Volume Title: The Economic Analysis of Substance Use and Abuse: An Integration of Econometrics and Behavioral Economic Research

Volume Author/Editor: Frank J. Chaloupka, Michael Grossman, Warren K. Bickel and Henry Saffer, editors

Volume Publisher: University of Chicago Press

Volume ISBN: 0-262-10047-2

Volume URL: http://www.nber.org/books/chal99-1

Conference Date: March 27-28, 1997

Publication Date: January 1999

Chapter Title: Applying Behavioral Economics to the Challenge of Reducing Cocaine Abuse

Chapter Author: Stephen T. Higgins

Chapter URL: http://www.nber.org/chapters/c11159

Chapter pages in book: (p. 157 - 186)

# 6 Applying Behavioral Economics to the Challenge of Reducing Cocaine Abuse

Stephen T. Higgins

Cocaine abuse remains a major U.S. public health problem. The number of frequent cocaine users (those who use once or more per week) remains stable at 500,000–750,000 individuals (Substance Abuse and Mental Health Services Administration 1996a), as many as half or more of newly arrested felons test positive for recent cocaine use (National Institute of Justice 1996), and demand for treatment for cocaine abuse is increasing (National Association of State Alcohol and Drug Abuse Directors 1996), as is the frequency of emergency room visits for cocaine-related problems (Substance Abuse and Mental Health Services Administration 1996b). While there is progress in the development of effective treatments for cocaine abuse, high rates of early attrition and continued drug use remain common (Higgins and Wong 1998), leaving no question about the need for additional and more-effective treatment interventions. Also important to keep in mind is that the majority of cocaine and other drug abusers are not enrolled in formal substance abuse treatment (Regier et al. 1993). Thus, strategies are needed for reducing cocaine abuse in other settings. Lastly, as in other areas of public health, prevention of cocaine abuse is preferable to having to treat the problem after it has emerged. There is a tremendous need for effective strategies to prevent cocaine abuse (Institute of Medicine 1996).

The purpose of this report is to discuss some potential implications that I see in reinforcement and consumer-demand theory for the development of effective strategies for reducing cocaine abuse.

Stephen T. Higgins is professor of psychiatry and psychology at the University of Vermont.

Preparation of this chapter was supported by RO1DA08076 and RO1DA09378 and General Clinical Research Center Award RR-109 from the National Institutes of Health.

## 6.1 Applying Reinforcement and Consumer-Demand Theory to the Study of Cocaine Abuse

An impressive degree of consensus exists within the scientific community that cocaine abuse is engendered, in part, by the drug's ability to act as a potent positive reinforcer in much the way that food, water, and sex act in that manner (Johanson and Schuster 1995). The reinforcing effect of cocaine is not unique to humans; it has been demonstrated in a wide variety of otherwise normal laboratory animals. Neither physical dependence nor even a prior history of cocaine exposure are necessary for cocaine to function as a reinforcer. Effects of alterations in cocaine dose, schedule of availability, and other environmental manipulations are orderly and have generality across different species (Johanson and Fischman 1989; Johanson and Schuster 1995). These commonalities across species support a theoretical position that cocaine produces use and abuse via basic, normal processes of conditioning.

Understanding that reinforcement and other basic aspects of conditioning are involved in the genesis and maintenance of cocaine abuse is important because it means that information from the larger conditioning literature potentially can be brought to bear on improving our understanding of cocaine abuse. The application of consumer-demand theory to the study of reinforcement, an area of investigation known as behavioral economics, is one example where concepts and principles from the larger conditioning literature have been successfully applied to the study of cocaine and other forms of drug abuse. Behavioral economics has been applied to a relatively broad range of topics in the area of substance abuse, ranging from carefully controlled experiments with laboratory animals to discussions of policy (e.g., Bickel et al. 1990, 1993, 1995; Bickel and DeGrandpre 1996a; Vuchinich and Tucker 1988). In this report, the economic concepts of demand, price, opportunity cost, and commodity interactions (i.e., substitution, complementarity, and independence) are utilized to illustrate how I believe behavioral economics can contribute to efforts to reduce cocaine abuse. *Demand* is used to refer to cocaine seeking and use. *Price* is used to refer to the amount of resources expended in acquiring, using, and recovering from the effects of cocaine consumption. *Opportunity cost* is used to refer to opportunities to consume other reinforcers that are forfeited via cocaine consumption. The concepts of *substitution, complementarity,* and *independence* are used to refer to the manner in which other reinforcers interact with cocaine. (See Bickel et al. 1993 for a more detailed discussion of these terms and concepts.)

