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DERIVING ADDICTION

An analysis based on three elementary features of making choices

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Introduction

Individuals make choices according to quantifiable behavioral principles. Depending on specifiable conditions, these principles produce optimal outcomes, near optimal outcomes, or seriously sub-optimal outcomes, which involve compulsive-like, excessive levels of consumption of a highly preferred substance or activity (Heyman 2009). In this chapter I focus on three elementary features of how people make choices. Although they are perfectly ordinary and are active in all decision making, they can result in drug binges, excessive drug use, and the pattern of remission and relapse that characterizes addiction. By analogy meteorology textbooks teach us that the physics that governs everyday weather is the same physics that foments typhoons. My analysis begins with a brief overview of the topic to be explained: addiction.

What is addiction like?

Clinicians and researchers rely on the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM*) to distinguish drug addicts from drug users so that this manual provides a useful starting place for characterizing addiction. The authors of the 4th edition (APA 1994), which is the reference for much of the research cited in this chapter, state:

> The essential feature of Substance Dependence is a cluster of cognitive, behavioral, and physiological symptoms indicating that the individual continues use of the substance despite significant substance-related problems. There is a pattern of repeated self-administration that usually results in tolerance, withdrawal, and compulsive drug-taking behavior.
>
> *p. 176*

Following this passage, the *DSM* lists several clinically significant behavioral features of drug use: tolerance, withdrawal, using more drug than initially intended, failing to stop using after vowing to do so, and spending excessive amounts of time chasing, procuring, and consuming

drugs. If three or more of these symptoms are present in the previous twelve months then the drug user is considered "drug dependent." However, the APA's account of addiction leaves out essential information and is misleading if this information is not included. (There is a 5th edition of the *DSM* (APA 2013), but I believe that it will prove less useful as a research tool than earlier editions because it relaxes the criteria for distinguishing between drug users and drug addicts.)

Common properties of addictive drugs

The temporal profile of costs and benefits. The positive hedonic effects of drug use are virtually immediate, whereas the costs are delayed and probabilistic. For instance, many smokers do not get cancer, and the delay from the onset of smoking to smoking-related illnesses is measured in decades. In contrast, the rewarding pharmacological and sensory effects of smoking are immediate and certain, taking place in seconds.

Sites of action, dose levels, psychological implications. With the exception of alcohol, addictive drugs bind to subcellular neuronal components that mediate neuronal communication. Consequently, they are highly potent; miniscule (milligram) doses produce dramatic changes in thought, feeling, and action. Nevertheless, the dose levels for self-administered drugs are several orders of magnitude greater than their naturally occurring counterparts (e.g., Comer *et al.* 2010; Dole 1980). This difference has important psychological implications. First, drugs are not satiating in the sense that food and drink are. This means that there are no naturally occurring self-inhibiting processes as in food consumption. Rather, the user has to judge whether he or she has taken enough drug. Second, addictive drugs can produce psychological effects that have no peer. For instance, a common theme in memoirs and interviews with addicts is that their drug highs are unlike anything else. Typical accounts of heroin include the following: "filling me up with a sensation I never felt before. . . . [i]t was the most intense nothingness there ever was. . . . There's no right, no wrong. Everything's beautiful." Addictive drugs corner the market on intoxication.

The natural history of drug addiction

The consequences of drug use change over time. Initially, there is a "honeymoon" period in which few, if any, of the costs of getting high have had time to emerge. But, as drug use continues and becomes more frequent, the consequences begin to include direct negative effects, such as tolerance and withdrawal, and indirect, socially mediated penalties, such as criticism from friends and family, legal problems, financial problems, workplace problems, and the like. Over time, the negative effects accumulate and the positive effects weaken (e.g., tolerance) so that, eventually, there is a period in which drug users often claim they want to stop using but keep using anyway. This is often described as loss of control.

Day-to-day patterns of use. Regular drug use requires planning and subterfuge. Drugs are often hard to come by and, if illegal, purchases must be made with care, planning and duplicity. To a lesser extent, legal addictive drug use comes with the same challenges. Implicit in these observations is that even the heaviest users are not high all the time. Indeed, many addicts have regular or part-time jobs and families that they tend to (e.g., Courtwright *et al.* 1989; Hanson 1985). Thus, addicts are not without opportunities for non-intoxicated reflection on whether to continue using drugs (e.g., Toneatto *et al.* 1999).

