Chapter 6: Addiction and choice

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Introduction

Tsunamis, cyclones and other natural disasters are orders of magnitude more powerful than their everyday counterparts, say the rolling waves of a seaside beach and the pleasant breezes of a cool summer evening. Understandably, events that are both massive and devastating have attracted explanations that operate on a similar scale, such as righteous gods who let loose earthquakes and floods to punish nonbelievers and evildoers. However, with the spread of scientific understanding, it has become widely accepted that extreme environmental events do not imply supernatural causes or even special principles. The physics of heat exchange, air pressure, moisture, and wind explain the modest and familiar transitions from a warm quiet afternoon to a cool breezy evening as well as the tumultuous and less common transitions from a tropical depression to the devastatingly high winds and drenching rains of a hurricane. The different outcomes reflect differences in the prevailing conditions, such as differences in latitude and water temperature, but not differences in governing principles.

In this chapter the lessons of natural science will be applied to the study of addiction. The guiding idea is that the same principles that explain everyday choices also explain addiction. The implication is that addiction is the result of an interaction: principles of voluntary behavior that normally produce adaptive outcomes, produce maladaptive outcomes when one of the choices is an addictive drug. For instance, when the choice is between cereal brands, the principles yield a beneficial or even optimal outcome, but when the choice includes a drug these same principles lead to overconsumption of the drug and a decrease in overall welfare.

The first task then is to identify a set of principles that will be used to describe choice.

These principles will be introduced with a thought problem, then presented in a graph, and then incorporated into a second graph that shows a hypothetical person who always chooses to use drugs and a hypothetical person who never chooses to use drugs. If the approach is valid, the condition for the graph that leads to exclusive preference for the drug will reflect well established features of addictive drugs.

Choice is studied on many levels by many disciplines. The resulting literature is huge. For the material presented in this chapter economic analyses of consumer choice and the research of Richard Herrnstein and his colleagues on the "matching law" and "melioration" are most important (e.g., Herrnstein, 1970, 1990; Herrnstein et al., 1993). The research results are very reliable. Indeed, it is possible to present them by way of a thought problem. The responses to the thought problem are also reliable and mimic the laboratory results.[1]

> Imagine that for the foreseeable future you will eat out every night at either a Chinese or Italian restaurant. Tell me how you would decide which one to eat at. The following conditions hold. (1) Prior to eating in either restaurant, your initial preference is for Chinese food. However, your preferences change as a function of which restaurant you choose. (2) Eating one type of food reduces your preference for it due to habituation. Conversely, not eating the other type of food increases your preference for it because of dishabituation.. (3) The habituation and dishabituation processes are stronger for Chinese than for Italian. That is, your taste for Chinese sours more quickly, but also regains its lost value more quickly. Tell me how you would proceed.

I then repeat this description and ask the audience how they would choose which restaurant to go to. The responses are surprisingly uniform. Almost everyone says that each night they would go to the restaurant that they currently preferred. Given the description, they say that

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[1] The thought problem is similar to ones that other authors have used to introduce some of the ideas presented in this chapter. See, for example, Herrnstein, R.J. (1990). Rational choice theory: Necessary but not sufficient. *American Psychologist*, *45*, 356-357.

this would usually be Chinese, but not always. Sometimes they would eat Italian but then they would switch back to Chinese, and so on.

Although this approach seems sensible if not ideal—what could be better than always doing what you liked best—there are usually a few people who offer a different approach. In so many words, they suggest that given that the meals change in value as a function of which one was chosen, it might be better to let the favorite type of meal get really good and then choose it. Implicit in this strategy is the idea that there might be an advantage in avoiding the option that is the current favorite.

The two strategies are similar in that the choice rule is to choose what is best. However, they differ in a way that proves very important. The difference is in how each strategy defines the options, where the options are the dimensions of the objects that are being compared. In the first and more likely strategy, the choice is represented as between two restaurants and each restaurant's value is its current value. This mirrors how the problem was presented, except that it does not explicitly address the habituation and dishabituation processes. In contrast, the idea of letting the value of the Chinese restaurant build up implies that each option involves more than the current situation. The build up of value has to occur over time, so that each option is necessarily a series of meals. Moreover, in order to let the Chinese meal get better the options will contain Italian as well as Chinese meals. Also notice, that to let the Chinese meal gain in value, it is necessary to avoid the Chinese restaurant even though its current value may be higher than the value of the Italian restaurant. That is, there is the possibility of a conflict between the choice dictated by the day-by-day strategy and the choice dictated by the multiple-day strategy.

The responses to the hypothetical choice problem echo three general principles that apply to all voluntary behavior. These will be listed and then displayed in a graph. The graph provides a convenient way to introduce basic features of voluntary behavior that are relevant to addiction, and once the responses to the thought problem are graphed, the same type of graph will be used to test whether these same principles also predict addiction.

