is the loss of the experience of value — and of the zest for living (Tomkins 1978: 212).
\end{quote}

In the absence of some factor that refreshes available appetite, ethologist Konrad Lorenz said:

\begin{quote}
The normal rhythm of eating with enjoyment after having become really hungry, the enjoyment of any consummation after having strenuously striven for it, the joy in achieving success after toiling for it in near-despair — in short, the whole glorious amplitude of the waves of human emotions, all that makes
Figure 3: (a) Cycles of growing reward potential (rising straight lines) and actual consumption (gray areas) leading to satiety. Consumption begins when discounted value of expected consumption reaches the competitive market level. Hyperbolic discount curves of the total value of each act of consumption decline with delay from its anticipated onset (right to left as delay increases). (b) Increased reward (stripes) resulting from increased appetite when there is an obligatory delay in the moment of starting consumption from the moment of choice (“{” brackets); the choice to consume occurs when the discounted value of the delayed consumption reaches the market level.

life worth living — is dampened down to a scarcely perceptible oscillation between scarcely perceptible tiny displeasures and pleasures. The result is an immeasurable boredom. [This is because] . . . the mechanisms equilibrating pleasure and displeasure are thrown off balance because civilized man lacks obstacles which force him to accept a healthy amount of painful, toilsome displeasure (Lorenz 1970: 355–357, brackets added).

Failure of appetite is familiar enough, but without hyperbolic discounting to explain why people don’t accept that “healthy amount of painful, toilsome displeasure” it has not made motivational sense. Premature satiation emerges as a pervasive impulse that is increasingly important as a society gets efficient at satisfying appetites. Where willpower can be effective, as in the timing of consuming externally supplied goods, we would expect people to develop personal rules for cultivating appetite. In effect: “save the best for last,” “don’t take vacation days until you must use them or lose them,” “don’t consume something until you start to get diminishing returns from anticipation.” The need to defend appetites from premature satiation explains the savoring that human subjects so often manifest, an apparent reversal of discounting that is actually a response to discounting. Where willpower
cannot be effective, as when the goods are entirely emotional and appetite can be spoiled by mere anticipation, we are apt to see people adopt even subtler strategies that peg their emotions to surprises — gambling in its many, often subtle, forms — consideration of which is beyond the scope of this paper (see Ainslie 2001: 161–197).

Converse to the problem of premature satiation is the problem of dread, the tendency of anticipated pains to have more impact than imminent pains with the same dimensions. The majority of normal human subjects choose an immediate shock over an equally intense delayed shock \(^5\) (Cook & Barnes 1964; Hare 1966a), and this tendency is most apparent when larger shocks are used (Hare 1966b). Similarly, negative discount rates in the domain of hypothetical losses have been observed in at least a portion of subjects (Chapman 1996; Chapman et al. 2001; Loewenstein 1987; van der Pol & Cairns 2001). Presumably, a week's postponement of a colonoscopy leaves us with both the pain of the procedure, plus the additional aversiveness of seven days of dread. Humans' preference for immediate aversive outcomes over less immediate ones has no documented analog in the Skinner box; like savoring, it seems to require a capacity for self-control. The phenomenon being controlled — the urge to rehearse the anticipated pain despite resulting distress in the present — is no more likely to respond to willpower than is premature satiation of anticipated emotional pleasure. The only discipline possible for the will is to hasten the cause of the distress and thus "get it over with."

**Conclusions**

Delay has a profound effect on the value of expected reward. In animal subjects the form of this effect is a highly reliable hyperbola. However, it is unlikely that the discount rates derived from human experiments similarly reveal the underlying relationship between delay and value. Mechanisms of self-control, in particular that by which choices take on heightened relevance as perceived precedents, can change the contingencies in unreported ways. The fact that discount rates in standard human experiments are so much lower than in animal experiments that it is a prima facie reason to suspect interposed cultural and cognitive layers of processing. The negative discount rates found in humans but not lower animals using some rewards and aversive experiences, and humans' reported preferences for ascending rewards when choosing a series, also point toward interposed control processes. In any case, the low correlation between discount rates across domains, noted earlier, indicates that delay experiments provide a highly imperfect measure of a person's general delay sensitivity.

Accordingly some authors are pessimistic about the existence of an underlying innate discount function. Indeed there is a movement to give up on the idea of constructing a general model of intertemporal choice. Roelofsma and Read write:

> The study of intertemporal choice is currently undergoing a change in emphasis, as has already occurred in the study of decision making under risk and uncertainty. Rather than searching for the holy grail of a single utility function, researchers now take the more pragmatic view that preferences are constructed based on the circumstances of their expression (Roelofsma & Read 2000: 172).
But this pessimism is premature. Although experiments elicit human behaviors toward delayed reward that are as variable as those in real life, there is good reason to believe that much of this variability results from exactly those strategic responses that are predicted by hyperbolic discounting. There are now good data supporting the intertemporal bargaining model of will, which transforms the task of impulse control from one of prior commitment to one of dealing with potential rationalizations. Furthermore, predicted problems with the use of will match clinical problems that are actually observed, including addicts' frequent rejection of binding commitments to sobriety. And the possibility of strongly motivated premature satiation of appetite provides what we believe to be the first explicit motivational theory for both the decline of emotional reward with familiarity and human countermeasures like savoring and gambling.

This is to argue that the preference patterns that have been described as anomalies for a theory of hyperbolic discounting are actually consistent with, and even predictive of, the implications of this theory. Hyperbolic curves cannot be substituted simply for exponential curves in an otherwise unchanged theory of maximizing expected utility. Hyperbolae imply temporary preferences that demand strategic responses, which with experience will weave a fabric of incentives much like that which interpersonal bargaining games have woven in societies. The addictions we deal with as therapists are embedded in this kind of incentive structure, and confront us with corresponding subtleties.

Notes

1. Most typically in behavioral economic experiments, the best fit discount parameter $k$ (from Equation (1) or some variant) is used as the measure of individual discount rate. Myerson and colleagues have recently argued that area under the discount curve makes for a less theoretically loaded measure (Myerson et al. 2001).

2. To save money, some experimental procedures use probabilistically real money. Subjects may be given their selected preference for just one trial, chosen randomly after the experiment (Crean et al. 2000; Richards et al. 1999).

3. At least one study reported that smokers had lower temporal discount rates (Chesson & Viscusi 2000). This study used complex stimuli, requiring subjects to both choose and provide indifference amounts between some amount of money delivered at a set time and another amount of money that would be delivered at one of two possible times, according to some specified probability. The study yielded several findings that are counter to other reported studies — lower temporal discounting in (1) smokers; (2) lower income subjects; (3) younger subjects; and (4) subjects with the most education.

4. The terms of the prisoner’s dilemma must be modified slightly to deal with the fact that future selves cannot retaliate strategically against past selves (see Ainslie 2001: 90–94).

5. Interestingly, subjects with Antisocial Personality Disorder, relative to normals, had a greater preference to choose more delayed shock (Hare 1966a).

References


Comments on Ainslie and Monterosso

William R. Miller

As a psychologist who studies ambivalence, I must confess to experiencing some as I reviewed this very rational paper and others presented at this conference. On the one hand, I find it fascinating to view behavior through lenses from other disciplines, to see how they may be useful in resolving puzzles of human nature. Economic models such as those being discussed here seem to be promising in this regard. On the other hand, I find myself dissatisfied with such mechanistic models of behavior, which seem in their economy to be missing something fundamental about human nature. Reliable rat and pigeon principles tend to break down somewhere in the human cortex. My remarks will therefore steer a course about halfway between hyperbolic adulation and outright discounting.

The Promise of Economic Models

Clearly approach-avoidance conflict is fundamental to the phenomenon of addiction, and economists surely have much to teach us about factors that attract or deter people to spend their time and money in particular ways. One of the entrapping elements of single or double approach-avoidance conflict is that the gradient of reward changes with proximity. When being torn between two lovers, as the person draws closer to one of them, that lover’s flaws become more apparent while the allure of the other increases. Even with one relationship, absence can make the heart grow fonder, whereas prolonged proximity may throw cold water on the fire. The concept of hyperbolic discounting is one component of this conflict paradigm, suggesting that with proximity, allure can increase dramatically, perhaps irresistibly, much as magnets are drawn to each other once they come within critical range. Proximity superheats utility. Yet at the same time there are processes at work by which distance may also enhance utility. Abstinence can make the heart grow fonder. The abstainer savors thinking about a drink, and any attempts not to think about it paradoxically enhance the obsession. Being conflicted is a common, even defining characteristic of addictive behavior (Miller & Rollnick 2002).