Laboratory studies illustrating the application of these concepts to cocaine use by nonhuman and human subjects are discussed first. Next, several treatment outcome studies are described to illustrate the applicability of these concepts to clinical populations and settings. Lastly, implications of these concepts for efforts to reduce use cocaine use via interventions applied in settings other than formal substance abuse clinics are discussed. A final point before turning to a discussion of empirical studies is that the focus of this report is on efforts

to reduce cocaine demand. I recognize that supply and demand are integrally related, but discussing both is not possible within the constraints of this manuscript. Readers interested in a discussion of the implications of behavioral economics for policy and other matters regarding drug supply should see Bickel and DeGrandpre (1996a, 1996b).

## 6.2 Laboratory Settings

### 6.2.1 Studies with Laboratory Animals

Results from a study by Nader and Woolverton (1992) conducted with three food-deprived rhesus monkeys illustrate nicely cocaine's reinforcing effects and how those effects are dependent on economic context. Subjects were fitted with venous catheters to permit drug infusions and resided in chambers equipped with two response levers. Responding on one of the levers resulted in the delivery of food or infusions of varying doses of cocaine, depending on the color of the associated stimulus lights. Responding on the other lever permitted subjects to alternate between the stimulus lights paired with cocaine or food availability (i.e., monkeys controlled which commodity they worked for). The number of responses necessary to obtain food remained at 30 throughout the experiment. The cocaine option was varied in two ways. First, the number of responses needed to obtain an intravenous infusion of cocaine (i.e., price) was varied from a minimum of 30 up to a maximum of 480 or 960 responses depending on the particular monkey. Second, a range of drug doses was examined at each cocaine price.

All three monkeys self-administered cocaine, and choice of the drug option increased as an orderly function of increasing drug dose (fig. 6.1). Note that at the two lowest prices (represented by circles and squares), intermediate doses of cocaine were sufficient to get all three monkeys to almost exclusively choose cocaine over food. That these food-deprived monkeys would voluntarily forgo food for cocaine illustrates the potent reinforcing effects of this drug. Note also, however, that cocaine choice was decreased below 50 percent in all three monkeys by increasing the price per cocaine infusion to 480 or 960 responses (represented by open and closed triangles). This latter observation illustrates how cocaine's reinforcing effects are dependent on economic context.

A study by Carroll, Lac, and Nygaard (1989) conducted with rats illustrates cocaine's reinforcing effects and how those effects are dependent on the presence or absence of a substitute for cocaine. A total of 55 rats participated and were divided into 11 experimental groups. All subjects were fitted with venous catheters. During 15 24-hour sessions, the various groups had continuous, concurrent access to intravenous infusions of either cocaine or saline via lever pressing and to either a glucose-plus-saccharin solution or water via tongue-operated drinking devices. Unlike in the Nader and Woolverton study, there were no experimenter-determined limits on the number of choices subjects

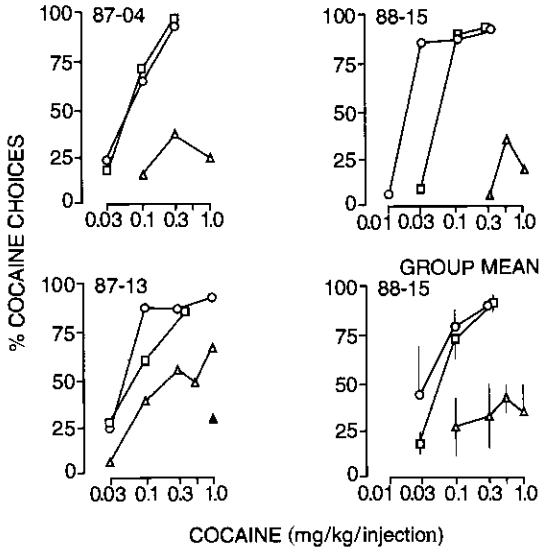


**Fig. 6.1 Cocaine versus food**

*Source:* Nader and Woolverton (1992).