Three principles of voluntary behavior

(1) Preferences are dynamic. Preferences change as a function of previous choices or simply time itself. In this example, preference led to a choice, which led to a meal, which reduced preference for the meal that was chosen. Conversely, not choosing a meal increased its value. Similarly preferences for physical and intellectual activities wax and wane as a function of engaging in these activities and as a function of the length of time since they were last engaged in. The dynamics linking preference, choice, time and outcomes are often quite complex. The first few bites of salty and sweet foods increase preference for sweet and salty foods, but then as eating continues these preference decline and may even turn into temporary aversions. For some people preferences relating to activities that involve skill and/or knowledge never seem to flag. However, regardless of the particulars, choice always interacts with the value of the available items so that they change in value.

(2) In a series of choices, there is more than one way to frame the possible options. It is always possible to choose between the available items one at a time, or to organize the items into sequences and then choose between different sequences. This will be called local and global-choice. Deciding each night which meal is better is the local approach. Deciding between

sequences composed of both Chinese and Italian meals is the global approach. Local-choice is simple but it ignores the dynamics that link choice and changes in value. In global-choice, the options (meal sequences) reflect the dynamic relationships between choice and changes in value.

(***3) Individuals always choose the better option***. In local-choice this means choosing the item that currently has the higher value. In global-choice this means choosing the collection or sequence of items that has higher value. (The local choice approach is also called "melioration" and has been the focus on a series of highly influential empirical and theoretical studies (e.g., Herrnstein & Prelec, 1992; Vaughan, 1981).

The restaurant problem as a window onto voluntary behavior

The responses to the restaurant problem point to the three principles just listed, and although self-reflections they also point to key features of the research literature on voluntary behavior. The relationships are most economically communicated by way of graphs.

Insert Figure 6.1 about here

Figure 6.1 displays a hypothetical pair of restaurants with meal values that correspond to the choice problem. The left panel represents someone who framed their choices on a meal-by-meal basis. The right panel shows someone who formulated the problem as if it were a choice among competing sequences each composed of several meals. Each definition of the problem can be represented by an equation, which results in the lines in the left panel and the curve in the right

panel.[2] The graph and equations show the following: (1) Each of the two ways of setting up the problem led to a stable overall choice proportion, called the *local equilibrium* and *global equilibrium*, respectively. (2) The two stable choice proportions differed. And (3) the (hypothetical) person who implicitly framed the problem as a matter of choosing between competing meal sequences experienced more enjoyment as measured by the overall value of eating out. This means that in the left panel, choice stabilized at a value that was associated with less than the maximum possible amount of enjoyment. Thus, how the options were framed, made a difference, all else the being the same.

The left- and right-panel perspectives led to different outcomes because the meal-at-a-time approach ignored the fact that current choices influence how enjoyable a meal would be in the future. In contrast, when options are framed as a series of choices, the choice-dependent changes in value are built into the choice unit. This is because the value of the string is determined by the frequency of each of its elements. Thus, one of the strings will contain the ideal number of Chinese meals. The ideal number increased overall enjoyment by about 20%. The next footnote gives a step-by-step account of how the three principles combine to yield two different outcomes.[3]

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[2] The left panel displays the value of a meal as a function of how frequently it was chosen. The value of a Chinese meal was set at (10 - 9p) and the value of an Italian meal was set at (3 + 1.5p), where p is the proportion of choices for the Chinese meal in the last 10 meals. The right panel displays the value of the possible combinations of Chinese and Italian meals. The equation is $10(p(10 - 9p)) + 10((1- p)(3 + 1.5p))$, where p is the proportion of Chinese meals and $(1 - p)$ is the proportion of Italian meals. The value/choice frequency relationships are the same in each panel. The only difference is in the "size" of the options.

[3] The problem specified that meal value varied as a function of frequency of meal choices. The graph captures this relationship by showing the frequency of Chinese and Italian meals on the horizontal (x-) axis and the value of the meals on the vertical (y-) axis. To make things more concrete, frequency was calculated over the last 10 meals. This means that each point on the x-

The implications of this result for the understanding of voluntary behavior are described next.

The lessons of dining out

The left and right panel summarize the research literature. In experiments on choice, choice proportions approximate either the local or the global equilibrium (e.g., Herrnstein, 1990). The typical finding is the local equilibrium. However, it is possible to teach both humans and pigeons to allocate choices as predicted by the global equilibrium (e.g., Heyman & Tanz, 1995;

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axis represents *n* Chinese meals and 10-*n* Italian meals. The *y*-axis shows how the value of a meal changed as a function of how frequently it was chosen (according to the equations in footnote 2). In the left panel the *y*-axis corresponds to the perspective of the person who chose which restaurant to go to on a meal-by-meal basis, which was what most people said they would do. The line sloping down from left to right is the current value of Chinese meals, and the line sloping down from right to left is the current value of Italian meals. (They slope down in opposite directions because the two types of meals are complementary.) The right panel shows the perspective of the few people who took into consideration that they might be better off of they selected the Chinese meal less frequently than their day-to-day preferences suggested. Hence, it shows the value of each possible series of 10 Chinese and Italian meals. These values were obtained by combining the equations for each type of meal (see footnote 2). For example, at *y*-axis point that correspond to 2-Chinese meals and 8-Italians meals shows the value of a string of ten meals composed of 2-Chinese meals and 8-Italian meals, using the values given in the left panel. Thus, the only difference between the two panels is in how the options were framed..