As Drs Ainslie & Monterosso recognize, such an economic model of human behavior must consider a daunting complexity of variables that affect the steepness of discounting. The devaluing of delayed reward varies in part as a trait (e.g. delay of gratification is a characteristic that is under-represented among people with substance use disorders), but it also varies within the individual across time and rewards. The utility gradient for any particular reward is affected by experience, satiety, and the other reinforcers with which
it is competing. For dependent people, the utility of the next dose can increase with each
dose. The use of “extrapsychic” devices such as disulfiram or naltrexone can affect utility
gradients, but so do higher cognitive processes of valuing. I often cite David Premack’s
example of a smoker who:

dates his quitting [smoking] from a day on which he had gone to pick up his
children at the city library. A thunderstorm greeted him as he arrived there;
and at the same time a search of his pockets disclosed a familiar problem:
he was out of cigarettes. Glancing back at the library, he caught a glimpse
of his children stepping out in the rain, but he continued around the corner,
certain that he could find a parking space, rush in, buy the cigarettes, and be
back before the children got seriously wet. The view of himself as a father
who would ‘actually leave the kids in the rain while he ran after cigarettes’
was . . . humiliating, and he quit smoking (Premack 1970: 115).

Reward value fell dramatically as smoking suddenly took on new meaning. Nothing else
had changed. The man had learned no new coping skills. No actual contingencies were
altered. No reconditioning occurred. There was no reduction in his nicotine dependence
level. Yet in the twinkling of an eye he became a non-smoker.

The Limitations of Economic Models

To some extent, the math can work in economic models. What troubles me about them,
and indeed about most of the models of behavior within my own discipline of psychology,
is the extent to which they construe the human person as a closed system, operating by
rational and lawful principles with, perhaps, a small error term for random chaos. To turn a
phrase from Ainslie and Monterosso, reductionism is a plague that grows proportionally as
our society gets more sophisticated at controlling human behavior. We come to experience
and conceptualize ourselves as powerless victims of mechanism, and thereby enter into a
self-fulfilling prophecy (Fromm 1941).

Some years ago the eminent learning theorist, Frank Logan, gave the keynote address to
the International Conference on Treatment of Addictive Behaviors. He offered a brilliant
and encyclopedic review of research on animal self-administration of alcohol (including one
ill-advised study of the effects of intoxication in elephants). He concluded that one needs
nothing more than animal learning models to explain how people get trapped in addiction,
but that there is no adequate animal model of recovery (Logan 1993). Animal learning
principles describe the dilemma but not its resolution. To understand how people escape
from addiction — be it in treatment, in Alcoholics Anonymous, or in the natural course of
life events — one must turn to that which is uniquely human, to the higher-order processes
of the human mind.

This brings us to the phenomena of agency, of the capacity for higher-order over­
ride of our animal nature (Howard 1986). It is the “you” noun in sentences where the
verb’s object is your self, your behavior, your appetite, your attention. It is the “self”
in “self-control.” With increased interest in and research on the automaticity of behavior
(Bargh & Ferguson 2000), human agency is sometimes dismissed as metaphoric, even though it is utterly self-evident to human beings (including most behavioral scientists) and in courts of law. To leave agency out of the equation when studying addictive behavior is like trying to understand traffic patterns or road rage by scrutinizing the automobile.

I also have several problems with the dominant model of *homo economicus* as a rational self-interested maximizer. First of these is the rather dubious assumption that human beings are rational, an assumption easily belied by spending a few hours in a psychotherapy clinic or a psychology department faculty meeting. Second is the dismal assumption that human beings are driven only, or even primarily by self-interest, which is but one vector in the cross-culturally consistent structure of values (Schwartz 1992). Third, as pointed out by Ainslie & Monterosso, is the fact that humans are not particularly efficient maximizers, at least when the criterion is self-interest.

Chief among human failings when it comes to efficient maximization of personal gain is the annoying tendency to guide one's behavior in accordance with higher-order principles that are little compromised by current contingencies. Rule-governed behavior is sometimes castigated by radical behaviorists as insufficiently responsive to extant contingencies. In other contexts there is a different term for governing one's behavior by higher-order principles that are minimally responsive to fluctuating material contingencies. It is called *character*.

I have long been interested in the phenomenon of "living as if," that is, behaving as though reality were different than its current state (Miller 1985). This is not a particularly good idea when dealing with physical laws; living as if one can fly will not help a jumper to do so. When it comes to complex social contingencies, however, living as if has a way of altering reality. This is the genius of Gandhi and Martin Luther King, the magic of *My Fair Lady* and *The Man of La Mancha*, and the wisdom behind the A.A. aphorism, "Fake it till you make it."

Empirical studies of change, including some unexpected findings in my own work, also offer ample reason to question mechanistic models (Miller 2000). It was the puzzle of how brief interventions could possibly work so well that led me to motivational interviewing. How is it that sitting with a listener for a single session can trigger change in addictive behaviors that have persisted for years despite substantial aversive consequences? My psycholinguist colleague, Paul Amrhein, has been analyzing client language in motivational interviewing, and now has persuasive evidence that the active ingredient is a change in client *commitment*. No actual contingencies have changed, but clients leave the session voicing stronger need, ability, and intention to change, and the pattern of their commitment language predicts their subsequent substance use (see Amrhein et al. in press). In sum, they have done the same thing that self-changers report when asked how they did it: they *decided*.

We have also been studying the phenomenon of *quantum change*: sudden, dramatic, and seemingly permanent transformations of the Ebenezer Scrooge variety (Miller & C'de Baca 2001). Decades later, quantum changers still remember their experience quite vividly, and speak of having passed through a one-way door. This is what happened to Bill Wilson, co-founder of A.A. (Kurtz 1979), and it is much more common than one might guess. For people previously struggling with addictions, a common report is of a sudden and permanent loss of desire to drink, of craving to use. In essence, within a span of minutes
or hours, the person's identity changed from addict to abstainer. It is not merely behavior change, they tell us. Unlike many who struggle with addictive behaviors, quantum changers may have no real concern about impending relapse. They also have little or no sense of having done it themselves, of coming to a conclusion or exerting will power, of maximizing self-interest. They were changed suddenly, utterly, permanently, and remain puzzled as to how it happened. This was a topic of considerable interest to William James (1902).

Finally, there are the puzzling findings of treatment outcome research in the addiction field. Why is it that the same treatment, when delivered by different therapists, has dramatically different outcomes (Najavits & Weiss 1994)? Why is it that therapist empathy is such a potent determinant of client outcomes (Miller 2000)? Why is it that the dose of treatment received, when studied in controlled trials, is largely unrelated to behavioral outcomes, while the voluntary length of stay in treatment is a reasonably good prognostic sign? Why is it that the teaching of behavioral coping skills has one of the strongest track records in addiction treatment research, yet outcomes appear to be unrelated to whether or not clients actually learn the target skills? (Morgenstern & Longabaugh 2000). And why is it, if people are rational maximizers of self-interest, that behavioral outcomes are so spectacularly unresponsive to education about consequences or confrontation with reality? (Miller & Wilbourne 2002).

I don't claim to have the answers to these questions, and I am always interested in models that may help us to account for more of the variance in change. I look forward to savoring the remaining papers and asking myself two questions: whether these economic models are something more than another metaphor to describe addictive behavior, and what such models might teach us about addiction that we didn't already know.

References


Reply to Miller

George Ainslie and John Monterosso

We agree with most of Dr. Miller’s points: being conflicted is a defining characteristic of addictive behavior; people are not “powerless victims of mechanism”; escape from addiction depends on the higher order processes of the human mind; human beings are often not rational and often not driven by self-interest, which in any case is not the same thing as rationality; their behavior sometimes changes in quantum leaps; the progress of psychotherapy is not proportional to the ostensible determinants of this progress; and (incidentally) Frank Logan, GA’s first teacher in psychology when both were at Yale, was a brilliant researcher and theorist.

We do not share Dr. Miller’s pessimism about reconciling the higher mental processes with reductionism. True, there is a well-entrenched dichotomy between “animal learning principles” and “higher-order processes”; but the “higher-order override of our animal nature” may not be so much a matter of rising above our animal nature as of riding it, as someone might ride a horse — a figure used by both Freud and the great neurologist Paul McLean. That is, we may have to go where our horse wants to go, and the skill of riding may be that of getting our horse to want to go where we do. Of course, the rider, the “you noun,” might conceivably have a separate, non-animal nature, and might dwell in a black box that is impenetrable to science and understandable only empathically. However, the finding of seemingly basic hyperbolic discounting suggests a more parsimonious model, one in which the rider grows organically from the horse. This model does not belittle the role of higher-order, autonomous agency. On the contrary, it argues against the possibility of either predicting human choice from a knowledge of external options or of controlling this choice by manipulating these options.