*Note:* Percentages of trials in which cocaine was chosen are shown as a function of cocaine dose; data are shown as individual-subject plots and group means. The alternative to cocaine was one food pellet available under a fixed-ratio (FR) 30 schedule. Cocaine was available under different FR values, which are represented by the different symbols (*open circles,* FR 30; *open squares,* FR 120; *open triangles,* FR 480; *closed triangle,* FR 960). Each point is the average of the last three sessions of a condition. Vertical lines in the group data represent 1 SEM.

could make between the two options, and choices were not exclusive. Additionally, subjects were not trained to self-administer cocaine prior to these sessions, which provided an opportunity to examine how the presence of a substitute affects the initiation of cocaine use.

As expected, infusion rates were significantly higher in rats given access to cocaine compared to controls given access to saline, demonstrating the reinforcing effects of cocaine. However, the sensitivity of cocaine use to the presence of a substitute was also demonstrated. Substitution of water for the glucose-plus-saccharin solution in rats initially exposed to concurrent cocaine and glucose-plus-saccharin availability produced nearly a twofold increase in cocaine self-administration. There was no change in saline self-administration in a control group exposed to the same changes in drinking solutions. Thus, rates of cocaine self-administration when the glucose-plus-saccharin solution was present were substantially below maximal levels; that is, the glucose-plus-saccharin solution effectively substituted for cocaine. Similarly, replacing water with the glucose-plus-saccharin solution in rats that were initially exposed to concurrent cocaine and water availability decreased cocaine self-administration. Again, there was no change in the rate of saline infusions in a control

group that experienced the same changes in drinking solutions. So, consistent with the findings of Nader and Woolverton, these results demonstrated cocaine's potent reinforcing effects and also the malleability of those effects dependent on economic context.

Another point of interest in the Carroll et al. report is that the magnitude of the increase in cocaine self-administration that resulted from replacing the glucose-plus-saccharin solution with water was substantially larger than the decreases in drug ingestion that resulted from replacing water with the glucose-plus-saccharin solution. Put differently, the ability of glucose-plus-saccharin to substitute for cocaine was greater during the initiation of cocaine-reinforced responding than it was once cocaine use was established. The methodological difference between the Carroll et al. and Nader and Woolverton studies noted above likely contributed to this differential effect of the glucose-plus-saccharin solution. Unlike in the Nader and Woolverton studies, choices between drug and food were not exclusive in this study; that is, there were no contingencies arranged in the Carroll et al. study requiring that subjects forgo cocaine in order to obtain the alternative. A plausible hypothesis is that simply enriching an environment in which cocaine is available by introducing nondrug substitutes without any explicit contingencies between their availability and drug use may more effectively interfere with the initiation of cocaine use than with a well-established pattern of cocaine self-administration.

A study by Carroll and Lac (1993) further illustrates the ability of a substitute reinforcer to interfere with the initiation of cocaine use. Four groups of 12 rats each were studied; a fifth group was studied as well, but is not directly germane to the present discussion. In a two-by-two experimental design, the four groups were exposed to glucose-plus-saccharin or water for three weeks prior to and then during 30 cocaine self-administration initiation sessions. An initiation criterion was established to determine whether cocaine self-administration was initiated during the 30-day acquisition period: Subjects had to achieve an average of 100 or more drug ingestions per session across five consecutive six-hour sessions. The group that had access to the glucose-plus-saccharin solution before and during initiation sessions had the greatest number of failures to initiate regular self-administration (50 percent), followed by the group with glucose-plus-saccharin during initiation sessions only (25 percent), and the two groups with water available during initiation sessions had no failures (0 percent) (fig. 6.2).