Each perspective led to a stable choice proportion. In the left panel this is the point at which the value lines cross. For example, to the right of the crossing point, the value of the Italian meal is higher, but choosing it, makes the value of the Chinese meal higher on the next night. Correspondingly, to the left of the crossing point, the value of the Chinese meal is higher, but choosing the Chinese meal, makes the value of the Italian meal higher on the next night. Thus, when someone chooses the best meal each night, choice proportions settle down to the crossing point. This is called the *local equilibrium,* because it is based on current conditions. In this example, it was at 67%, meaning an overall preference for Chinese food. In the right panel the stable choice proportion is the highest point on the curve because no other choice proportion provides more meal enjoyment. This is called the *global equilibrium* because it is based on current conditions plus the impact of choice on future conditions. It was at 40%, meaning an overall preference in favor of Italian food. Thus, the two perspective led to different overall choice proportions even though the restaurants are the same and equations for value and choice frequency were the same (see footnote 2).

Kudadjie-Gyamfi & Rachlin, 1996).

Voluntary behavior does not necessarily lead to the best outcome. In the left panel choice proportions stabilized at a suboptimal equilibrium. This was a logical consequence of the three principles and the fact that the meals had different initial values. Assuming the generality of the principles, suboptimal outcomes are inherent to voluntary behavior.

The suboptimal outcome was associated with overconsumption.. From the perspective of the global equilibrium, 40% of the meals should have been Chinese. Instead, local-choice led to a 67% preference for Chinese food. More than 50% too many. If Chinese food were a drug, the graph could be presented as model for drug abuse.

The contingencies that guide choice are ambiguous. There were two best ways of making the next choice. For any individual who sometimes employs a local choice strategy and sometime a global choice strategy, this implies that at times they will feel ambivalent.

Summary

Figure 6.1 provides a concise summary of key features of literally hundreds of studies on choice. Its implications differ from the understanding of choice that has informed the discussion of addiction. It shows that choice can stabilize at a suboptimal level of benefits, indeed this is the typical result, and that the contingencies that guide choice are ambiguous, thereby providing the necessary conditions for ambivalence. These are characteristics of voluntary behavior and they are also "reduced" or moderate versions of characteristics of addiction. For example, addiction is by definition a suboptimal choice, and relapse and attempts to quit using drugs are signs of ambivalence.

Graphing addiction

Applying the lessons of dining out to drug use. The restaurant graph is a representation of the three principles of voluntary behavior that followed from the restaurant thought problem. They are elementary observations that do not need proof. Thus, it will be of interest to see if these same three principles can also generate a graph that depicts a choice pattern that is consistent with addiction. This pattern should have two properties. The choice for the drug should increase as a function of drug use, and the value of the drug and of nondrug activities should decrease as a function of drug use. That is, as drug use increases, everything should get worse. But how can a graph like Figure 6.1 represent a drug? The *DSM* account of addiction provides the most appropriate guidelines. It is the most widely accepted characterization of addiction, and its approach is to addiction is largely descriptive.

Recall that the essential feature of addiction was that the drug user kept using drugs despite their "significant substance-related problems." This statement implies that the substances cause problems, and that these problems affect nondrug activities. Thus, the graph should show that as drug use increases, the values of the competing nondrug activities decrease. With this in mind, the three principles were combined so as to produce a graph that displayed the relationship between the frequency of drug choice and the values of the drug days and nondrug days. As before, one panel represents these relationships from the local-choice, and the other panel represents these relationships from the perspective of global-choice. The principles are the same as in Figure 6.1, but now one of the "commodities" is a drug that embodies the properties implied by the *DSM* account of addiction. In other words, the graph will simply combine what the *DSM*

manuals says about addictive drugs to the three principles. There are no other assumptions.

Insert Figure 6.2 about here

The left panel shows that local-choice led to an all out binge in which every choice was a drug choice. In contrast, the right panel shows that global led to abstinence, the drug was never chosen. Importantly, the equations were written so that the individuals represented by the left and right panels had precisely the same the same preferences for drug day and nondrug days. Yet, when the drug and nondrug day equations were combined so as to represent the value of 30-day sequences, the sequence with the highest value contained no drug days. Same preferences, same drugs, yet depending on how the options were framed, different choices. To see how this is possible, we need to examine the graph in some detail.

The x-axis in each panel of Figure 6.2 displays the number of days an individual chose to use a drug in the last thirty days. As in the restaurant graph, the x-axis represents a moving window. It shows the most recent thirty choices, not necessarily the first thirty opportunities to use the drug. The y-axis in the local-choice panel (left side) lists the current values of drug days and nondrug days. These values change as a function of how frequently the drug was used. In the global-choice panel, the y-axis is the value of each possible 30-day sequence of drug days and nondrug days. For example at $x = 12$, the y-axis displays the value of 12 drug days and 18 nondrug days. (As in the restaurant problem graph, order is not represented.) The value of each 30-day series was obtained by adding and properly weighting the value of x-drug days and (30-x)-

nondrug days.[4] The inner dialog that might accompany the left panel is " should I get high today?" The inner dialog that might accompany the right panel is "do I want to be high all the time, just on Saturday nights, or none of the time?" An important feature of the graph is that the same equations for the relationship between value and choice were used in each panel. However, they were combined differently so as to represent local options and global options (see footnote 4 for the combination rule).