Filling in the gaps in the DSM account of addiction

This overview is based on observations and reflections on drug use in addicts (e.g., Biernacki 1986; Waldorf *et al.* 1991). Although the reports were not aimed at providing diagnoses, they are consistent with the APA account—with one exception: the word "compulsive." However, the *DSM* authors (APA 1994: 178) go on to say that what they mean by "compulsive" is that drug users take more drug than they initially intended or for longer than they intended and tried to cut back or quit but didn't. However, taking more drugs than intended does not imply compulsion; it could mean that there were consumption-dependent changes in preference. For example, it would be surprising if preferences did not change while intoxicated. More generally, all of the *DSM*'s examples of compulsion serve equally well as examples of ambivalence or changes in preference. Addictive drugs are uniquely attractive as well as uniquely perverse.

Three elementary features of choice

This next section identifies three elementary features of making choices. They are in play whenever anyone chooses between two or more substances or activities. Although they are perfectly ordinary, and usually lead to adaptive if not optimal outcomes, they can produce seriously suboptimal, pathological outcomes under certain conditions. Addictive drugs provide these conditions.

(1) *Preferences are dynamic.* The value of a substance or activity changes as a function of previous choices and/or the passage of time. In most instances the relationship is negative, as when eating reduces the value of food because of satiation. The positive instances are less common but familiar. Salty, sweet, and fatty foods whet appetite, at least at first, and activities that foster greater skill and knowledge grow in value as a function of practice.

(2) *Individuals always choose the better option*. This is true by definition. However, what is the best choice is ambiguous because there is usually more than one way to frame the options. As described below, and as is shown in Figures 2.1 and 2.2, it is possible for the best choice from a "local" perspective to be the worst choice from a "global" perspective.

(3) *In a series of choices between two or more items, it is possible to aggregate the options in different ways, which, in turn, yield different choices*. For instance, given a series of choices between two items, say, "A" and "B," consumers may choose more of "B" if they frame their choices as a series of independent trials, but then choose more of "A" if they frame their choices as bundles composed of different proportions of "A" and "B." It is convenient to label individuals who frame their choices as independent trials "local bookkeepers" and to label individuals who frame their choices as bundles "global bookkeepers."

Figures 2.1 and 2.2 are based on these three principles. They mimic graphs that researchers use to illustrate quantitative models of the relationship between reward and choice in laboratory studies of choice (e.g., Herrnstein *et al.* 1993). In the lab, the equations accurately predict the relationship between choice and reward rates. However, as models of addiction they are necessarily highly schematic simplifications that leave much out. Nevertheless, Figures 2.1 and 2.2 predict the essentials of addiction as well as some of the details that distinguish addiction from other psychiatric disorders.
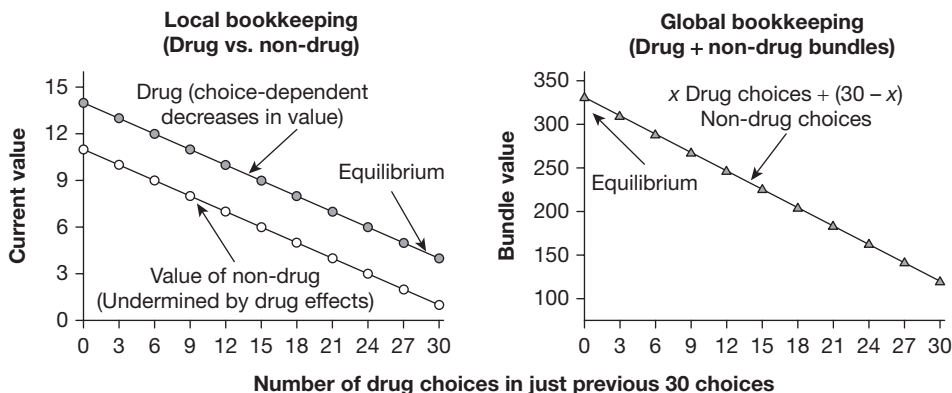
Figure 2.1 Choice for drug and non–drug days. In a highly schematic way the graph mimics the *DSM's* account of addiction.