The key lies in understanding the person, not as a passive consumer in a market economy, but as a market economy in her own right — a population of partially conflicting interests in a limited-warfare relationship with one another (Schelling 1960: 53–80), which make decisions somewhat with a view to influencing each other. We argue that, just as economics came to understand more complex financial transactions when it used game theory to analyze them strategically (Smith 1992), a strategic approach can let psychology combine “animal learning principles” to describe how a very intelligent horse can come to generate a rider. That the rider never replaces the horse, but only brokers its incentives, is fated by the relentless motivational pressure from hyperbolic discount curves.

The distinguishing features of the rider are foresight and the flexibility to see its current choices as predictive of future ones. The mechanism of will that we presented here meets Dr. Miller’s test of being “uniquely human” — GA tried and failed to find evidence that
pigeons which improved their delay tolerance were using their current choices as cues predicting long range reward (unpublished data). In this model the will is not controlled by external incentives (what we take as Dr. Miller's "closed system") with "a small error term for random chaos." Rather, it is chaotic in the technical sense (Ayers 1997): its choices are fed back recursively, so that their implications for future choice may be the greatest determinant of which ones will be final. If decisions were randomly chaotic, they would be experienced as "more like epileptic seizures than free responsible choices" (Kane 1989: 231). However, in the recursive kind of chaos caused by intertemporal bargaining, a person's choice is sensitively dependent on her own interpretation of that choice itself, which, we argue, should engender a feeling of owning the choice (see Ainslie 2001: 129–134).

Such sensitive dependence will sometimes lead to the quantum change that Dr. Miller describes: a chance juxtaposition on a rainy day that reveals smoking as a dangerously coercive motive suddenly makes the act a more damaging precedent, that is, one which imperils a greater stake; given this interpretation, the father's subsequent act of smoking would damage his will proportionately more, by the abstinence violation effect (e.g. Marlatt & Gordon 1980). The will is not, then, a "powerless victim of mechanism," except in the general sense that all phenomena have causes. And it is certainly not a mere metaphor.

The premature satiation hypothesis that we described in the last part of the present paper suggests fixes for Dr. Miller's remaining two problems with maximizing mechanisms: elementary strategic thinking will lead a person to empathize with others, and to construct beliefs beyond the objective evidence for them. This reasoning is developed in Ainslie (1995, 2001: 161–197), and is only sketched here:

Maximal satisfaction from otherwise freely available emotional rewards depends on their deferral and the consequent build-up of appetite for them. Hyperbolic discount curves create a relentless urge to harvest these rewards prematurely. Therefore, unless people peg their emotions to occasions that are both optimally unresponsive to their current wishes and optimally surprising, their emotional lives will have the highly satiated quality of daydreams. That is, we have to keep our appetites fresh by gambling. The richest source of external occasions to gamble on is the apparent experience of other people, creating an incentive to "put ourselves in their shoes." Emotions that we generate by the occasion of other people's emotions avoid the drawback of arbitrary control and thus stay fresh. Here is a mechanism for vicarious experience as a primary good, rather than some kind of ploy; whether a theorist wants to call the pursuit of this good "self-interest" is a matter of taste.

By similar logic, performing tasks efficiently often means getting done too soon for optimal emotional arousal. Merely conveying facts to a patient about substance abuse, for instance, need not entail any emotional engagement. Where therapeutic change depends on this engagement, the patient, and probably the therapist, must believe in the importance of a longer, indirect task that keeps them appropriately occupied while empathy develops. This, we suspect, accounts for the profusion of comparably effective schools of psychotherapy that each claim exclusive validity, and that succeed even when their supposed mechanisms are disproven.

We agree with Dr. Miller that the most effective psychotherapy depends on the therapist's empathic engagement with, rather than technical understanding of, the addict or other patient. Still, advancing the science of motivational conflict can only help therapists understand the incentives their patients face. Conventional motivational theory gets in the
way of understanding, not because it is reductionistic, but because it is wrong: A person cannot act rationally without commitments; the will is very real but not an organ; its use brings pathologies of its own, which may make someone sometimes prefer an addiction; and risk per se, including the risk of vicarious experience, is a basic necessity for emotional satisfaction. Without a recognition of such properties, person’s choices may seem irrational or even perverse when they are actually complex strategic moves.

References

Chapter 3

Evolving Models of Addictive Behavior: From Neoclassical to Behavioral Economics

Frank J. Chaloupka, Sherry Emery and Lan Liang

Introduction

Although there has been a market for cigarettes and other addictive substances virtually since these substances were discovered, it is only relatively recently that economists have begun to characterize the demand for addictive products. According to neo-classical economic models, rational consumers maximize their utility (happiness or well-being) through their market transactions. Many researchers, however, once viewed cigarette smoking and other addictive behaviors as irrational and therefore unsuitable for conventional economic analysis (Elster 1979; Schelling 1984b; Winston 1980). If demand for cigarettes were not "rational" in this neo-classical framework, it would therefore violate the basic laws of economics, including perhaps the most fundamental law, that embodied in the downward-sloping demand curve. As the now-substantial body of economic research demonstrates, however, the demand for cigarettes clearly responds to changes in prices and other factors, as found in applications of both traditional models of demand and more recent studies that explicitly account for the addictive nature of smoking.

Conceptually, economists use a relatively broad definition of price that includes not only the monetary price of purchasing a product, but also the time and other costs associated with using the product. Restrictions on smoking in public places and private work-sites, for example, impose additional costs on smokers by forcing them to go outdoors to smoke, raising the time and discomfort associated with smoking, or by imposing fines for smoking in restricted areas. Similarly, limits on youth access to tobacco may raise the time and potential legal costs associated with smoking by minors, while new information on the health consequences of tobacco use can raise the perceived long-term costs of smoking.

In addition to price, a variety of other factors can affect demand for cigarettes and other tobacco products. For example, nearly all econometric studies of cigarette demand use a variety of factors to control for tastes, including gender, race, education, marital status, employment status, and religiosity. In addition, factors such as income, advertising and other promotional activities have been shown to influence demand for cigarettes and other
tobacco products. These factors may also be related to the likelihood of addiction, and thus affect demand for cigarettes in multiple ways.

This paper begins with a review of conventional studies of the impact of money price on cigarette demand. This is followed by a discussion of economic models of addiction and their applications to cigarette demand. Implications for the effects of price on cigarette demand from the relatively new field of behavioral economics are then reviewed.

Conventional Economic Analyses of Individual Level Smoking Data

A relatively small but growing number of cigarette demand studies have used data on individuals taken from large-scale surveys to examine the relationship between cigarette prices and demand for cigarettes, or cigarette consumption. Among the earliest of the cigarette demand studies employing individual-level data were those conducted by Lewit and his colleagues (Lewit & Coate 1982; Lewit et al. 1981). These studies estimated an overall price elasticity of demand for cigarettes of approximately \(-0.40\). In other words, Lewit and his colleagues showed that demand for cigarettes fell by approximately 4% when cigarette prices increased by 10%. In studies, like the Lewit studies, which use individual level data on smoking behavior, overall price elasticity of demand for cigarettes can be broken down into two components: participation elasticity, or the extent to which price influences the decision to be a smoker; and conditional demand elasticity: the extent to which price influences the amount smoked (number of cigarettes) among smokers. Slightly over half of the decrease in demand shown in the Lewit studies could be accounted for by reductions in the number of smokers, or participation elasticity. The remaining decline could be attributed to reductions in the amount smoked by the remaining smokers, or conditional elasticity of demand. Several subsequent studies using individual level data have approximated Lewit and colleagues' results (e.g. Hu et al. 1995a), producing a general consensus among economists that the overall price elasticity of demand for cigarettes among adults is approximately \(-0.40\) (NCI 1993).

Several studies have investigated the relationship between age and responsiveness to cigarette prices, and found an inverse relationship between (the absolute value of) price elasticity and age (Chaloupka & Grossman 1996; Chaloupka & Wechsler 1997; Evans & Huang 1998; Farrelly & Bray 1998; Grossman et al. 1983; Lewit & Coate 1982; Lewit et al. 1981, 1997; Tauras & Chaloupka 1998). Estimates of youth price elasticity of demand for cigarettes from these studies were as much as two to three times larger than adult elasticities. At the same time, however, several studies have failed to find a statistically significant estimate for the price elasticity of demand for cigarettes among youth (DeCicca et al. 1998a; Douglas 1998; Douglas & Hariharan 1994; Wasserman et al. 1991).