The left panel represents what the APA account of addiction "looks" like. In the left panel the lines slope downward. This means that as the frequency of drug use increased, the value of drug and nondrug days decreased—everything got worse. The decrease in the value of the drug represents tolerance. The decrease in the value of the nondrug activities represents the direct and indirect effects of drug use that are referred to or alluded to in the *DSM* manual. . Intoxication and withdrawal impede normal functioning, particularly the activities called upon by conventional social situations and work. Someone who is high on heroin or who is going through withdrawal symptoms cannot properly tend to family responsibilities or fulfill most work expectations. The indirect costs are the socially mediated liabilities of drug use. These include legal consequences, such as an arrest record, and the stigma that often accompanies heavy drug use. In sum, the graph represents the fact that drug use undermines the value of legitimate activities that normally compete with drug use. Consequently, the value of the drug, although declining, remained higher than the value of nondrug activities. In the end, this dynamic process

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[4] The equation for the value of the drug is (14 -0.33x), where x is the number of drug days. The equation for the value of nondrug competing activities is (11- 0.33x). The equation for 30-day bundles is 30 ((p(14 -10 p) + ((1- p) (11- 10p))), where p is the proportion of drug days and (1 - p) is the proportion of nondrug days

stabilized at exclusive preference for the drug, even though the value of the drug had declined more than 60%.

Global-choice predicts abstinence. The right panel represents a global-choice version of the same person. His taste for drug and nondrug days has not changed, and the relationships between the frequency of drug use and value are the same as in the left panel. However, in the right panel drug and nondrug days are framed as elements in 30-day long sequences. Although the values of the constituent elements have not changed, the graph shows that the pattern of choices has changed. Now, instead of choosing drug every day, the drug is never chosen. This is because the 30-day sequence that had the highest value was the one that contained no drug days. Again, it should be emphasized that nothing has changed other than the frame of reference. According to the equations that were used to draw the lines in the left panel, the "person" represented in right panel never chose drugs although he liked drugs just as much as the "person" represented in the left panel.

The results are consistent with the initial hypothesis

This chapter began with the hypothesis that the principles that predict everyday choice also predict addiction. Figures 6.1 and 6.2 confirm the hypothesis. The pattern of choices in Figure 6.1 is consistent with the results of literally hundreds of studies (e.g., Davison & McCarthy, 1988; Williams, 1988), whereas the pattern of choices in Figure 6.2 is consistent with the *DSM* description of addiction. Importantly, the graphs include no other variables than the three principles, the assumption that there was a person who liked Chinese food more than Italian food, the assumption that there was a person who liked drug days more than nondrug days, and

the *DSM* account of addictive drugs. I chose the equations on the basis of simplicity. Elsewhere it is shown that other, more complicated equations produced similar results (e.g., Heyman, 1996). Thus, voluntary behavior can lead to a self-destructive state in which every option is at its lowest possible value.

Next, Figures 6.1 and 6.2 will be used as a model for explaining various features of addiction.

The lessons of Figure 6.2 for the understanding of addiction

Why addiction

Although highly simplified, the graph captures key features of addiction. From, the perspective of the right panel, the "person" represented in the left panel was highly self-destructive and excessive. "He" always chose the drug, and this resulted in more than a 60% decrease in overall benefits (assuming no drug use at the start).This came about because of an interaction. As the graph includes but two factors: the interaction was due to the principles of voluntary behavior and the fact that drug use undermined the value of the nondrug activities. In local choice, the value of each option is its current value. Hence, the drug's impact on other activities was ignored. As local choice is the typical experimental finding, local choice is typically led astray by addictive drugs.

Another property of addictive drugs that leads local choice astray is that their positive effects are occur virtually immediately, whereas their negative effects (such as withdrawal) are greatly delayed. This is not mentioned in the DSM manual. However, it is a common property of the major addictive substances, and it wreaks havoc with local choice. The delayed negative

effects either escape notice or are discounted. For example, as rewards and aversive events temporally recede their value decreases very steeply (according to a hyperbolic function, e.g.,Ainslie, 1975).

Thus, according to Figures 6.1 and 6.2 addiction is due to the mismatch between the properties of local choice and the properties of addictive drugs.

Why it is hard to quit using drugs

According to the right panel of Figure 6.2, a heavy user who switches to a global choice perspective will stop using drugs. However, the graph also reveals that it would be difficult to maintain this new perspective. This is because the rewards associated with the global perspective accrue rather slowly, implying that they would be difficult to detect, and they are delayed. The details of the graph reveal these dynamics.

The left panel shows that daily drug use secured 4.0 units of enjoyment a day. As this is the lowest point on the drug value line, it is also the worst that the drug had to offer. Now assume that drug use stops. If it stopped for 30 days, the right panel shows each day would now provide 11.0 units of day of pleasure, a substantial improvement. However, it would take 30 days to reach this goal. Moreover, the graph also shows that it would take about 13 days of not using drugs to create an average day that was as good as the worst heroin day. (It takes about 13 moves from left to right along the *x*-axis on the right panel to produce an average day of the same value as the worst drug day (4.0).) In other words, at the beginning of abstinence, there were lots of days that were worse than the most recent memory of a drug day.