On the *x*-axis of the left and right panels of Figure 2.1 is the number of choices for the drug out of the most recent 30 choices. The *y*-axis in the left-side panel represents the value of each item at the moment of choice. For instance, if 15 of the just previous 30 choices are for the drug then the current values of the drug and non–drug are "9" and "6" (arbitrary units). The *y*-axis for the global bookkeeper (right-side panel) lists the value of every possible combination of 30 drug and non–drug days. For instance, the global bookkeeper asks "what is the best combination of the two items: 15 drug days and 15 non–drug days or maybe 10 drug days and 20 non–drug days?" Put another way, global bookkeepers frame their options as rates of consumption, just as someone might choose between two or more weekly meal plans composed of different proportions of meats, vegetables, salads, and soups, or someone might choose between two or more schedules of going to the gym, working in the garden, spending time in service activities, shopping, cooking, etc. According to this analysis, a key component of how individuals make choices is how they frame them.

Binging on drugs, remission, and relapse as shifts in how choices are framed

According to the *DSM*, addicts are compulsive drug users, e.g., binge on drugs, take more drugs than initially intended, quit using but then relapse. Figures 2.1 and 2.2 illustrate these patterns, although the underlying principles are the general properties of all choices, not compulsion. Consider Figure 2.1 first.

The negative slope for the drug represents its decline in value due to tolerance. The negative slope for the non–drugs represents the toxic effects of drugs on other aspects of life, e.g., drug-related problems at home, in the neighborhood, and at work (what the *DSM* refers to as "significant substance-related problems"). Since by definition individuals always choose what is best, the local bookkeeper keeps choosing the drug over the non–drug even though this is making everything worse. The result is an all-out binge, and, according to the right-side panel, the lowest possible combination of drug and non–drugs days.

Now, imagine a dramatic change in circumstances that turns the local bookkeeper into a global bookkeeper. For instance, a common theme in the ethnographic literature is an event that precipitates taking stock of one's life. The examples are witnessing an overdose or the

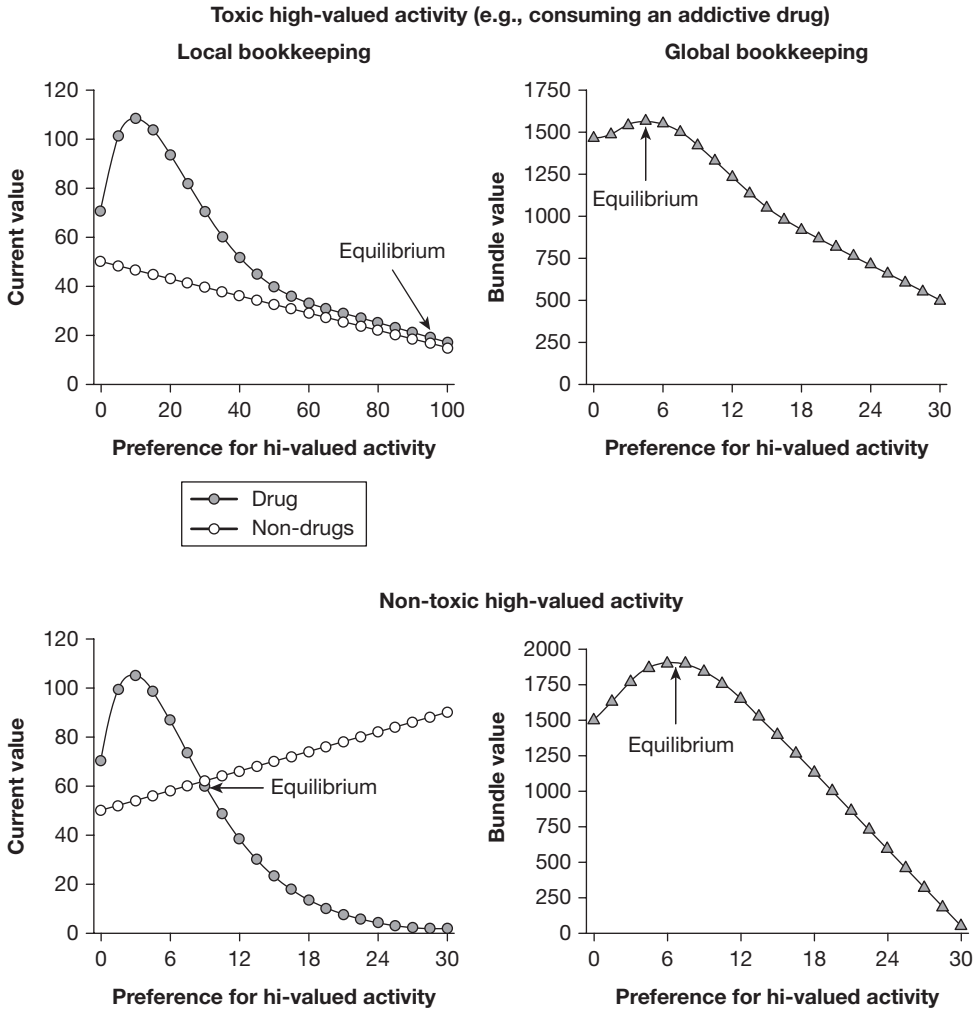**Toxic high-valued activity (e.g., consuming an addictive drug)**