In general, researchers examining the effects of price on smoking participation using individual-level data from cross-sectional surveys have assumed that much of the price effect estimated for youth smoking participation reflects the impact of price on smoking initiation, while the estimate for adults is largely capturing the effects of price on smoking cessation. A few recent studies have attempted to directly examine the impact of cigarette prices on smoking initiation among youth, producing mixed results (DeCicca et al. 1998a; Dee & Evans 1998). Emery and her colleagues (2001) differentiated between experimenters
(youth who had smoked less than 100 cigarettes in their lifetime) and established smokers (youth who had smoked at least 100 cigarettes and had smoked in the past 30 days), finding statistically insignificant price elasticities among experimenters. Their models estimated a total price elasticity of \(-1.7\) among current smokers, which is quite comparable with many other previous studies. For established smokers, their models estimated a total price elasticity of \(-2.24\), with a conditional demand elasticity of \(-0.68\). These results suggest that cigarette prices may not be an important factor in youth's experimentation with (or initiation to) cigarettes, but may play an important role in deterring progression to established smoking and may moderate the amount smoked among those who become established smokers. Thus, while no clear consensus currently exists for the estimates of adolescent price elasticity of demand for cigarettes, the weight of the evidence suggests that youth are significantly more sensitive to cigarette price changes than are adults.

Lewit 
\textit{et al.} (1981) offered two hypotheses why youth should be more price sensitive than adults, at least in the short run. First, given the addictive nature of smoking, long-term adult smokers are likely to adjust less quickly to changes in price than youth who have been smoking for a relatively short time, if at all. In addition, peer behavior is likely to be much more influential for youth, multiplying the effects of price on youth smoking. That is, an increase in cigarette price directly reduces youth smoking and then again indirectly reduces it through its impact on peer smoking. Grossman 
\& Chaloupka (1997) offered two additional potential explanations. First, the fraction of disposable income a young smoker spends on cigarettes is likely to exceed that spent by an adult smoker. Second, compared to adults, youth are more likely to be present-oriented — to discount the future more heavily than adults. In the context of an economic model of addictive behavior (discussed below), Becker 
\textit{et al.} (1991) predicted that changes in money price will have a greater impact on individuals with higher discount rates since they give less weight to the future consequences of addictive consumption.

In addition to age, several studies have examined the relationship between gender, race, and responsiveness to cigarette prices. Chaloupka 
\& Pacula (1998b) concluded that young men and young blacks were more responsive to price than young women and young whites. Similarly, Farrelly and his colleagues estimated that blacks were about twice as responsive as whites to cigarette prices, while Hispanics were even more price sensitive. In addition, they found that men were more price sensitive than women. Finally, they estimated that individuals with family incomes below the sample median were about 70% more responsive to price than those with higher family incomes. The higher elasticity estimates for minorities may reflect demographic patterns of smoking behavior and therefore conform to the hypotheses about the relationship between addictiveness and price responsiveness postulated in the context of youth smoking behavior. Historically, at a population level, Blacks and Latinos have smoked less than Whites (Haynes \textit{et al.} 1990; Navarro 1996; Palinkas \textit{et al.} 1993; Perez-Stable \textit{et al.} 1993). Thus, it is conceivable that, similar to youth, they are less addicted and therefore potentially more able to change their smoking behavior in response to cigarette price changes. The higher elasticities found among men and lower income smokers are more difficult to explain.

Evans 
\& Farrelly (1998) recently examined a phenomenon not previously studied by economists: the compensating behavior by smokers in response to tax and price changes. They found consistent evidence that, although smokers reduced daily cigarette consumption
in response to higher taxes, they also compensated for that reduced number of cigarettes in several ways. In particular, smokers in high-tax states consumed longer cigarettes and those that are higher in tar and nicotine, with young adult smokers most likely to engage in this compensating behavior. As a result, they argued that the perceived health benefits associated with higher cigarette taxes are likely to be somewhat overstated. Given this compensating behavior, Evans and Farrelly suggested that if cigarette taxes are to be used to reduce the health consequences of smoking, then taxes based on tar and nicotine content would be appropriate, an idea first suggested by Harris (1980).

In summary, conventional studies of the demand for cigarettes have shown that, despite the addictiveness of the nicotine in cigarettes, demand for cigarettes behaves much like demand for other goods, falling when prices rise. The conventional models of demand found, however, that different types of individuals respond differently to changes in cigarette prices. One plausible explanation for these differences is variations across groups in the extent to which they are addicted to cigarettes. These studies suggest a relationship between addiction levels and the demand function.

Addiction Models and Cigarette Demand

The first discussion by an economist of the effects of addiction on demand can be found in Marshall’s (1920) *Principles of Economics*, where he observed that:

> Whether a commodity conforms to the law of diminishing or increasing return, the increase in consumption arising from a fall in price is gradual; and, further, habits which have once grown up around the use of a commodity while its price is low are not so quickly abandoned when its price rises again (Appendix H, Section 3: 807).

As Phlips (1983) noted, Marshall’s statement clearly introduced the three basic dimensions of addiction (U.S. Department of Health and Human Services 1988) of gradual adaptation (tolerance), irreversibility (withdrawal), and positive effects of habits (reinforcement) that are used in many of the more recent formal models of addictive behavior. Until recently, however, economists have either ignored the addictive nature of goods such as cigarettes when estimating demand or have assumed that behaviors such as smoking were irrational and could not be analyzed in the rational, constrained utility maximizing framework of economics.

Many of the most recent studies of cigarette demand explicitly address the addictive nature of cigarette smoking. Economic models of addiction can be divided into three basic groups: imperfectly rational models of addictive behavior, models of myopic addictive behavior, and models of rational addictive behavior.

*Imperfectly Rational Addiction Models*

Elster (1979), McKenzie (1979), Winston (1980), and Schelling (1978, 1980, 1984a, b) best exemplify the economic models of imperfectly rational addictive behavior. These
models generally assume stable but inconsistent short-run and long-run preferences. This is seen, for example, in Schelling's (1978: 290) description of a smoker trying to "kick the habit":

> Everybody behaves like two people, one who wants clean lungs and long life and another who adores tobacco . . . The two are in a continual contest for control; the "straight" one often in command most of the time, but the wayward one needing only to get occasional control to spoil the other's best laid plan.

Thus, the farsighted personality may enroll in a smoking cessation program, only to be undone by the shortsighted personality's relapse in a weak moment. Winston (1980) formally modeled this behavior and described how this contest between personalities leads to the evolution of what he called "anti-markets," which he defined as firms or institutions that individuals will pay to help them stop consuming.

Strotz (1956) was the first to develop a formal model of such behavior, describing the constrained utility maximization process as one in which an individual chooses a future consumption path that maximizes current utility, but later in life changes this plan "even though his original expectations of future desires and means of consumption are verified" (165). This inconsistency between current and future preferences only arises when a non-exponential discount function is used. Strotz went on to suggest that rational persons will recognize this inconsistency and plan accordingly, by pre-committing their future behavior or by modifying consumption plans to be consistent with future preferences when unable to pre-commit. Pollak (1968) went one step further, arguing that an individual may behave naively even when using an exponential discount function. Thaler & Shefrin (1981) described the problem similarly, referring to an individual at any point in time as both a "farsighted planner and a myopic doer" (392), with the two in continual conflict. While these models present interesting discussions of some aspects of addictive behavior, they have not been applied empirically to cigarette smoking or other addictions.

**Myopic Addiction Models**

The naive behavior described in some of the imperfectly rational models of addiction is the basis for many of the myopic models of addictive behavior. As Pollak (1975) observed, behavior is naive in the sense that an individual recognizes the dependence of current addictive consumption decisions on past consumption, but then ignores the impact of current and past choices on future consumption decisions when making current choices. Many of these models treat preferences as endogenous, allowing tastes to change over time in response to past consumption (El-Safty 1976a, b; Gorman 1967; Hammond 1976a, b; Pollak 1970, 1976, 1978; von Weizsäcker 1971).

These models are similar in spirit to those in which tastes change in response to factors other than past consumption, including advertising (Dixit & Norman 1978; Galbraith 1958, 1972) and prices (Pollak 1977). Others allow past consumption to affect current consumption through an accumulated stock of past consumption (e.g. Houthakker & Taylor, 1966, 1970).
These models are comparable to those of the demand for durable consumer goods that use a stock adjustment process (e.g. Chow's [1960] model of the demand for automobiles, and Garcia dos Santos' [1972] analysis of the demands for household durables.) As Philips (1983) noted, however, the distinction between models with endogenous tastes and those with stable preferences within a household production framework is purely semantic, since the underlying mathematics of the two are the same.

The earliest theoretical models of demand in the context of myopic addiction can be traced to the irreversible demand models (Duesenberry 1949; Farrell 1952; Haavelmo 1944; Modigliani 1949). Farrell, for example, described an irreversible demand function as one in which current demand depends on all past price and income combinations. As a result, price and income elasticities are constant, but may differ for increases and decreases in price and income. Farrell tested this model empirically, using U.K. data on the demands for tobacco and beer from 1870 through 1938, in a model that included not only current price and income, but also price, income, and consumption in the prior year. In general, his estimates were inconclusive, although he did find limited evidence of habit formation for tobacco use.