These numbers of course are based on a hypothetical situation. However, the principle

holds. The advantages of global bookkeeping take time to realize, and even in a situation in which the global equilibrium provides a marked improvement in the quality of life, it will take time to achieve the transition. In contrast the full advantages of local choice show up immediately. As noted this is important because delay has such a large impact on the value of both rewards and aversive events. Thus, according to Figure 6.2 quitting has to be difficult. Indeed, the figure suggests that it is only possible if the ex-drug user has some confidence that things will get better.

The vocabulary of relapse.

Relapse and other forms of backsliding are often attended by a number of formulaic excuses. The following list will likely sound familiar: "It's a special occasion . . . It's just this one time . . . My friends are here for only one more weekend; when they go, I will stop drinking so much . . . It's the last time. Tomorrow, I'll turn over a new leaf . . . It's a once in a lifetime chance,"and so on.

The common theme in these remarks is that the next occasion of drug use is unique and/or it is just for one more time. Interestingly, over a hundred years ago a similar list was compiled. William James, who is sometimes referred to as the first American experimental psychologist, documented the "drunkard's excuses." (1899) They echo the same themes as those listed above:

> He has made a resolve to reform, but he is now solicited again by the bottle. . . .If he says that it is a case of not wasting good liquor already poured out, or a case of not being churlish and unsociable when in the midst of friends, or a case of learning something at last about a brand of whiskey which he never met before, or a case of celebrating a public holiday, or a case of stimulating himself to a more energetic resolve in favor of abstinence than any he has ever yet made, then he is lost. His choice of the wrong name seals his doom. But if, in spite of all the plausible good names with which his thirsty fancy so copiously furnishes him, he unwaveringly clings to the truer bad name, and apperceives the case as

> that of "being a drunkard, being a drunkard, being a drunkard," his feet are planted on the road to salvation. He saves himself by thinking rightly.

James's list shows that the "last time" and "special occasion" excuses were alive and well in the 19th century. This generality raises two questions. Why is relapse so often preceded by the statement that this is a "special occasion," why do these words work as an excuse? That is, an excuse must reflect some mitigating circumstance. This implies the phrases the "last time" and "special occasion" must also identify a mitigating circumstance.

The excuses apply to those occasions in which the local and global perspective require opposing actions. The ideal solution is to somehow do both. This is impossible except in one situation. On the last choice in a series of choices, the distinction between the local and global perspectives disappears. The global perspective requires a continuing sequence of choices. When there is just one choice, only the local perspective applies. When a meteor is heading for earth, it is OK to eat cheese cake.[5] Thus, if the situation can be framed as the "last time," then the dilemma dissolves. The same reasoning applies to "special occasions."

However, it is highly unlikely that the series of opportunities to use drugs again really came to a halt. Under these circumstance, the excuse will either be reiterated or the drug will simply be used with no excuses. In either case, the relapse is underway. Thus, the "last time" excuse establishes a frame of reference in which the drug is the right choice (assuming it really is

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[5] This may not always be true. There is a character in *To Kill a Mockingbird,* who is addicted to morphine and dying of cancer. She decides she wants to die drug free. This entails a painful bout of withdrawal, which she goes through, aided in part by readings from one of the book's heroes, Scout. The example suggests that values play an important role in drug use, as discussed in the next chapter.

the last time), but then when opportunities for drug use reoccur, the excuse implies that the local perspective is in charge—hence, a relapse.

Spontaneous recovery. The analysis of choice and some of the material presented in Chapter 2 suggest that spontaneous recovery rate is substantially higher in addiction than in other disorders. First, for a heavy drug user, the global choice perspective offers the opportunity for a speedy recovery. Second, the research results summarized in Chapter 2 supported the hypothesis that addiction was more context dependent than other disorders. For instance, the epidemiological data showed that historical factors had a strong influence on whether drug use led to drug dependence. Third, it is reasonable to suppose that context influences whether options are local or global. Thus, as context changes, a heavy drug user may shift from a local to a global perspective. This would look like spontaneous recovery, and to the extent that choice did not play a role in other disorders, spontaneous recovery would distinguish addiction from other disorders.

Three lines of evidence support this line of reasoning. The biographical accounts of drug use revealed that a number of the addicts quit all at once. Scott abruptly quit using heroin; Patty and Jessie abruptly quit using cocaine. A computer search for the terms "spontaneous recovery" and "spontaneous remission" yielded about seven times as many hits for addiction and alcoholism than for obsessive compulsive disorder and Tourette's syndrome. In line with these observations, addiction is the only *DSM* psychiatric disorder that has been a source of new words for spontaneous recovery. The phrases "going cold turkey" and "kicking the habit" identify specific heroin withdrawal symptoms and were first used to refer to quitting heroin all at once. They are now used to describe quitting any drug—or habit—all at once, but these terms occur rarely if at

all in association with other psychiatric disorders. It is not likely that anyone ever referred to recovery from obsessive compulsive disorder or schizophrenia as "going cold turkey." Thus, the idea that addiction involves voluntary drug use, and that voluntary behavior involves local and global choice equilibria predict the distinctive manner in which addiction sometimes ends as well as how people talk about addiction.