Figure 2.2 The relationship between choice and changes in value for a behaviorally toxic activity (e.g., drug taking, the top panel) and non-toxic but highly valued activity (bottom panel). The differences provide clues as to why certain substances are addictive and why they are usually drugs.

Source: the author.

realization that drugs have become more important than family (e.g., Biernacki 1986; Jorquez 1983; Premack 1970; Waldorf *et al.* 1991). According to the value functions in Figure 2.1, the best bundle contains exactly zero drug days, thereby bringing a halt to drug use. In other words, Figure 2.1 provides a schematic account of "hitting rock bottom" motivated recoveries. But, of course, events can also invite local bookkeeping. According to the same sources that provide first-hand accounts of remission, there is a pattern to the events that trigger relapse. They are "special occasions" and so-called "one last times." For instance, running into an old drug buddy, a recent setback, or, perhaps, just the opposite, a recent success, can trigger the myopic "today is an exception" and a return to heavy drug use. (See below for further discussion of the psychology of "special occasions.") Thus, depending on the frame of reference, simple choice principles

predict either an all-out binge or abstinence, as well as some of the language that accompanies them. Also notice that the graph illustrates the AA saying that "for an alcoholic, one drink is too many and a thousand are not enough."

In the top panel of Figure 2.2, local bookkeeping also leads to binging on the higher valued activity. However, the comparison with the value functions of the lower panel provides clues as to why most highly valued activities are not addictive. Figure 2.2 also helps make the point that the conflicting predictions of local and global bookkeeping are not restricted to the highly simplified value functions of Figure 2.1.

What makes a substance or activity addictive?

The three principles that generated drug binging in Figure 2.1 and in the top panel of Figure 2.2 say nothing about drugs. But of the many activities and substances that people find highly rewarding, relatively few are the focus of addictions, and of those few, most—or all—are drugs. These two observations invite two questions: what makes something addictive and why are drugs the most likely addictive substances? Figures 2.1 and 2.2 suggest two answers. First, the comparison of the top and bottom panels of Figure 2.2 says that substances and activities that undermine the value of the competing choices are more likely to become addictive. For instance, preference for the high valued activity in the bottom panel of Figure 2.2 does not lead to binging because the non-drug activity maintains its value. Indeed, as is typically the case for conventional rewarding activities, the value functions in the bottom panel of Figure 2.2 follow the rule of diminishing marginal returns. As shown in the top panel, addictive drug consumption leads to violations of this rule for the competing goods. Second, regardless of how toxic a substance and activity might be, Figures 2.1 and 2.2 say that global bookkeeping will prevent addiction. Thus, substances that undermine or challenge cognitive capacities necessary for global bookkeeping are likely candidates for addiction. Drugs do this in three ways. Intoxication undermines judgement; the combination of immediate rewards and greatly delayed costs that are typical of addictive drugs make estimating the drug's net value difficult; and that drugs do not satiate robs the user of simple cues as to how much is enough. Hence drugs end up as the most likely candidates for supporting addictive behavior.

Addictive drugs may also induce residual cognitive deficits that interfere with global bookkeeping. Given their potent intoxicating effects, this is highly plausible. However, the evidence on this question is inconsistent (Heyman 2009; Toomey *et al.* 2003). For instance, Figure 2.3, presented below, suggests that if there are serious drug-induced cognitive deficits, they do not appear to prevent most addicts from remitting.