Interestingly, this same group of investigators failed to significantly influence self-administration in monkeys smoking cocaine (Comer, Hunt, and Carroll 1994). In that study, a saccharin solution was introduced after cocaine self-administration was already established. While this manipulation decreased cocaine's behavioral control to a limited extent in several subjects, the effects were relatively unimpressive. No doubt many differences between this study and others discussed in this report make comparisons difficult. Those differences notwithstanding, the data are consistent with the position that substan-

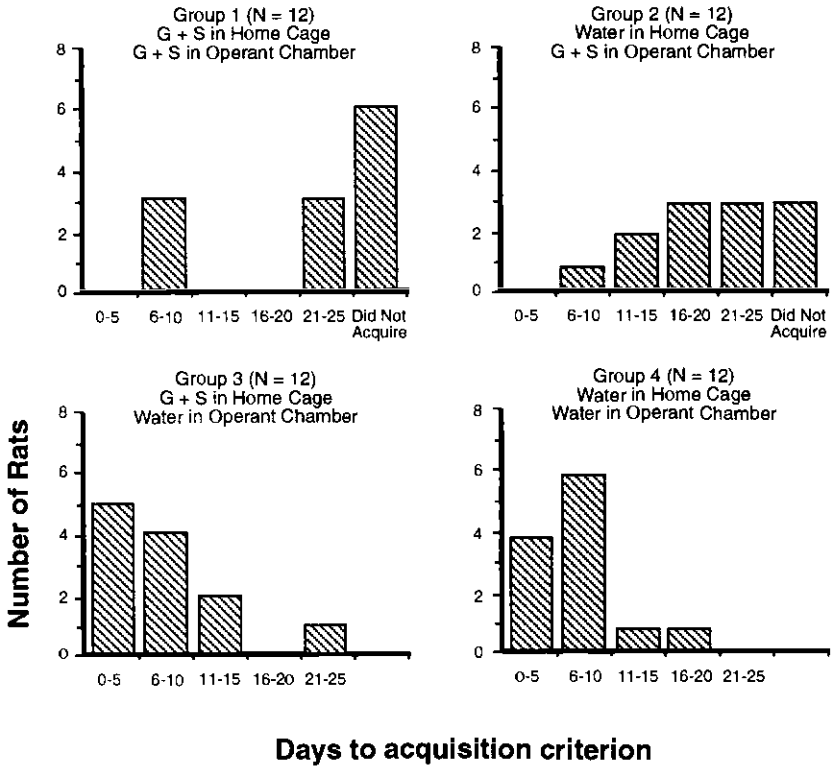


**Fig. 6.2 Acquisition of cocaine self-administration**

*Source:* Carroll and Lac (1993).

*Note:* Frequency distributions are presented for groups 1–4. The number of days until the acquisition criterion was met is divided into five, five-day intervals, and the number of rats that acquired within each interval is represented by the height of each bar. No rats met the criterion between 26 and 30 days. The last column depicts the number of rats that did not meet the criterion within the 30 days allotted. The two upper panels show the two groups that received access to glucose-plus-saccharin in the operant chamber, and the two lower panels indicate that only water was available in the operant chamber. The left panels show the two groups that were exposed to glucose-plus-saccharin in the home cage, while the right panels show the groups exposed to only water in the home cage.

tially reducing cocaine self-administration once it is already well established may require an arrangement in which access to the other commodity is made contingent on forgoing the cocaine option. Such additional contingencies appear unnecessary to significantly interfere with the initiation of cocaine use.