The notion of asymmetric responses to price and income reappeared in Scitovsky (1976) and was applied to cigarette demand by Young (1983) and Pekurinen (1989), using data from the U.S. and Finland, respectively. Both found that smoking was almost twice as responsive to price reductions as it was to price increases, which they interpreted as evidence of addiction.

Most empirical applications of myopic models of addiction are based on the pioneering work by Houthakker & Taylor (1966, 1970), which formally introduced the dependence of current consumption on past consumption by modeling current demand as a function of a "stock of habits" representing the depreciated sum of all past consumption. Houthakker & Taylor estimated demand functions for a variety of goods, including cigarettes, using annual aggregates for the U.S. and several western European countries. Their estimates provided considerable support for their hypothesis of habit formation in demand for almost all of the non-durable consumer goods, including cigarettes, they examined.

Mullahy (1985) took a similar approach in his empirical examination of cigarette demand using individual level data from the 1979 National Health Interview Survey. In his model, the stock of past cigarette consumption has a negative impact on the production of commodities such as health and the satisfaction received from current smoking. Mullahy found strong support for the hypothesis that cigarette smoking is an addictive behavior, as shown by the positive and significant estimates he obtained for the addictive stock in both the smoking participation and conditional demand equations. His estimates for price are quite similar to those obtained by Lewit & Coate (1982), with the overall price elasticity of demand centered on -0.47. In addition, Mullahy estimated that men were more price responsive than women (total price elasticities of -0.56 and -0.39, respectively). Finally, using an interaction between the addictive stock and price, Mullahy concluded that more-addicted smokers (defined as those with a larger addictive stock) were less responsive to price than their less-addicted counterparts. Other approaches to estimating myopic demand models have similarly concluded that cigarette smoking is an addictive behavior and that price has a significant impact on cigarette demand (e.g. Baltagi & Levin 1986; Jones 1994).
Evolving Models of Addictive Behavior

Rational Addiction Models

Several researchers have modeled addiction as a rational behavior. In this context, rationality simply implies that individuals incorporate the interdependence between past, current, and future consumption into their utility maximization process. This is in contrast to the assumption, implicit in myopic models of addictive behavior, that future implications are ignored when making current decisions. In other words, myopic behavior implies an infinite discounting of the future, while rational behavior implies that future implications are considered, while not ruling out a relatively high discount rate. Several of the rational addiction models, including those of Lluch (1974), Spinnewyn (1981), and Boyer (1983), assume that tastes are endogenous. These models build on the significant contributions of Ryder & Heal (1963), Boyer (1978), and others in the optimal growth literature who have developed endogenous taste models with rational behavior. Spinnewyn (1981) and Philips & Spinnewyn (1982) argued that incorporating rational decision making into models of habit formation results in models that are “formally equivalent to models without habit formation” (Spinnewyn 1981: 92). Thus, they argue, assuming rationality only leads to unnecessary complications.

This assertion was challenged by Pashardes (1986) who derived demand equations for a rational consumer in which current consumption is determined by past consumption and current preferences with full knowledge about the impact of current decisions on the future costs of consumption. Pashardes found considerable empirical evidence to support the hypothesis of rational behavior in general, as well as evidence that cigarette smoking is an addictive behavior. Finally, he noted that expectations concerning the future price and other costs of consumption played an important role in consumer behavior.

Becker & Murphy (1988) similarly rejected the notion that myopic behavior is empirically indistinguishable from rational behavior in their theory of rational addiction. They assumed that individuals consistently maximize utility over their life cycle, taking into account the future consequences of their choices. In their model, utility at any point in time depends on current addictive consumption, current non-addictive consumption, and the stock of past addictive consumption. Tolerance is incorporated by assuming that the marginal utility of the addictive stock is negative. Reinforcement is modeled by assuming that an increase in the addictive stock raises the marginal utility of current addictive consumption. Finally withdrawal is captured since total utility falls with the cessation of addictive consumption.

Becker & Murphy (1988) and Becker et al. (1991) developed several hypotheses from this basic model. First, addictive consumption displays “adjacent complementarity”; that is, due to reinforcement, the quantities of the addictive good consumed in different time periods are complements. As a result, current consumption of an addictive good is inversely related not only to the current price of the good, but also to all past and future prices. Consequently, the long-run effect of a permanent change in price will exceed the short-run effect. Moreover, in the Becker and Murphy model, the ratio of the long-run to short-run price effect rises as the degree of addiction rises. In addition, they predict that the effect of an anticipated price change will be greater than the impact of a comparable unanticipated price change, while a permanent price change will have a larger impact on demand than a temporary price change. Finally, price responsiveness varies with time preference: addicts with higher discount rates
will be relatively more responsive to changes in money price than those with lower discount rates. The opposite will be true with respect to the effects of information concerning the future consequences of addictive consumption. Thus, the model suggests that younger, less educated, and lower income persons will be relatively more responsive to current changes in the money price of cigarettes, while older, more educated, and higher income persons will be relatively more responsive to new information on the health consequences of cigarette smoking and future price changes.3

Strong adjacent complementarity, reflecting strong addiction, can lead to unstable steady states in the Becker and Murphy model. This is a key feature of their rational addiction theory, helping to explain the binge behavior and "cold turkey" quit behavior observed among addicts. Furthermore, these unstable steady states imply that there will be a bimodal distribution of consumption, again something that is observed for many addictive goods. In addition, Becker and Murphy’s model implies that temporary events, including price reductions, peer pressure, or stressful events, can lead to permanent addictions.

Chaloupka (1988, 1990, 1991, 1992) used data from the Second National Health and Nutrition Examination Survey conducted in the late 1970s in the first empirical application of the rational addiction model. He found consistent evidence that cigarette smoking was an addictive behavior and that smokers did not behave myopically. Chaloupka’s (1991) estimates of the long-run price elasticity of demand fell in the range from \(-0.27\) to \(-0.48\), larger than the elasticities obtained from conventional demand equations using the same data. In addition to estimating the rational addiction demand equations for the full sample, Chaloupka also explored the implications of the Becker and Murphy model with respect to the rate of time preference by estimating comparable demand equations for subsamples based on age and educational attainment. Chaloupka’s (1991) estimates were generally consistent with the hypothesis that less educated or younger persons behave more myopically than their more educated or older counterparts. In addition, less educated persons were more price responsive, with long-run price elasticities ranging from \(-0.57\) to \(-0.62\), than were more educated persons, who were generally unresponsive to price. Chaloupka (1990) also estimated separate demand equations for subsamples based on gender, concluding that men behaved more myopically and were relatively more responsive to price (long-run price elasticity centered on \(-0.60\)) than women (statistically insignificant effect of price on demand).

Similar findings were obtained by Becker et al. (1994) using aggregate, state-level sales data for the U.S. over the period from 1955 through 1985. They found clear evidence that smoking was addictive, as well as evidence of non-myopic, although not fully rational, behavior.4 Estimates from other studies employing U.S. data (Keeler et al. 1993; Sung et al. 1994) and data from other countries, including Finland (Pekurinen 1991) and Australia (Bardsley & Olekalns 1998) are generally consistent with the hypothesis of rational addiction. In contrast, Duffy (1996a), Cameron (1997), and Conniffe (1995), using annual time-series data for the U.K., Greece, and Ireland, respectively, found little support for the rational addiction model. These latter studies, however, are generally limited by the relatively small number of observations available for their analyses, and by the use of several highly correlated regressors.

Douglas (1998) used hazard models to examine the determinants of smoking initiation and cessation in the context of the Becker & Murphy (1988) rational addiction
model. In contrast to his finding that price does not significantly affect the hazard of smoking initiation, Douglas concluded that increases in price significantly increase the likelihood (hazard) of smoking cessation. He estimated a price elasticity for the duration of the smoking habit of $-1.07$ with respect to future price, consistent with the hypothesis of rational addiction; paradoxically, past and current prices were not found to have a statistically significant effect on cessation. Similarly, his parametric and non-parametric results imply that the hazard of smoking cessation has a positive duration dependence, a finding Douglas suggested is consistent with rational addiction in that the rational smoker will discount future health costs less as they become more imminent.

**Critiques of the Rational Addiction Model**

While the rational addiction model has gained acceptance among some economists, many object to several assumptions of the model. Perhaps the most criticized aspect of the model is the assumption of perfect foresight. As Winston (1980: 302) explained, in the context of the Stigler & Becker (1977) model:

[T]he addict looks strange because he sits down at period $j = 0$, surveys future income, production technologies, investment/addiction functions, and consumption preferences over his lifetime to period $T$, maximizes the discounted value of his expected utility, and decides to be an alcoholic. That's the way he will get the greatest satisfaction out of life. Alcoholics are alcoholics because they want to be alcoholics, ex ante, with full knowledge of its consequences.

Similarly, Akerlof (1991) noted that individuals who become addicted in the rational addiction model do not regret their past decisions, given that they are assumed to have been fully aware of the consequences of their consumption of a potentially addictive good when making those decisions.