Local and global bookkeeping provide guides to the unique vocabulary of addiction

The terms "hitting rock bottom," kicking the habit," "going cold turkey" are specific to addiction. No one goes "cold turkey" from depression or diabetes. There are also addiction-specific excuses, as intimated above. A theory of addiction should be able to predict the unique features of addiction.

Relapse and other forms of backsliding are often precipitated by the verbal formulas "this is a special occasion," or "this is the last time," or "tomorrow I turn over a new leaf." According to Figures 2.1 and 2.2, these are perfect excuses. On the last choice in a series of choices, the conflicting dictates of local and global choice disappear. The global perspective requires future choices whose values are affected by the present choice. When it is the last of a series of choices,

the only possible framework is the present, which is to say the local perspective. If drug use makes the "last" few moments the best possible last few moments, there is no reason to abstain. Of course, it may turn out that there are more "last" times and more "new leafs" to turn.

Idioms emerge "spontaneously" as a function of experience. The idioms "kicking the habit" and "going cold turkey" refer to the fact that heroin addicts sometimes quit drugs all at once and on their own. Figures 2.1 and 2.2 provide mechanisms for such sudden shifts in symptoms. These idioms are now common parlance for all drug addictions but have not become part of the conversation in regard to other psychiatric disorders. This suggests that local and global book-keeping, although part and parcel of all decision making, play more of a role in addiction than in other psychiatric disorders. In any case, the graphs help explain drug binging, remission, relapse, and the psychology and conversation that accompanies these fundamental features of addiction.

What is the evidence for the role of local and global bookkeeping in making choices?

Local and global bookkeeping are well represented in experiments on choice, in economic analyses of consumer choice, and every-day observations. Consider local bookkeeping first.

The equilibrium points in the local bookkeeping panels of Figures 2.1 and 2.2 are identical to experimental psychology's "matching law" equilibrium points (Herrnstein 1970). This result, as the label "matching law" suggests, has been observed in hundreds of experiments, conducted both in and outside of laboratory settings (Davison and McCarthy 1988). In experiments with infra-human subjects, matching is the expected result, despite reliably producing substantially suboptimal returns under some conditions (e.g., those shown in Figure 2.1). However, in a choice experiment with pigeons in which the experimenters introduced stimuli that explicitly signaled global bookkeeping reward bundles, the pigeons deviated from matching as predicted by global bookkeeping thereby increasing reward rate (Heyman and Tanz 1995)—a result that underscores the cognitive dimensions of local and global bookkeeping.

In experiments with human subjects the results vary. In many studies the subjects routinely match choice and reward proportions as in the animal research, whereas, in others, some sub-jects make choices that approximate the maximizing global bookkeeping predictions (Davison and McCarthy 1988; Herrnstein *et al.* 1993). These differences may reflect individual difference in the capacity to detect higher-order relations in the structure of the reward contingencies. For example, in a study in which the choice trials occurred every ten seconds or occurred in a pattern of three closely bunched trials separated by 30 second gaps, choices shifted from the pattern predicted by local bookkeeping towards the pattern predicted by global bookkeeping (Kudadjie-Gyamfi and Rachlin 1996). In other words, when the researchers introduced a cue that highlighted the ways in which the apparently competing choices could be treated as bun-dles, the subjects switched to the more profitable bundle approach.

Global bookkeeping is how economists depict consumer choice. For example, in a widely used text that has gone through at least 13 editions, Baumol and Blinder (1994) whimsically provide the example of consumers choosing between the best combinations of packs of rubber bands and pounds of cheese, e.g., "do I prefer two packs of rubber bands and three pounds of cheese or three packs of rubber bands and two pounds of cheese?" Although professors Baumol and Blinder may be alone when it comes to aggregates of rubber bands and cheese, people routinely aggregate their options. Competing bundles are what is at stake when we decide between different menus that each list different diets, when we decide between different schedules that each list different arrangements of a set of events, and even when we decide among different lifestyles and identities. For instance, a workaholic is someone who does not schedule in leisure time, and a "wild and

crazy guy" is someone who does not schedule. One implication of these observations is that life styles and prudential rules (e.g., "dessert comes after the main dish," "don't drink before noon") are a culture's way of signaling the advantages of bundling choices, just as researchers arrange stimuli that encourage choice bundling when they want to teach their subjects to maximize reward.

