The Unintended Consequences of Regulating Addictive Substances

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Former Food and Drug Commissioner David Kessler, former Surgeon General C. Everett Koop, and a legion of others argue that significant government regulation is needed to protect consumers from nicotine, which has been shown to be addictive, and from smoking, which increases the risk of lung cancer, heart disease, and a host of other health problems. The biology and the economics of addiction, however, suggest that government regulation can result in harmful unintended consequences to the consumers of potentially addictive substances.

Adverse policy consequences result from the workings of the biological mechanisms of addiction. Specifically, addictive substances activate the motivational area of the brain, an area that allows animals, including humans, to use environmental cues to predict rewards. As part of the motivational process, the cues become a *desirable complementary* component of the process of acquiring the reward. Additionally, the consumption of addictive goods tends to lead to "set-point" behavior where the individual will attempt to maintain the set-point level of blood and brain concentrations of the active substance. As the set point is determined in part by the initial consumption history, higher levels of initial consumption, for example, lead to a higher set point. The complementary and set-point characteristics of the consumption of addictive substances interact with various substitution effects predicted by economic theory and result in negative consequences.

Motivation, Value, and Association

Reinforcement of behavior depends on a goal-directed arousal system in the brain that is responsible for learning at a basic level, and

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this learning involves the creation of memories necessary for the survival of individuals and species. According to Heather Ashton (1992: 83):

> The idea of a goal-directed arousal system in the brain implies the existence of some mechanism for selecting appropriate goals, for initiating the behaviours required to achieve them, and for signaling when they have been attained. If a goal proves favourable for survival in the prevailing circumstances, it is advantageous to reinforce behaviour leading to it; if the goal proves to be unfavourable, behaviour leading to it must be suppressed and avoidance action taken in the future.

This motivational system allows creatures from bees to humans to take the measure of their environment in a very specific and sophisticated fashion. When an animal finds and consumes a good, a value—in economic terms, a marginal value—becomes attached to an internal representation of that good. This value is based on the ability of a good to enhance the fitness of an individual—that is, to increase the likelihood that an individual will survive and procreate (see Edelman 1992: 100). Furthermore, associations will be created between the good, its value, and characteristics such as location, complementary goods, and other environmental cues. In this example, the location where the good was found will be stored in memory, subject to recall when the animal seeks the good in the future. The associated goods and cues are used by the animal to predict when and where the primary reinforcing good can be found. Since the probability of finding a good in this same location in the future is uncertain, the motivational system enables the animal to form expectations about the probability of finding it there in the future. Expectations about associated or complementary cues and about the ability of a good to enhance fitness are formed and stored during a learning process, and the values attached to these expectations motivate behavior and generally allow the animal to organize that behavior in an efficient manner. The addictive properties of certain substances are a result of their effects on the motivation-reinforcement system.

Addictive substances are defined as those that activate these reinforcing systems (see Ashton 1992: 104–6; Carlson 1994: 582–93; Kupfermann and Schwartz 1995: 626; and Pinel 1993: 444–53). However, the activation of the reinforcement area of the brain by psychotropic substances is generally different from its activation by ordinary reinforcing goods such as food. Food, for example, is only reinforcing when an animal is hungry—only a hungry animal will seek a location where, from past experience, it expects to find food (see Carlson 1994: 472). Addictive substances seem to be much more capable of

reinforcement effects, independent of the animal's internal state. Also, the value assigned to an ordinary good reflects its expected ability to enhance the animal's fitness. The values assigned to potentially addictive goods may exceed the value that measures the ability of the good to satisfy these requirements.

The associated or complementary goods and cues by themselves will begin to activate the motivational area of the brain; they become conditioned reinforcers (see Carlson 1994: 472).[1] These associations can be positive, as with the association of a good bottle of wine with a fine meal. The associations can also be adverse, such as when smoking and drinking alcohol become associated, making it difficult to quit one activity without quitting the other (see Gulliver et al. 1995: 202–6). Similarly, the sight of the needle used to inject heroin can become associated by reinforcement with the effects of the drug itself, so that simply seeing a needle can stimulate craving for the drug. And an associated location or social environment, for example, back alley needle sharing, can even become a sought-after aspect of the consumption of heroin.

The Set-Point Mechanism

In a recent set of experiments Ahmed and Koob (1998: 299) found that rats allowed to self-administer cocaine "regulated their intoxication around some endogenous reference or 'hedonic set point.'" The initial consumption history, in part, determined the level of the set point.[2] Animals given longer initial access periods to the drug escalated use over time and reached a higher set point then those with shorter access. For both low- and high-set-point animals "decreasing the [concentration of each] dose produced an increase in cocaine self-infusions," so that the rats could attain their set-point concentration levels in response to the diminished concentration of each dose (Ahmed and Koob 1998: 299). The same response has been seen in

[1]Montague, Dayan, and Sejnowski (1996) develop and test a computational model of the motivational area of the brain. In their model, "a set of sensory cues associated with the administration of . . . [psychotropic] compounds would predict an effect [on the motivational area] attributable partially to . . . [that of, for example,] cocaine" (p. 1945). They explicitly model the process by which the cues become conditioned reinforcers. For a general review and discussion of this model, see Schultz, Dayan, and Montague (1997).