A recent theoretical paper by Orphanides & Zervos (1995) addressed this and other perceived inconsistencies of the rational addiction model that arise largely from the assumption of perfect foresight. In particular, the authors introduced uncertainty into the model by assuming that inexperienced users are not fully aware of the potential harm associated with consuming an addictive substance. Thus, it is possible to explain the regret often observed in addicted individuals, but which cannot be accommodated in the Becker & Murphy models. Orphanides & Zervos describe a model where not every individual is susceptible to addiction. Thus, there is a probabilistic calculation involved with the consumption of an addictive good: the consumer gambles that they are not among the group susceptible to addiction. An individual's knowledge about their probability of addiction comes from the observed effects of that good on others, as well as through his or her own experimentation with that good. More specifically, they assume that the harmful effects (including addiction) of consuming a potentially addictive good are not the same for all individuals, that each individual possesses a subjective understanding of his or her potential to become addicted, and that this subjective belief is updated via a Bayesian learning process as the individual
consumes the addictive good. Thus, an individual who underestimates his or her potential for addiction and experiments with an addictive substance can end up becoming addicted. Rather than the "happy addicts" implied by the rational addiction model (Winston 1980), these addicts will regret becoming addicted. As Orphanides & Zervos noted, the incorporation of subjective beliefs into the rational addiction model helps explain youthful experimentation, the importance of peer influences, and other commonly observed facets of addiction.

More recently, in a model focusing on cigarette smoking, Suranovic et al. (1999) also reconsidered the Becker & Murphy (1988) model of rational addiction. As described above, adjacent complementarity is a key feature of the rational addiction model. Suranovic et al. noted, however, that one implication of adjacent complementarity is that efforts to reduce current consumption will lead to reductions in utility. These "quitting costs" are an important feature of their model and help explain the seeming inconsistency between smokers' stated wishes to quit smoking and their continued cigarette consumption. In addition, they help explain why smokers engage in various behavior modification treatments, such as the use of the nicotine patch, which help make quitting easier.

A second point of departure from the Becker & Murphy model concerns the timing of the consequences of smoking, which Suranovic et al. assume are concentrated at the end of a smoker's life. In addition, rather than assuming that individuals choose a lifetime consumption path that maximizes the present value of their lifetime utility, Suranovic et al. assume "boundedly rational" behavior, implying that individuals choose current consumption only. As a result, their model suggests that aging is enough to induce cessation among some smokers. As in the Becker & Murphy model, their model implies that quitting "cold-turkey" is likely in the case of a strong addiction (one where quitting costs rise rapidly for small reductions in consumption). However, in contrast to Becker & Murphy, Suranovic et al. predicted gradual reductions in consumption progressing to quitting in the case of relatively weak addictions. Interestingly, some newly emerging epidemiologic evidence supports this prediction (Farkas 1998).

In addition, as Becker & Mulligan (1997) describe, addiction and time preference may be related. As discussed above, the Becker & Murphy (1988) model of rational addiction implied that people who discount the future more heavily were more likely to become addicted (and hence less price responsive, but addicted individuals are more price responsive in the long run than are less addicted individuals). In their theoretical discussion on the determination of time preference, Becker & Mulligan suggest that addictive consumption, by raising current utility at the expense of future utility, can make even rational persons behave more myopically.

Finally, Showalter (1998), in his analysis of the behavior of firms producing an addictive good, suggests an alternative interpretation for the finding in most empirical applications of the rational addiction model that future consumption has a significant impact on current consumption. Rather than resulting from rational behavior on the part of consumers, Showalter shows that the same finding could result from myopic behavior by consumers coupled with rational behavior by firms. In his empirical applications of this model, Showalter finds that the rational and myopic demand models produce similar predictions, but that neither does well in predicting actual behavior, a finding he attributes to the difficulties of accurately forecasting prices.
Behavioral Economic Analyses of Cigarette Demand

Behavioral economics involves the application of the principles of consumer demand theory to experimental psychology (Hursh & Bauman 1987), and offers another set of tools and hypotheses for understanding some of the contradictions and conundrums that persist in the economics of addictive behavior. Over the past decade, there have been numerous behavioral economic analyses of a variety of addictive behaviors, including cigarette smoking (Bickel & DeGrandpre 1996). These studies examine the impact of price and other factors on the self-administration of a number of addictive substances by humans as well as a variety of non-human species in a laboratory setting. Price, in this context, is defined as the response or effort required to receive one dose of a drug (Bickel et al. 1993). As in standard economic analyses, an increase in price is expected to lead to a reduction in the quantity of drug demanded. One advantage of this experimental approach for the analysis of cigarette demand, both in general and as it relates to policy debates specifically, is that it allows researchers to study the effects on demand of changes in cigarette prices that are many times larger than the price differences that are observed in the cross-sectional or time-series data that have been used in the econometric studies of demand. One limitation of the approach, however, is that these methods are generally applicable only to dependent individuals. For example, for ethical reasons (and others), they cannot be used to address issues related to the effect of price on smoking initiation.

In a series of papers, Bickel, DeGrandpre, and their colleagues have reported the results of research on cigarette smoking conducted in their behavioral economics laboratory (Bickel & DeGrandpre 1996; Bickel et al. 1991, 1995; Bickel & Madden 1998; DeGrandpre & Bickel 1995; DeGrandpre et al. 1992, 1994). These experiments typically involved individuals aged 18 and older who smoked a pack or more of cigarettes per day, and who participated in between two and five three-hour experimental sessions per week. Price, in these experiments, was defined as the number of complete pulls and resets of a plunger required to receive a preset number of puffs on a cigarette. For example, 50 pulls on the plunger may be required to obtain two puffs on a cigarette. Puffs were monitored by a puff-volume sensor so that each subject receives essentially the same dose per puff (Bickel & Madden 1998).

A wide range of prices was used in these experiments. In some, respondents were also presented with an opportunity to earn money for pulls on the plunger that could then be spent on cigarettes. As in the econometric studies described above, the behavioral economic analyses have consistently found an inverse relationship between cigarette smoking and price. Estimates of the price elasticity of demand obtained from these studies were surprisingly consistent with those obtained from econometric studies. For example, Bickel et al. (1995) estimated a mean price elasticity of demand of −0.56 for five subjects in an experiment in which price ranged from 12 to 1600 pulls per puff. A particularly interesting finding from the behavioral economics research was that the price elasticity of demand rises as price rises. For example, DeGrandpre & Bickel (1995) estimated a mean price elasticity of −1.58 for prices ranging from 400 to 4500 pulls per puff. These findings appear to be generalizable not only across drugs but also across species (Bickel et al. 1990).
Theoretical Advances in the Behavioral Economics of Smoking

In addition to the empirical work conducted in laboratory settings, in recent years a growing body of theoretical work has evolved out of explorations of the application of psychological theories to economic models of addictive behavior in general and cigarette smoking in particular. Such models evolved to explain seemingly irrational behavior exhibited by individuals with self-control problems, both in their dynamic decisions with respect to consumption and their approaches to addressing these self-control problems.

In this context, a person is characterized as having a self-control problem if their long-term utility is diminished by decisions or actions taken to maximize utility in the short run. For example, in the long run, a smoker may want to quit smoking. Thus, having a cigarette today diminishes their long-run utility at the same time that it also maximizes their current utility. In order to reach their long-run goal, a smoker may impose rules on themselves or create other structures that appear to constrain current utility, but help them to maximize long-run utility. These self-control mechanisms can appear to be irrational from an economic perspective unless viewed as means to address the contradictions represented by self-control problems.

As described above, Thaler & Shefrin (1981) explained such behavior by characterizing the individual as embodying two agents, the planner and the do-er. The planner has one set of preferences that apply to future behavior: for example, to save money in the future or to quit smoking. The do-er, however, has another set of preferences that apply only to current behavior: for example to spend money or to smoke. In order to prevent the do-er from diminishing the long-run utility of the planner, the individual adopts commitment devices, such as savings plans or enrollment in a costly smoking cessation treatment rather than quitting cold-turkey. In the case of an integrated individual, where there is no distinction between the planner and the do-er, such commitment devices would appear irrational from an economic perspective. However, the inter-temporal variability in preferences means that integration does not occur without commitment devices, and therefore these devices begin to make sense.

Laibson (1997) describes a model that can account for the conflict between today’s preferences and future preferences, which was characterized as a self-control problem by earlier economists. Laibson explains these intertemporal inconsistencies as a function of a hyperbolic discount structure. This idea differs from the traditional economics and rational addiction models, which allow for changing tastes over time but apply a constant discount rate to decisions about current and future consumption made by one individual. These traditional models reflect the assumption of an exponential discount function over time. A hyperbolic discount rate implies that an individual is relatively impatient in the short run, but will apply a lower discount rate to decisions made in the future. However, when the future arrives, these decisions become subject to the short-run high discount rate. This model explains how an individual can plan to make more difficult decisions, like quitting smoking, in the future, but when the future becomes the present will pursue a strategy of more immediate gratification.