### 6.2.2 Studies with Humans

A study by Higgins, Bickel, and Hughes (1994) illustrates the application of these concepts to human cocaine users responding under controlled laboratory

conditions. Subjects were four healthy individuals who did *not* meet diagnostic criteria for cocaine or any other form of drug dependence (except nicotine) but were recent, occasional users of cocaine. Drug was administered intranasally in 10 mg unit doses of cocaine hydrochloride or a placebo consisting of approximately 0.4 mg cocaine and 9.6 mg lactose. The maximum dose of cocaine allowed per session was 100 mg, which is a psychoactive dose. Subjects sampled cocaine and placebo under double-blind conditions in two separate sessions, with the compounds labeled drug A and drug B. During a third session, they made a maximum of 10 exclusive choices between drugs A and B. Choices were registered by completion of a fixed-ratio (FR) 10 schedule on either of two concurrently available levers associated with drug and placebo options. Subjects could also forgo either option. Session duration was a maximum of two hours. Subjects had to choose cocaine over the placebo seven or more times during that double-blind cocaine-versus-placebo choice session in order to participate in the subsequent cocaine-versus-money sessions. Subjects were *not* informed of that criterion. The reason for the criterion was that we wanted to study subjects for whom cocaine functioned as a reinforcer, since that is a central feature of cocaine abuse. Cocaine-versus-money sessions were structured like the cocaine-versus-placebo session, except that now subjects chose between cocaine and varying amounts of money. Subjects were informed of monetary values prior to each cocaine-versus-money session, and values were varied across each session. Values varied from zero to $2.00 per choice or, in total sums, from zero to $20.00 per session. Payment occurred immediately after each session.

All four subjects exclusively chose cocaine over the placebo, demonstrating that the drug functioned as a reinforcer and satisfying the eligibility criterion for participation in the second phase of the experiment. During sessions comparing cocaine and money, choice of cocaine decreased as the amount of money available in the monetary option increased, with all subjects exclusively choosing the monetary option in the $2.00 per choice condition (fig. 6.3). In economic terms, choice of cocaine decreased as opportunity cost (i.e., amount of money forfeited) increased.

A second study following the same procedures as outlined above further illustrates these points (Higgins, Roll, and Bickel 1996). Subjects were 11 volunteers with the same characteristics as those described in the previous discussion. Nine of the 11 subjects reliably chose cocaine over the placebo in the choice session, demonstrating that the drug functioned as a reinforcer and establishing their eligibility for the cocaine-versus-money sessions. Two subjects who did not meet the eligibility criterion and two additional subjects who had scheduling conflicts were excluded from the cocaine-versus-money sessions. Again, cocaine preference decreased as an orderly function of opportunity cost (fig. 6.4). However, this study had an additional feature that distinguished it from the prior study. Prior to each cocaine-versus-money session, subjects

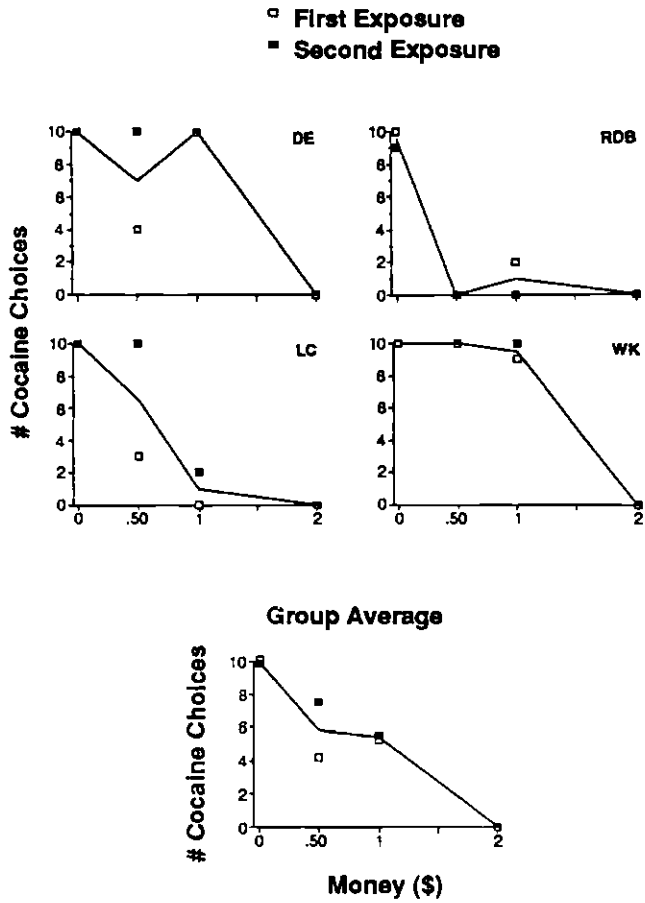


**Fig. 6.3 Cocaine versus money**

*Source:* Higgins, Bickel, and Hughes (1994).