[2]Various set-point or homeostatic mechanisms in the body regulate, for example, temperature, feeding, and responses to thirst. Body weight is regulated by a set point that can become destabilized in a manner similar to the set-point mechanisms that control the intake of potentially addictive substances. Short-term destabilization of both the body weight and the addictive substance set points can result in bingeing behavior—this is not surprising since both regulatory processes rely on an overlapping set of mechanisms (see Kupfermann and Schwartz 1995: 613–27).

human smokers, where "dependent smokers adjust their smoking to maintain constant blood and brain nicotine concentrations" (Pianezza, Sellers, and Tyndale 1998: 750).

What the set-point response suggests for cigarette regulation is that if regulation mandated lower nicotine levels in cigarettes, individuals would simply adjust their smoking behavior to return their blood and brain nicotine concentrations to their set-point level by increasing the volume and depth of inhalations or the number of cigarettes smoked in a given period of time. The extent to which the smoker uses one or both of these methods to maintain nicotine concentration levels will depend on, among other factors, the economic costs of each method. Both methods will increase the harmful effects of smoking resulting from the absorption of nitrosamines, collectively referred to as tars, and from the absorption of carbon monoxide.[3] Ironically, then, one of the results of reducing the nicotine levels in cigarettes is a potential increase in the injurious effects of smoking caused by tars and other harmful substances. It seems that this effect could, in part, be alleviated by reducing nitrosamine levels. However, it is primarily the tars that give cigarettes their taste and, in dependent smokers, that taste becomes associated with the pleasure of smoking by the reinforcing effects of nicotine. Like needle sharing, the associated taste becomes a feature of smoking sought after for its own sake. Consequently, reduced-tar cigarettes are not popular with smokers. In fact, it is possible that a set point for tar concentrations could result from the association effects of reinforcement. In the next section, the effects of the interaction of set-point behavior and excise taxes will be discussed.

An often implicit assumption of those who argue in favor of the government regulation of addictive substances is that their consumption yields few or no benefits to the consumer. Though most economists reject this conclusion, I want to mention a few of the known biological benefits derived from consuming various psychotropic substances. One of the effects of many of these substances, including alcohol, barbiturates, heroin, tobacco, and marijuana, is that they reduce anxiety. Further, alcohol reduces inhibitions, and while this effect can sometimes result in trouble, by reducing social anxiety it probably increases the enjoyment of many individuals in certain social settings. Reduced cognitive activity is an effect related to the consumption of various psychotropic substances, and another suggested effect on individuals is short-term "myopia for the future" (Damasio 1994:

[3]Cigarette smoke contains a number of other potentially harmful substances, including formaldehyde and cyanide (Fowler et al. 1996: 735).

218). All of these effects can be considered beneficial if not carried to the extreme, since they allow the individual a temporary respite from social anxieties and other cares, and they probably explain why most societies past and present have their equivalent of the six pack or glass of wine.[4]

Interestingly, some substances can be said to increase cognitive ability by increasing alertness. Since some minimum level of alertness is necessary for rationality, substances like nicotine, caffeine, and even cocaine taken in small doses yield utility by increasing alertness and thus could be said actually to enhance rational thought. Of course, in larger doses cocaine can make users feel more rational and powerful than they actually are, and this can create problems. One of the interesting aspects of smoking is that there is evidence that it enhances memory formation and may be useful in enhancing the memories of Alzheimer's patients (Gray et al. 1996: 713–16) Smoking may also result in a lower incidence of Parkinson's disease and can relieve some of its symptoms (Fowler et al. 1996: 735).

Evidence of the Effects of Regulatory Policy

When the state makes the decision to regulate the consumption of a psychotropic substance, it has several policy tools it can use. It can use taxes, including taxes set so high that they drive legal provision to zero; it can use outright prohibition; and finally it can turn to a modern innovation—it can allow and encourage the use of the legal system to sue the legal producers of addictive substances out of the market. Increasing the "cost" of the legal consumption and production of potentially addictive substances by the various regulatory means will result in substitutions along several margins. The effects of these substitutions combined with the biological properties discussed above are the topic of this section.