Ainslie (1992) describes a discount function that is a modification of the hyperbolic discount function, and which allows for willpower or personal rules (Ainslie 1992). Thus, an individual may still value future abstention over future consumption, only to have these
values reverse as the future becomes the present. The key distinction, however, is that in the present an individual can take into account more than the current period as they are considering present consumption. If the discounted values of later decisions are evaluated at the same time as the individual is considering whether to consume or abstain in the present, it is possible that the sum of current and future discounted consumption events is less than the value of the sum of current and future discounted abstention. In such a scenario, an individual will choose to abstain in the current period even though current consumption, taken alone, is clearly superior. In this framework, Ainslie shows that any temptation may be resisted if an individual with a hyperbolic discount function takes into account enough future time periods. Individuals may differ in their ability or inclination to consider future time periods when making current consumption choices, but have the potential to make consistent choices — to abstain in the present if future abstention is valued higher than future consumption even if current consumption is valued higher than current abstention. The ability to make consistent choices depends on the individual's willpower, or length of time horizon they take into account.

Finally, O'Donoghue & Rabin (1999, 2000) have developed further modifications of the hyperbolic discounting function to describe individuals' self-control problems and variations across individuals in their methods of managing self-control problems. In this framework, individuals can be described as either sophisticated or naïve with respect to their self-control problem. Much like Ainslie's characterization of willpower, when making decisions about consumption of an addictive good, a sophisticated individual in O'Donoghue & Rabin's models will foresee their self-control problems and take them into account in their current decisions. Thus, a sophisticate will correctly predict that they may have self-control problems in the future, and adjust their current consumption decisions accordingly. In contrast, the naïf will not foresee their future self-control problems, and thus cannot appropriately adjust their current behavior to take the future into account.

The behavioral implications of sophistication and naivety depend on the type of activity being considered: whether there are immediate costs or immediate rewards. In cases where there are immediate costs and delayed rewards, sophisticated individuals have a clear advantage over naïves. For example, when considering quitting smoking, a naïf will procrastinate and as a result will continue to smoke in future periods. The result is analogous to simple hyperbolic discounting, whereas the future period becomes the present, the procrastinator will pursue the immediate gratification of indulging rather than abstaining as planned. In contrast, a sophisticate may procrastinate (smoke now, but plan to quit in the future), but will not procrastinate when the future costs become too high. This case is similar to Ainslie's characterization of willpower, where the sophisticate will take into account future utilities when considering the utility of indulging (smoking) in the present.

In O'Donoghue & Rabin's framework, however, when the consumption involves an immediate reward and delayed costs, the outcomes differ slightly. Again, it is useful to consider the case of quitting smoking. This time, there is an immediate reward and delayed costs in continuing to smoke, rather than the immediate cost and delayed reward of quitting. In this scenario, the naïf will again continue to smoke because they fail to foresee the later costs and will indulge in the present. The sophisticate, on the other hand, will foreseeable the later costs, but correctly predict that they will have self-control problems in the future — in this case, they will likely relapse. As a result, the sophisticate will view quitting in the
present as a lost cause, since they foresee relapse in the future, and therefore will not quit in the present.

**Conclusions: The Relationship Between Rational Addiction and Behavioral Economics Models of Addiction, and Next Steps**

In sum, the recent theoretical developments in the behavioral economics of addiction in general and smoking in particular provide a framework for considering behavior that the traditional economics and rational addiction models do not fully address. These rational addiction models, however, represented important advances in our understanding of addictive behaviors. Indeed, in order to understand addiction, economists needed to address the issue of whether addiction behavior could be characterized as rational. Early models of addiction characterized smokers' preferences as generally stable, but imperfectly rational (Baltagi & Levin 1986; Jones 1994; Mullahy 1985; Pekurinen 1989; Pollak 1975; Young 1983). In these models, addiction was explained by inconsistencies between smokers' short-run and long-run preferences, whereby smokers wanted to quit in the long run but were driven by their short term preference to have a cigarette now. These ideas are echoed in Thaler & Shefrin's (1981) characterization of the "planner" and the "do-er." Formal modeling of imperfect rationality required a non-exponential discount function, which foreshadowed Laibson's notion of a hyperbolic discount curve.

Early models of addiction characterized demand for addictive products, like cigarettes, as myopic. In other words, demand depended on past and perhaps current levels of consumption but ignored future preferences. By incorporating future expectations about prices and consumption levels into the myopic model, the idea of rational addiction evolved. Becker & Murphy (1988) described a model of rational addiction that allowed for three key attributes of addiction: tolerance, reinforcement, and withdrawal. This rational addiction model, however, presumed perfect foresight of the future; critics noted that such a model did not allow for an addict's regret. Under rational addiction, therefore, an addict essentially chooses to be an addict ex ante.

Addicts' regret was addressed with the introduction of the idea that consumers of an addictive product recognize that addiction is not a certainty (Orphanides & Zervos 1995). Thus, consumers must subjectively judge the probability that they will experience the harmful effects of the addictive product, based on their observations of others' experiences as well as their own experiences with that or similar products. If this judgment of these probabilities, or gamble, is wrong, the consumer can become a regretful addict. This model helped explain youthful experimentation that evolves into addiction. Suranovic et al. (1999) advanced the theory of rational addiction by describing that one implication of the complementary relationship between current, past and future consumption is that efforts to reduce current consumption will lead to reductions in future utility. These "quitting costs" thus explain the addict's regret: the seeming inconsistency between smokers' stated wishes to quit smoking and their continued cigarette consumption. The behavioral economics approach described by O'Donoghue & Rabin (1999) applies a slightly different perspective to this phenomenon, by dividing individuals into those who are sophisticated and can correctly predict how they will behave in the future, and those who are naïve and fail to do so.
While there is substantial overlap between the rational addiction and behavioral economics models of individuals' demand for addictive products, in many cases behavioral economics models promise to explain complexities in addictive behavior that the rational addiction models have not fully addressed. In large part, however, the theoretical explanations of behavioral economics largely remain to be confirmed empirically, and also raise several additional important empirical questions. For example, is the hyperbolic discount function a generalizable model, or is there a segment of the population that applies the traditional exponential discount function, and its assumptions about intertemporal consistency, to decisions about the consumption of addictive goods? Similarly, even considering only hyperbolic discounters, how does this population vary in the degree to which it takes into account future time horizons? To what extent are individuals in the population sophisticated or naïve, and how does this vary across age groups or educational levels? Since these models and the questions they raise involve behavior and choices over time, detailed longitudinal data from a broad population are necessary to address these empirical considerations.

Notes

1. Vuchinich & Simpson (1998) provided an interesting application of this idea to the demand for alcoholic beverages, comparing behavior under hyperbolic vs. exponential discounting.
2. Myopic addiction models also predict that the long run price elasticity of demand will be larger than the short run elasticity.
3. See Chaloupka (1988, 1990, 1992) or Becker et al. (1994) for a more formal discussion of these price effects.
4. The authors concluded that there was insufficient information in the data to accurately estimate the discount rate, but that their estimates were clearly inconsistent with myopic behavior.
5. For a discussion of a number of other requirements for the participants and more detail on the features of these experiments, see Bickel & Madden (1998).

References


Comments on Chaloupka, Emery, and Liang

Robert MacCoun

Frank Chaloupka has made major contributions to the empirical study of addictive drug use, and he and his colleagues provide a valuable review of the growing economic literature on addiction. Their paper documents recent movement away from the strict “rational addiction” framework of Gary Becker and his colleagues, in the direction of models that correspond more closely to recent psychological theorizing about addiction. This is a shift in orientation as well as content. The newer theories tend to start with the behavior of addicts and try to model it; Becker and colleagues started with a model (rational choice) and tried to make it behave like an addict.

By focusing my brief comments on Becker’s rational addiction theory (RAT), I necessarily exaggerate the differences between economics and psychology regarding addiction, because Becker’s model is economics’ least psychological statement. Elsewhere, Peter Reuter and I described RAT as “an intellectual tour de force of unknown relevance to the phenomenon of real-world addiction” (MacCoun & Reuter 2001: 64). Here, writing without my economist co-author, I am inclined to be less equivocal. There are good reasons to believe that RAT is wrong as a model of the addiction process. But at the same time, I think it is a mistake to dismiss its contribution to drug policy analysis.