*Note:* Number of cocaine choices are plotted as a function of the value of money available per choice in the monetary option. Subjects made a maximum of 10 choices between cocaine and money during each session. Data are presented for each of the four individual subjects and as a group average. Results from the first and second exposures to the different monetary values are shown separately.

were treated with varying doses of alcohol (placebo, 0.5, and 1.0 g/kg). Pretreatment with the active doses of alcohol increased preference for cocaine over the monetary reinforcer, with that effect being most discernible in the high money condition. In economic terms, alcohol and cocaine functioned as complements; that is, as consumption of alcohol increased, so too did consumption of cocaine. Note that, on average, alcohol pretreatment did not eliminate sensitivity to opportunity cost (it did in some individuals), but it modulated that relationship.

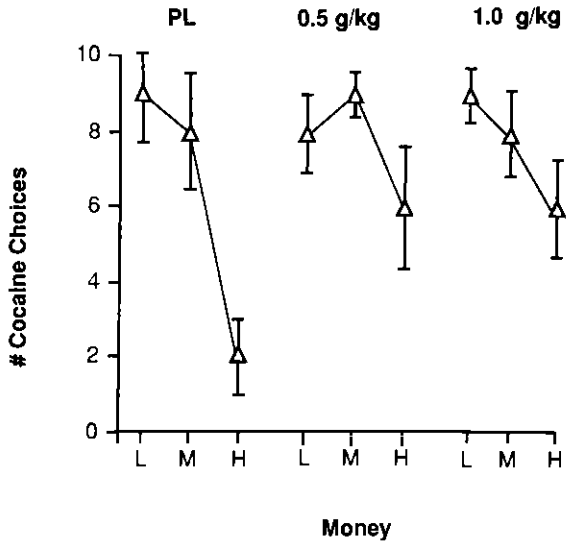


**Fig. 6.4 Cocaine versus money: Effects of alcohol**
*Source:* Higgins, Roll, and Bickel (1996).
*Note:* Number of cocaine choices during sessions involving alcohol pretreatment are shown as a function of three money conditions (low [L], medium [M], and high [H] monetary values), with separate functions presented for each of the three alcohol doses (placebo [PL], 0.5 g/kg, 1.0 g/kg). All data points represent means from seven subjects who completed the experiment; brackets represent ± SEM.

## 6.3 Clinical Applications: Contingency Management

Contingency-management interventions are commonly used in the treatment of illicit-drug abuse (Stitzer and Higgins 1995), and can be conceptualized as interventions that directly and systematically increase the opportunity cost of drug use (cf. Bickel et al. 1993). That is, conditions are arranged such that drug use results in the forfeiture of an altemative reinforcer. In that sense, the price of ingesting cocaine or another drug is the usual price associated with its acquisition and consumption plus the forfeiture of the reinforcer that would have been available had the individual abstained (i.e., opportunity cost). I am aware of 13 controlled trials examining the efficacy of different contingency-management interventions for reducing cocaine use, either alone or as a part of multi-element treatment packages (Higgins 1996). Significant treatment effects supporting the efficacy of the interventions in reducing cocaine use were observed in 11 (85 percent) of those 13 trials. No other type of treatment intervention has a comparable level of empirical support for its efficacy in reducing cocaine abuse. Considered together, these studies provide compelling evidence for the sensitivity of cocaine use in clinical populations to contingency-

management interventions, or, in economic terms, opportunity cost. Two studies are described for illustrative purposes.