In summary, the research suggests that local bookkeeping prevails to the extent that the items and activities in question are perceived in terms of their "natural" perceptual differences, whereas conditions that promote the capacity to form more abstract option categories, composed of combinations of the substances and activities, promote global bookkeeping.

Voluntary drug use predicts that addiction is a limited disorder

Voluntary actions and involuntary activities differ in the degree to which they are maintained by their consequences. Examples include winks versus blinks, kicking a ball versus the patellar reflex, putting on rouge versus blushing, and so on. Elsewhere the importance of these contrasts has been discussed at some length (e.g., Heyman 2009). For the purposes of the next prediction, it is sufficient to point out that if voluntary behavior is guided by its consequences then it should be self-correcting, granted that (1) the consequences are deleterious and (2) there is a better alternative at hand. Applying this rule to addiction, the implications are that (1) addiction should not occur or (2), if it does occur, it should not persist for long (assuming better alternatives are available), and (3) addicts should be able to turn away from drugs on their own without the benefits of interventions.

The logic is correct but it leaves out the natural history of addiction. As described above, there is an initial honeymoon period in which drug use is, on balance, beneficial, followed by a period in which the costs and benefits may more or less balance each other out. Nevertheless, if addiction is a disorder and addicts really do remain voluntary drug users, as assumed in the discussion of Figures 2.1 and 2.2, dependence must voluntarily come to an end. In contrast, among many experts and the informed public, addiction is widely understood to be a chronic relapsing disease and that only treatment can help addicts stay clean.

Do most addicts quit using drugs as predicted by the claim that they remain voluntary drug users?

Figure 2.3 shows the cumulative frequency of remission as a function of the onset of dependence in a nation-wide representative sample of addicts (Lopez-Quintero *et al.* 2011). The researchers recruited approximately 42,000 individuals, with the goal that their sample would mimic the demographic characteristics of individuals between the ages of 18 and 64 living in the US. Once enrolled, the participants were interviewed according to a questionnaire designed to produce an APA diagnosis, when so warranted. On the x-axis is the amount of time since the onset of dependence. On the y-axis is the proportion of individuals who, according to the interviews, met the criteria for dependence for a year or more in the past, but did not meet these same criteria in the year prior to the interview or longer. The fitted curves are negative exponentials. They were drawn according to the assumption that each year a constant proportion of those still addicted remitted independently of how long they had been using drugs.

The cumulative frequency of remission increased each year for each drug, and the good fit of the equations to the frequencies of quitting says that addicts did so at a constant rate, regardless of time since the onset of dependence. By year 4, half of those who were ever addicted to cocaine had stopped using cocaine at clinically significant levels; the half-life of dependence on marijuana was six years; and for alcohol, the half-life of dependence was considerably longer, sixteen years. Taking into consideration typical onset ages for addiction (Kessler *et al.* 2005a), the results say that most of those
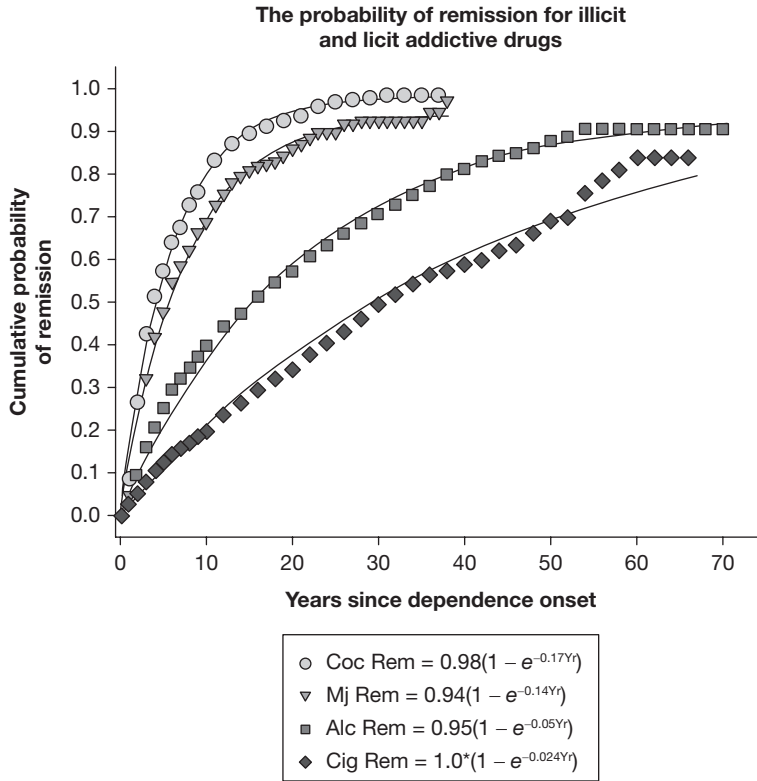
The probability of remission for illicit and licit addictive drugs