RAT as a Process Model of Addict Choice

I will not rehearse the cogent points about RAT made in other papers in this volume (or in Skog’s (1999a, b) sophisticated and fair-minded assessments). But in brief, there is now a wealth of evidence suggesting that important aspects of RAT are almost certainly wrong. First and foremost, in dozens of direct empirical tests, temporal discounting — by addicts, non-addicted people, and animals — is better described by hyperbolic discounting than by exponential discounting (see, e.g. Ainslie & Monterosso Chapter 1, Rachlin Chapter 4, Skog Chapter 5, Cardinal et al. Chapter 6, Bickel and Johnson Chapter 8, Mitchell Chapter 11, this volume). Exponential discounting implies, as Chaloupka and colleagues put it, “that individuals consistently maximize utility over their life cycle.” Hyperbolic discounting implies preference reversals over time.

Moreover, it is not at all clear that people — be they pension managers or heroin addicts — have anything like a coherent “lifetime utility function.” The notion is contradicted by much theory and evidence in cognitive psychology (see Kahneman & Tversky’s 2000 edited collection), behavioral finance (e.g. Benartzi & Thaler 1995), and behavioral economics
(Rabin 2000; Rabin & Thaler 2001) showing a disconnect between our assessments of isolated, moment-by-moment choices and the way we might assess aggregated, lifetime utility — if we actually did so.

For example, Rabin (2000) has shown that the degree of concavity necessary to describe risk attitudes in low stake situations generates preposterous predictions for high stake choices. Rabin & Thaler (2001: 225) argue that “the correct conclusion for economists to draw, both from thought experiments and from actual data, is that people do not display a consistent coefficient of relative risk aversion, so it is a waste of time to try to measure it.” In fairness, this body of work does not examine drug addicts, but everything we know about addicts suggest less planning, not more, than recent studies find in college students and financial investors.

**Price Matters**

If I and others are correct that RAT is wrong as a process model of addict choice, then what are we to make of the moderate empirical success of the theory in econometric tests? RAT's greatest empirical success, and its most important contribution, is the notion that addicts are sensitive to current drug prices. For the rationality debate, this is more molehill than mountain. Responsiveness to price is about as minimal a requirement for rationality as one could ask for. Pigeons are price-sensitive in the psychology laboratory; most animals are price-sensitive in ethological studies of foraging behavior in the wild.

But for policy analysis, addict sensitivity to prices is enormously useful information. For a long time, many of us had unthinkingly accepted the idea that addicts were so chemically enslaved that they'd obtain their daily dose at almost any cost. If addicts are indifferent to price, then any intervention that drives up the price of a drug will have unintended deleterious consequences — addicts will divert more of their income from the support of their household and dependents; they may commit more income-generating crime; and illegal drug traffickers or licit tobacco companies will earn more profits at the expense of public health.

Chaloupka and colleagues cite evidence that smokers engage in compensatory behavioral responses to tax and price increases, which would imply that “the perceived health benefits associated with higher cigarette taxes are likely to be somewhat overstated.” (For further evidence, see MacCoun & Reuter 2001, Chapter 15; Stratton et al. 2001.) Of course, a corollary is that these compensatory responses imply that estimates of price elasticity of demand probably overstate smokers' willingness to reduce their habit in the face of rising prices. At least initially, smokers can reduce the quantity of tobacco they purchase without reducing the quantity of tars and nicotines they consume, by inhaling deeper, holding the smoke in longer, or switching to brands with more tars or less efficient filters.

The behavioral economics literature suggests that there may be better ways to model addiction than the RAT account, but Becker and his colleagues surely deserve credit for establishing price as an important variable in a literature previously dominated by classical conditioning cues, faulty parenting, peer pressure, and other variables less amenable to aggregate measurement and forecasting.
Back to the Future

Accepting that current prices matter is quite different from accepting that future prices matter. Chaloupka, Emery, and Laing review evidence that future prices are associated with current tobacco consumption, and following Becker and colleagues, they interpret this as an indication that users form rational expectations and incorporate those expectations into their current choices. I do not contest the notion that addicts, like non-addicts, sometimes consider the future consequences of their actions. As a father of two young children, I am quite preoccupied with college tuition levels two decades from now. Because it clearly affects my concerns about how to pay for their education, rather than my decision about whether to pay for it, there's a temptation to say, "Well, of course, but that's your child's education, not your cigarette (coffee, cocaine, etc.) habit." But, of course, that response begs the question that we are asking: Just how important is the addict's habit to the addict?

Economists who believe in rational expectations need to shoulder more of the burden of proof here. Our understanding of hyperbolic discounting and temporal myopia, as well as a rich ethnographic literature on addict behavior, make it hard to swallow the idea that future price changes play anything but a trivial role in addicts' current choices.

If addicts aren't considering future prices, why are future prices associated with current use? Future prices might be an econometric proxy for unobserved concurrent rational expectations about the future. But they might also be a proxy for a host of other concurrent factors that are correlated with future prices. Tobacco prices can increase because of rising agricultural and other business costs. But they can also rise because of increases in tobacco taxes. It takes tremendous political mobilization to raise "sin" taxes in the face of powerful industry opposition (see MacCoun & Reuter 2001, Chapter 8). How can we be sure it is the anticipated price rise, rather than the impassioned anti-smoking campaigns, that is producing reductions in current consumption? One could make a similar argument at a smaller scale about price increases due to rising tort litigation expenses.

So if future prices are associated with current consumption, the burden would seem to lie with RAT theorists to do more to show that this indicates a rational expectation effect. On the dependent measure side, one would like to see direct measures of perceived expectations about cigarette prices, and statistical evidence that such expectations mediate the "effect" of future prices on current consumption. On the independent variable side, one might test the differential "effects" of future tax increases vs. non-tax price increases, and the effects of tax initiatives vs. non-tax anti-smoking campaigns. One could operationalize anti-tobacco campaigns using advertising budgets, minutes of radio and TV airtime, newspaper column inches, and so on. Supplementing U.S. data with evidence from other nations might provide more variance in tax levels and price trends.

Tobacco is Different

Chaloupka and his colleagues have published important studies of illicit drug use, but their review indicates that most of the econometric work on addiction has focused on tobacco. From a public health standpoint, this focus makes great sense, as tobacco’s health harms
swamp those of the other drugs. And from a methodological standpoint, there's no question that tobacco data are far richer and more reliable than data on illicit drug use. Still, the heavy focus on tobacco does create some inferential problems.

On the demand side, tobacco differs from other addictive drugs in many ways. It is less intoxicating and more easily integrated into daily activities than other drugs (at least outside the U.S.!). Until recently, the costs it imposed on others were not seen as a significant factor, so anti-smoking stigma is far less developed than, say, anti-heroin stigma. And nicotine is probably more dependency-promoting than many drugs, a fact that probably strengthens the case that Becker, Chaloupka and others are making about rationality; if nicotine is more addictive than other drugs and tobacco addicts appear rational, there is an a fortiori case that other addicts might be rational too.

On the supply side, the fact that tobacco is legal makes the case for generalization more daunting. Tobacco can be readily purchased in many different locations (no network or dealer contacts needed). Tobacco prices are surely lower than they would be in an illicit market. Tobacco users are far less likely to be criminally active than, say, heroin addicts, who often commit crimes to raise money for their habit, and who by definition are willing to break the law. We know far less about the case for rational addiction involving illegal drugs, and the data (especially on prices) are far noisier (Manski et al. 2001).

From a policy perspective, the fact that tobacco is legal means that it can be advertised and promoted, and it can be regulated and taxed. Regulation creates a host of policy levers unavailable to the prohibitionist (MacCoun et al. 1996). Because taxes and other price controls are possible, the rational addiction formulation has clear policy relevance. But the policy implications for a prohibition regime are far murkier. If correct, RAT encourages us to drive up drug prices, since that should reduce consumption with little increase in income-generating crime. But our only mechanisms for doing so are the various forms of supply reduction: interdiction, source-country controls, aggressive enforcement against street dealers. And there are serious questions about whether these efforts actually reduce illicit drug supplies to any significant degree, and whether the benefits outweigh the collateral damage (see Caulkins & MacCoun in press; Manski et al. 2001; Reuter et al. 1988).

Notes

1. In their paper, Chaloupka and colleagues describe Laibson's model as hyperbolic, and Ainslie's model as quasi-hyperbolic. In fact, it is the other way around. Laibson's model comes closer to a step function; it is more tractable but fails to capture some empirical subtleties of discounting behavior.
2. One possibility is that price increases are a response to current prevalence, though I think at least some analyses rule this out.
3. Over the period 1985–2000, average real tobacco prices (excluding tobacco taxes) have risen 100%, while average combined state and federal tobacco taxes have risen 56%. (Rosalie Pacula, Senior Economist at RAND, personal communication on 30 January 2003.)
4. Specifically, current consumption should be correlated more strongly with expected future prices than with actual future prices, because expected prices are the intermediate causal link and because if prices diverge from expectations, it is the expectations that should drive choices. See Baron & Kenny (1986).
References