A few examples will serve to illustrate the perverse effects of the state's attempt to regulate addictive substances. In 1644 the emperor of China banned the smoking of tobacco, which resulted in many Chinese smokers switching to opium (Pinel 1993: 438). The Harrison Narcotics Act of 1914 made it illegal in the United States to sell or

[4]Andrew Sherratt (1997) has examined the use of alcohol, opium, and hemp derivatives dating back to the 5th millennium BCE. Sherratt argues, from the archeological evidence, that alcohol was used in "social contexts . . . when [it was] introduced" (p. 389). Further, "the introduction of alcoholic drinks, with their properties of intoxication and the generation of conviviality—a socially accepted alteration of consciousness—is a major event for any society" (p. 391). "What we are actually looking at is the origin of a tradition of alcohol-based hospitality" (p. 392).

use opium, morphine, or cocaine. As a result many opium addicts switched to the more highly addictive heroin, which was not covered by the act (Pinel 1993: 439). Crack cocaine, introduced as a cheaper alternative to regular cocaine in the 1980s, partly in response to the increases in street prices brought about by the War on Drugs, "is probably the most effective reinforcer of all available drugs" (Carlson 1994: 585). The search for possible legal substitutes for various psychotropic drugs led to the introduction of so-called designer drugs. In 1992 a contaminated batch of these designer drugs resulted in several individuals developing the symptoms of severe Parkinson's disease—the victims froze up and could not talk or move (Youdim and Riederer 1997). And in the second half of the 19th century, high taxes on whisky in the United States led many individuals to substitute opium and hashish (Hu 1950: 40). Obviously, attempts to regulate along one margin simply lead to a shift to another, and often the substitute product is a more highly concentrated form than the one it replaced and thus potentially more harmful. Furthermore, a potential effect of the consumption of substances with higher concentration levels of their active ingredient will be a higher set point than would otherwise be the case, and, as a result, regulation may increase the average severity of the addiction problem for users of potentially addictive substances.

In sum, prohibition results in substitutions along several margins, most of which, when coupled with biology effects, work in the opposite direction of the goal of reducing harmful outcomes. Prohibition has adverse effects that complicate the addiction problem. By increasing concentrations, it increases the reinforcing strength of substances and thus is more likely to lead to naïve users quickly becoming addicted and increase the severity of the addiction resulting from increasing the set point. Also, variations in the quality and concentration increase the difficulty of the learning problem faced by naive users—for example, unanticipated variations in concentration can lead to fatal overdoses. Our experience with the prohibition of alcohol illustrates these points.

After the passage of the 18th Amendment and an adjustment period, alcohol consumption was reduced by only a third over pre-Prohibition consumption when measured in units of pure alcohol. The adjustment period resulted from the time lag in the establishment of extensive sources of illegal supply. Of equal importance was a significant shift in the composition of consumption away from beer and toward more highly concentrated forms of delivery, wine, and distilled spirits (Hu 1950: 52–54). This shift in consumption to stronger and more concentrated forms of a reinforcing substance affects the

strength of reinforcement, as well as the association/complementary and set-point effects. In a more recent example, there has been a proliferation of intensive indoor cultivation of marijuana, which has resulted in as much as a fourfold increase in the levels of THC, the active chemical, of the product sold on the street (Navarro 1996).

The shift in concentration brought about by prohibition might be called the Alchian and Allen Effect, since it is a result similar to their proposition that fixed shipping costs skew the quality mix of shipped goods toward higher quality (Alchian and Allen 1983: 36; see Gifford 1997 for a more detailed discussion of these points). The penalties associated with getting caught with many illegal substances like opiates do not vary significantly with their concentration. Like a shipping cost, the penalty will skew the mix of smuggled goods toward more highly concentrated forms of the substance that will have a higher market value per pound or for a given bulk. The actual shipping costs also contribute to the shift toward higher concentrations. These effects are compounded by the fact that higher concentration levels are more easily concealed. Furthermore, by significantly reducing the value of seller brand-name capital, prohibition tends to increase the variance of the quality and strength of addictive substances.

Miron and Zwiebel (1991) estimate the effects of the 18th Amendment on alcohol consumption using related variables: alcoholism deaths, drunkenness arrests, cirrhosis deaths, and alcoholic psychosis figures. With the onset of Prohibition there was the initial period of steep decline after which all the time series data show a steady increase, consistent with earlier studies (Miron and Zwiebel 1991: 244–45). They further find that the reduction in alcohol consumption was due to the increased economic costs facing the consumer, and that any effects caused by the moral climate of condemnation or by respect for the law were negligible (Miron and Zwiebel 1991: 245–46). Their evidence lends support to the proposition that Prohibition increased the variance of quality and concentration and thereby increased the risks associated with alcohol consumption. Specifically, alcoholic deaths did not show the same post–initial response decline as the other variables even though per capita alcohol consumption (measured in terms of pure alcohol) dropped by about a third. Deaths caused by alcohol were much closer to their pre-Prohibition levels. This result suggests that prohibition increased the cost of estimating harm because of increases in concentration and quality variability, resulting in an increased death rate per gallon of pure alcohol consumed.