The first study was conducted with 40 cocaine-dependent adults who were randomly assigned to behavioral treatment with or without an added incentive program (Higgins et al. 1994). Subjects in the group with incentives earned points recorded on vouchers that were exchangeable for retail items when thrice-weekly urine-toxicology screens indicated cocaine abstinence. Subjects assigned to the no-incentives group received slips of paper after each urinalysis screen, but those vouchers had no monetary value. All other aspects of the treatment were identical for the two groups. Subjects in both groups received counseling based on the Community Reinforcement Approach (CRA). Vouchers were discontinued after week 12 of the 24-week treatment program. In economic terms, the opportunity cost associated with cocaine use was increased for 12 weeks in the incentive group, but remained unchanged in the no-incentive group.

Approximately twofold longer durations of continuous cocaine abstinence were documented in the incentive group during the 24-week treatment period than in the no-incentive group (means were 11.7 ± 2.0 weeks in incentive group versus 6.0 ± 1.5 in the no-incentive group; see fig. 6.5). Additionally, those assigned to the incentive group evidenced greater reductions in the Addiction Severity Index (ASI) Composite Drug Scale one year after treatment entry (nine months after cessation of vouchers) compared to those assigned to the no-incentive group (Higgins et al. 1995). This difference was largely due to three items: (i) the mean number of days of cocaine use in the past 30 days decreased from 11.0 ± 1.3 at baseline to 0.9 ± 1.4 at one-year follow-up in the incentive group, versus 8.8 ± 1.3 to 2.3 ± 1.3 in the no-incentive group; (ii) the mean number of days in the past 30 days on which patients experienced drug problems decreased from 15.7 ± 1.9 at baseline to 1.8 ± 2.3 at one-year follow-up in the incentive group, versus 9.1 ± 1.9 to 6.1 ± 2.2 in the no-incentive group; and (iii) how troubled or bothered patients were in the past 30 days by these drug problems (rated from 0 to 4, with higher scores indicating

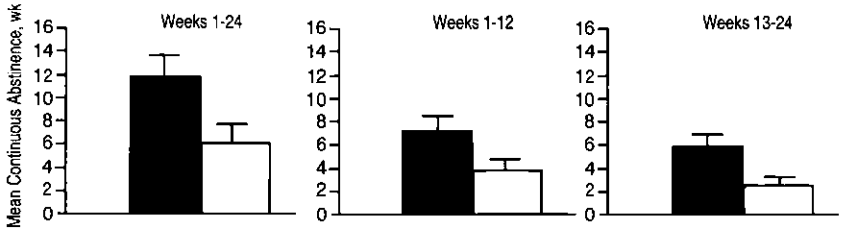


**Fig. 6.5 Continuous cocaine abstinence**

*Source:* Higgins et al. (1994).

*Note:* Mean durations of continuous abstinence achieved in each treatment group during weeks 1–24 (left panel), 1–12 (center panel), and 13–24 (right panel). *Solid bars* represent the incentive group and *open bars* the no-incentive group.

more problems) decreased from 3.6 ± 0.3 at baseline to 0.9 ± 0.3 at one-year follow-up in the incentive group, versus 3.3 ± 0.2 to 1.6 ± 0.3 in the no-incentive group.

The other study illustrating the sensitivity of cocaine use to opportunity cost in clinical populations was conducted in a methadone-maintenance clinic located in Baltimore, Maryland (Silverman et al. 1996). Subjects were 37 intravenous cocaine abusers enrolled in outpatient methadone-maintenance treatment for opioid dependence. Subjects were selected for the study after being identified as regular abusers of cocaine via urinalysis monitoring. Patients were randomized to routine methadone counseling plus contingent incentives or the same counseling plus noncontingent incentives. The contingent incentives were vouchers exchangeable for retail items delivered for 12 weeks just as in the study described previously. In contrast to the prior study, however, subjects assigned to the control group in this study also received vouchers, but they were delivered independent of urinalysis results and according to a schedule that was yoked to the contingent group (i.e., a noncontingent control group). Note that the manner in which alternative reinforcers were made available in this control group mimics in some important respects the methods used by Carroll and colleagues; that is, the alternatives were available independent of whether subjects self-administered cocaine.