Voluntary addiction does not mean someone chooses to be an addict (rather, it means that they choose to do heroin one more time). The view that addicts are voluntary drug users is sometimes rejected on the grounds that "no one would choose to be an addict." The implication of this statement is that no one would choose the miseries usually associated with heavy drug use. However, Figure 6.2 does not say that someone chooses addiction. The left panel says that what the addict chooses is to use the drug one more time, nothing more. The point is that one day of heroin does not mean addiction, just as eating dessert once does not make one fat. Of course as the days accumulate, the characteristics of addiction emerge, and as the desserts accumulate fat cells get bigger. However, from the local bookkeeping perspective. the options relate to the current situation not a state of being. Consequently a person who never chose to be an addict ends up an addict. Similarly, someone who has a second helping of dessert every night ends up twenty pounds heavier than they had planned.

Explaining consumerism and excess

The analysis presented in this chapter applies to the tendency for people to do too much of anything that they like, not just drugs. This tendency is long and widely recognized. Aristotle preached "moderation in all things," something he would not have done if excess were not a

problem in Third Century BC Athens. Similarly, Thoreau would not have escaped to Walden Pond if 19th century New England had not seemed too cluttered and materialistic. But despite this long history of criticism, excess has persisted and may even be on the rise. According to recent reports, Americans of all ages are getting fatter, houses are getting larger—"McMansions"—and for a good while cars have been tank-sized. It seems fair to say that excessive consumption is an age-old problem and one that has increased over time rather than abated despite the warnings and counter movements.

Why excess?

In particular cases of excess, there are theories as to why it happens. The disease theory explains excessive drug use, and some have blamed advertising and super-sized meals for overeating. However, history shows that concerns about excessiveness predate addictive drugs, predate the advent of advertising, and predate McDonalds. These observations suggest that a theory of excessive consumption should apply widely. In should explain too many shoes, too many sweaters, and the excesses of 3rd Century Greece and 19th Century Concord Massachusetts.

But there is no such theory, and this is not by oversight. Both economics and behavioral biology imply that a theory of excess is not needed. According to economics, individuals and firms tend to end up at the global equilibrium. In cases where this is not achieved, the explanation is that some sort of mistake or bias is at play, not principle. According to biologists organisms maximize fitness. This precludes persistently excessive consumption patterns. For both disciplines, excessive maladaptive consumption patterns are a kind of irrationality or accident; phenomena that do not fit the standard analyses.

Local choice predicts that the most preferred good will be consumed excessively. In contrast, in the local/global analysis, excess is a fundamental feature of voluntary behavior. This was hinted at in the discussion of the restaurant problem and the addiction graphs. Recall that in the restaurant problem, the local equilibrium was associated with too much Chinese food, and in the addiction graph, it was linked with too much heroin. In both examples, the favorite item was consumed excessively. These were not special cases. Given a set of items, the local equilibrium implies that the one that is most favored is overconsumed. As shown next, this conclusion is a logical consequence of the relationship between the local equilibrium and the global equilibrium.

Recall that the global equilibrium identifies the ideal consumption level. Each item is consumed at just the right amount to insure that the overall benefits of consumption are maximized. Also notice that the two graphs were drawn from the perspective of the good or activity that had the highest value prior to any consumption. For instance, the vertical axis in the restaurant graphs showed preferences for someone who liked Chinese food more than Italian food, and, accordingly, the horizontal axis was the number of Chinese meals. Similarly, the drug graph showed someone who liked drug more than the nondrug alternatives, and accordingly the x-axis depicted the number of heroin choices. Now notice that in both graphs the local equilibrium is to the right of the global equilibrium. Since the global equilibrium defines the ideal consumption level, this means that the local equilibrium entails too much consumption of the favorite good—too much Chinese food and too much drug. The following graphs show that these relations are quite general.

Insert Figure 6.3 about here

The graphs are just like the restaurant and heroin graphs. On the x-axis is the frequency of choices for the commodity that was initially liked best (prior to any choices). On the y-axis is the choice-dependent changes in value. The curved lines show the choice-dependent changes in value for a commodity that replenishes and depletes according to exponential functions (Heyman, 1992, 2003). However, despite the particular shape of the value curve and the distance between the local and global equilibrium, the local equilibrium is always to the right of the global equilibrium. This means that even when the local equilibrium is highly efficient (as measured by its close proximity to the global equilibrium), the favorite good is still consumed a little too much Pirooz Vakili, of Boston University's College of Engineering, has derived a proof that confirms the implications of the graphs.[6]

Critics of consumerism have often blamed social institutions or "society." The analysis presented here does not deny that social forces play an important role in promoting excessive consumption levels. What it adds is the point that there would be excessive consumption even if advertising did not exist. As long as choices are made from the local perspective, and this is usually the perspective that people take, the favored good will be consumed excessively. Advertisers and merchants encourage this tendency, and conversely, ascetic movements counter this tendency.