Per unit excise taxes, like prohibition, tend to cause a substitution toward "quality" goods, very often with higher concentrations of the "desired" active ingredients (see Barzel 1976). An excise tax on distilled

spirits was the first internal tax passed by the government of the new United States, in March 1791. Because the tax per gallon on low-quality "Western" whiskey was the same as that on the higher-quality Eastern whisky, which before the tax commanded twice the price, the effect of the tax was to reduce the price of Eastern whisky relative to that distilled in the West.[5] This excise tax led to the Whisky Rebellion.

Returning to the cigarette issue: Per unit excise taxes on cigarettes lower the relative price of those with more nicotine and tar—the desired attributes of cigarettes—since they are taxed at the same rate as those with lower nicotine and tar. The set-point model suggests that consumers will adjust consumption to maintain the same set-point level of nicotine and possibly tar in their systems. The reduction in the relative price of high-nicotine and -tar cigarettes brought about by higher excise taxes coupled with set-point behavior should lead to the increased consumption of high-nicotine and -tar cigarettes relative to those with low levels of these substances. Evans and Farrelly (1998) examine the responses of smokers across states to different levels of excise taxes. Their variables include average total cigarette consumption, average cigarette length, and average tar and nicotine intake per day. Although they are not specifically testing the set-point hypothesis their evidence is consistent with that model. They found that "smokers in high-tax states are more likely to smoke cigarettes higher in tar and nicotine. Although taxes reduce the number of cigarettes consumed per day among remaining smokers, total daily tar and nicotine intake is unaffected. Young smokers . . . [are even] more responsive to changes in taxes. . .their total daily tar and nicotine intake actually increases after a tax hike" (Evans and Farrelly 1998: 1). Evans and Farrelly suggest that taxes should be based on tar and nicotine levels instead of simply on the unit of the pack (p. 23). Though this would tend to reduce tar and nicotine level per cigarette, set-point maintaining behaviors (including inhaling more deeply and smoking more of the now relatively inexpensive low nicotine and tar cigarettes) will tend to maintain constant nicotine and tar levels.

An additional problem with the ability of government to use taxes to regulate smoking is limited by the ease of smuggling cigarettes into high tax jurisdictions. Current estimates suggest "that about 280 billion of the 1 trillion cigarettes exported each year pass through the hands of smugglers" (Bonner and Drew 1997: C12). Price increases resulting from the potential legal settlements between the tobacco industry and various plaintiffs are predicted to be in the range of 62 cents per pack. When those increases are coupled with a possible federal tax

[5]The West at this period in time was Western Pennsylvania, Virginia, and North Carolina.

increase of $1 or more and likely state tax increases, the overall price increase may be as much as $2 per pack. Increases of much less magnitude have resulted in a significant increase in smuggling worldwide. In Spain for example, "Winston is the most popular foreign brand, and last year 60 percent of its sales were contraband" (Bonner and Drew 1997: C12). Illegal Winstons sold for $1.30 to $1.60 per pack, approximately one third less than the legal price (Bonner and Drew 1997: C12). An additional concern is that teenage smokers, who are considerably more sensitive to increases in price than adults, are much more likely to switch to cheaper, lower-quality black market cigarettes with perhaps higher nicotine and tar content, and some will also substitute marijuana or other illegal substitutes.

Smugglers appear to be able to tap sources of production on a worldwide scale, and introduce their goods at low cost into any country where the government attempts to control access. This suggests that U.S. efforts to regulate tobacco consumption through a combination of litigation and excise taxes is bound to be less than successful and may result in the consumption of cigarettes with higher tar and nicotine levels, especially among teens.

A final problem with prohibition is that, by making an addictive substance illegal, it fosters behaviors that by themselves can be more harmful than the addiction itself. By driving the use of psychotropic substances "underground," behaviors that individuals would never otherwise engage in can become desirable by association. When activities such as needle sharing in hidden alleys and cruising for drug deals can become sought-after activities, when consumed in conjunction with the self-reinforcing substances, it is even more difficult to reduce or discontinue consumption of a given substance. These activities obviously can, by themselves, result in harm to the user by leading to consequences such as becoming a victim of crime and the transmission of hepatitis and AIDS.

Conclusion

An examination of the biology and economics of addiction suggests that government regulation of these substances can have significant adverse, unintended consequences. The association and set-point effects and various substitution effects can potentially result in increased harm over preregulation levels to the users of addictive substances. This, perhaps, still leaves a policy role for government: to simply provide information about the harmful effects of the various substances. We know that this approach has been successful, for

example, in reducing adult smoking rates (Bartecchi, MacKenzie, and Schrier 1995: 44–51).

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