Figure 2.3 The cumulative frequency of remission as a function of time since the onset of dependence, based on Lopez-Quintero *et al*.'s report (2011). The proportion of addicts who quit each year was approximately constant. The smooth curves are based on the negative exponential equations listed in the figure.

Source: the author.

who became addicted to an illicit drug were "ex-addicts" by age thirty. Of course, many may have switched drugs rather than quit drugs, but other considerations indicate that this does not explain the trends displayed in Figure 2.3. For example, dependence on all drugs decreased as a function of age, which would not have been possible if addicts switched drugs rather than quit drugs. However, it is possible that one of the reasons that dependence on alcohol persisted so much longer than did cocaine and marijuana addiction is that a significant number of drug addicts continued to drink after stopping illicit drug use. Nevertheless, most alcoholics eventually became ex-alcoholics.

How did addicts quit?

The idea that voluntary behavior is self-correcting predicts that addicts can quit without the assistance of explicit clinical interventions. As predicted, researchers invariably report that most addicts do not seek treatment (e.g., Anthony and Helzer 1991; Robins 1993; Stinson *et al*. 2005). But there must be reasons for dependence ending. In the absence of clinical interventions, it is reasonable to suppose that the motivation was in response to the events of everyday life, such as economic issues, family pressures, concerns about staying out of jail, concerns about health, and the difficulties that attend any illegal and/or stigmatized pattern of behavior. In support of this inference, when

addicts talk about why they quit drugs they point to the sort of necessities of life just listed. In addition, accounts of quitting drugs often include moral concerns. With some frequency, ex-addicts explain that they wanted to regain the respect of family members, to better meet their image of how a parent should behave, and to better approximate their image of a person who is competent and in control of their life (e.g., Biernacki 1986; Jorquez 1983; Premack 1970; Waldorf *et al.* 1991).

The logic of voluntary behavior predicts that dependence is a limited disorder and that it can end without the benefits of interventions. Figure 2.3 and the finding that most addicts were not in treatment support these two predictions. However, it is not unreasonable to question the reliability of the results summarized by Figure 2.3 given that they disagree so with received understandings of the nature of addiction. This issue has been discussed in detail in previous publications (e.g., Heyman 2013). Some of the key findings are that (1) the results in Figure 2.3 are not new, but replicate the findings of the three previous US surveys of psychiatric disorders (Anthony and Helzer 1991; Kessler *et al.* 2005b; Warner *et al.* 1995). (2) Unreliable self-reports cannot explain the high remission rates. And (3) missing addicts due to mortality or unwillingness to cooperate with the researchers also cannot explain Figure 2.3. The good fit of the exponential model also deserves attention. It says that the likelihood of quitting was constant regardless of how long dependence had persisted. This is a surprising result, but one that has been reported elsewhere (Vaillant 1973). See Heyman 2013 for further discussion of this finding and Cantin *et al.* 2010 for analogous results.

Before concluding, it should also be pointed out that unassisted quitting is not an argument against helping addicts quit drugs. It is routine and sensible to use coaches and teachers to help facilitate mastery of difficult voluntary activities. Similarly, there are proven programs for accelerating the rate at which addicts quit using drugs (Davis *et al.* 2016). Given the great damage that addiction causes, effective treatment programs should be strongly supported.

Conclusion

Figures 2.1, 2.2, and 2.3 strongly support the idea that how individuals frame their options plays an important role in their welfare, the welfare of their family and the welfare of their community. Yet, the experiential and biological determinants of local and global bookkeeping remain largely unexplored. What is needed is a program of research that focuses on the factors that encourage global bookkeeping. The results may not only help us understand addiction better but also help us understand better the too familiar, often disastrous, shortcomings of human decision making in general.

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