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[6] Vakili, P. June 19, 2006.*Personal communication.*

Why does local bookkeeping persist?

Local choice has serious drawbacks. As just demonstrated it sets the stage for addiction. The example was a drug. But for local choice, the problems posed by drugs apply to any substance or activity that undermines the competition and has immediate positive consequences accompanied by negative consequences that lag far behind. This category includes many foods, sex, gambling, and perhaps various computer games. These are well known problems that many theories of choice address. There is also a subtle, possibly more costly drawback. In almost all ordinary situations, the local equilibrium provides a lower rate of overall benefits than does the global equilibrium.[7] Often the differences are quite small. But as creatures are almost always in a setting that offer more than one alternative, the differences should add up. Thus, everyday events as well as highly seductive opportunities lead local choice astray.

These observations say that the local perspective should give way to the global perspective. Learning is like natural selection. Thus, if local and global choice compete for the same niche, global choice should win. Nevertheless, local choice prevails. As mentioned, in most studies the local equilibrium, which is known in behavioral science as the "matching law," prevails (Davidson & McCarthy, 1988; Williams, 1988).. In sum, it would be hard to find a phenomenon in psychology that had more support than the statement that choice proportions approximate the local equilibrium (matching law predictions). However there are exceptions, and they provide

[7]The mathematics of local and global choice imply a few setting in which the local and global equilibrium are the same, see Heyman 2003 for a few examples.

insight into why the local equilibrium prevails despite its drawbacks.

What follows is a brief reviews of a few studies that managed to teach subjects to make choices in accordance with global choice. The basic finding is that it is possible to teach individuals to allocate their choices in the most optimal way. This is relevant to addiction in that a global choice strategy precludes addiction.

How to teach "economic rationality"

The relevant studies were conducted with various species as subjects. In experiments in which the local equilibrium and global equilibrium were very different, there was much more subject-to-subject variation in the human studies (e.g., Herrnstein et al. 1993). In the human studies, a few subjects "spontaneously" allocated their choices as predicted by the global equilibrium. This has never happened in non-human studies. As a way of determining the factors that promote the local equilibrium, some researchers have manipulated the conditions in ways that they thought would promote the global equilibrium (e.g., Silberberg & Williams, 1974) The basic finding is that cues that highlight the global equilibrium, pushed choice proportions toward the global equilibrium. An interesting study by Kudadjie-Gyamfi and Rachlin (1996) showed this effect. The subjects were college students, and the procedure arranged a competitive choice game. Under standard laboratory conditions, the students allocated their choices as predicted by the local equilibrium. However, when the choice trials were presented in "threes" so that they established a rhythm or tempo, choice proportions shifted toward the more profitable global equilibrium Establishing a tempo drew attention to the choice-dependent changes in value. As a result the subjects behaved as if the options were now competing sequences, each three trials

long.

A somewhat similar study shows that it is even possible to teach pigeons to allocate responses in the manner predicted by the global equilibrium. Larry Tanz, a graduate student in the Department of Psychology at Harvard, and I arranged for a light to go on when choice proportions approximated the global solution (so that it was correlated with higher reward rates).. For instance, the combination of choices "8 left responses and 2 right responses" turned on the light. The pigeons, who had heretofore distributed their choices as called for by the local equilibrium, shifted to the more efficient global response pattern. That is, they learned to keep the light on. However, note that in this example, the environment provided the global solution. The pigeons did not have to calculate choice-dependent changes in reward value, they just had to keep the light on. The experimenters made the calculations and encouraged the pigeons to follow along by linking the light to a higher overall reward rate. The pigeons rapidly learned re-allocate their choices so as to keep the light on (and earn more food).

Summary: local choice is the default state. The experiments indicate two trends. First, in experiments with humans, some subjects "spontaneously" allocated their choices as predicted by the global perspective. However, as in the animal studies, most subjects followed a local choice strategy. Second, it is possible to teach members of various species to allocate their choices as predicted by the more efficient global strategy. The research also offers an explanation for this pattern.

Local choice is cognitively simpler, its advantages are immediate, and its categories correspond to the natural fracture lines of nature .By the same token, the disadvantages of global

choice are that it is complicated, its advantages accumulate slowly, and its categories are abstract.

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How rational is voluntary behavior?

According to economics, individuals and firms either maximize overall well-being are on the road to doing so. This result is built into the economic model of choice. It is a global maximizing process. In biology it is often assumed that evolution guarantees optimal outcomes. In both disciplines voluntary behavior guarantees success. This chapter tells a very different story. It shows that it is always possible for choice proportions to stabilize at a less than optimal equilibrium. When this occurs the analysis of consumerism showed that the commodity that was initially the favorite was overconsumed. Most likely the number of extra "helpings" of the favorite good is usually small, but it is an ever present phenomenon. To be sure, the global equilibrium is also ever present, and it provides the best possible outcome. But choice is very complex, requires much patience, and is out of step with perceptual experience.

Research supports this darker image of voluntary behavior. In labs and in natural settings, choice proportions approximated the local not the global equilibrium. This in turn suggests that addiction and other forms of excess should be quite common. However, societies cannot function well if their member are so easily seduced by "specious" rewards (Ainslie, 1975). These considerations suggest that there is a role for measures that protect people from themselves. This issue is one of the topics of the next chapter.

Fig. 6.1

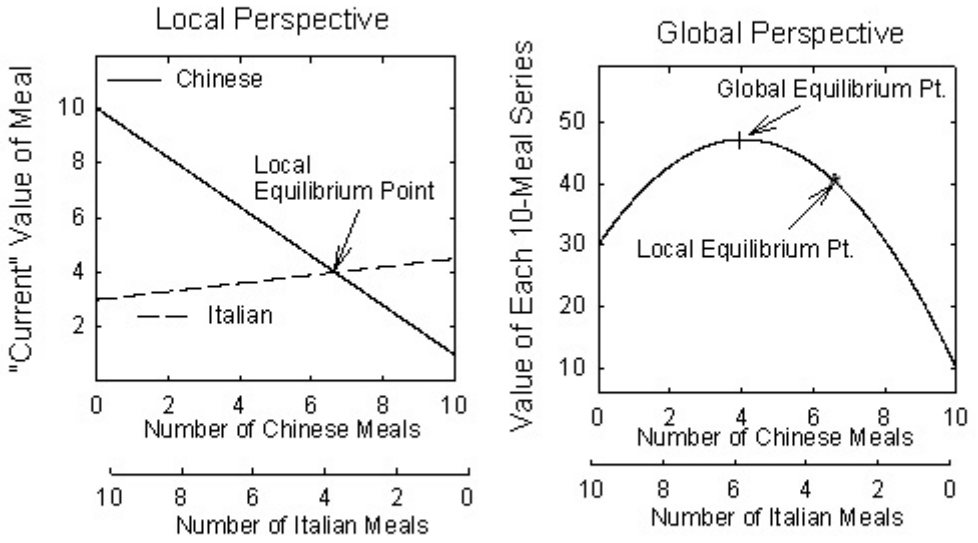
Local Perspective
"Current" Value of Meal
Chinese
Local
Equilibrium Point
Italian
10
8
6
4
2
0
2
4
6
8
10
Number of Chinese Meals
10
8
6
4
2
0
Number of Italian Meals
Global Perspective
Value of Each 10-Meal Series
Global Equilibrium Pt.
Local Equilibrium Pt.
50
40
30
20
10
0
2
4
6
8
10
Number of Chinese Meals
10
8
6
4
2
0
Number of Italian Meals

Fig. 6.2

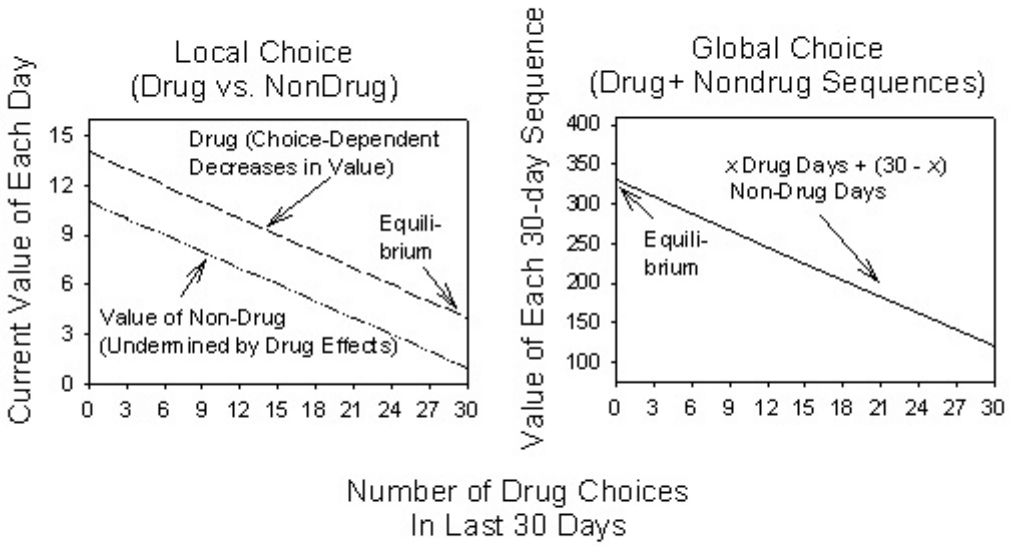
Local Choice
(Drug vs. NonDrug)
Current Value of Each Day
Drug (Choice-Dependent
Decreases in Value)
Equili-
brium
Value of Non-Drug
(Undermined by Drug Effects)
0 3 6 9 12 15
0 3 6 9 12 15 18 21 24 27 30
Global Choice
(Drug+ Nondrug Sequences)
Value of Each 30-day Sequence
x Drug Days + (30 - x)
Non-Drug Days
Equili-
brium
100 150 200 250 300 350 400
0 3 6 9 12 15 18 21 24 27 30
Number of Drug Choices
In Last 30 Days

Figure 6.3

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