Subjects who received contingent vouchers achieved significantly greater durations of continuous cocaine abstinence (fig. 6.6) than those assigned to the control group, further illustrating the effects of opportunity cost in clinical populations of cocaine abusers. The control group evidenced little discernible benefit from the alternative reinforcers in terms of reducing their cocaine use. The failure of the vouchers to substantially reduce cocaine use in the control group suggests that the reductions observed in the contingent group were due to increases in opportunity cost and not substitution per se. If substitution was the important variable, effects should have been comparable across the two groups.

Consistent with the laboratory study on alcohol and cocaine described above, the ability of contingent vouchers to decrease cocaine use appears to be modulated by alcohol use. This point is illustrated by the results from a chart review conducted with 16 individuals who met diagnostic criteria for cocaine dependence and alcohol abuse/dependence (Higgins et al. 1993). All subjects were treated with contingent vouchers and CRA. Disulfiram therapy for alcohol abuse/dependence is a routine component of CRA. Disulfiram interferes with alcohol metabolism such that an unpleasant physical reaction usually occurs if one consumes alcohol while taking the medication. Subjects were included in the chart review on the basis of having two or more weeks on and off disulfiram therapy during their current treatment episode, which permitted an opportunity to assess for associated benefits. Subjects reported an average of 0.05 ± 0.02 drinking days weekly while taking disulfiram versus 1.5 ± 0.4 off of the medication. The average number of drinks per drinking occasion

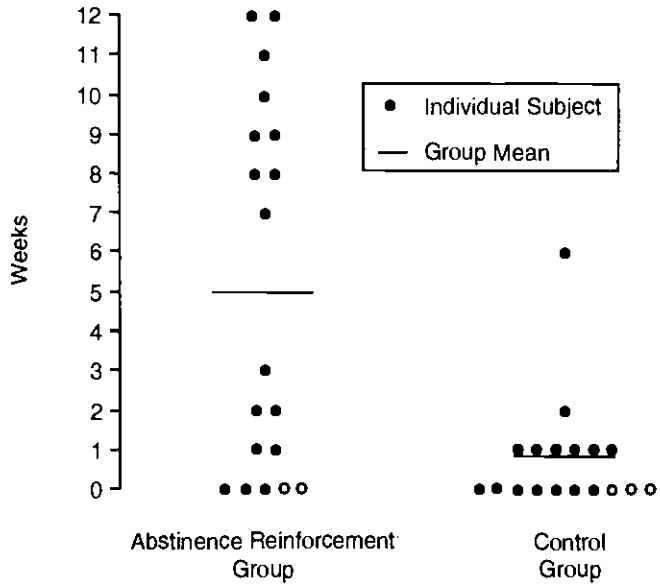


**Fig. 6.6 Continuous cocaine abstinence**
*Source:* Silverman et al. (1996).
*Note:* Longest duration of continuous cocaine abstinence achieved during the 12-week voucher condition. Each point represents data for an individual patient, and the lines represent group means. The 19 abstinence-reinforcement patients are displayed in the left column, and the 18 control patients in the right.

while taking disulfiram was 4.7 ± 2.2, versus 10.9 ± 2.6 off of the medication. Changes on both of those drinking measures were statistically significant and expected based on what is known scientifically about disulfiram therapy. What was unexpected was that disulfiram therapy was associated with significant reductions in cocaine use. The percentage of cocaine-positive specimens while taking disulfiram was 11 percent ± 3 versus 25 percent ± 6 off of the medication, a statistically significant difference. In economic terms, cocaine and alcohol appeared to act as complements. That is, when subjects were off of disulfiram and drank more frequently, cocaine use also increased, and when they were on disulfiram and drank less frequently, cocaine use decreased (i.e., complementary relationship).

## 6.4 Applications beyond the Drug Abuse Treatment Clinic

As was noted above, the majority of cocaine abusers are not enrolled in formal substance abuse treatment. Thus, there is a need to devise strategies for reducing cocaine abuse in other settings. That raises the question of what additional evidence exists that cocaine use in naturalistic settings is sensitive to the economic factors under discussion in this report.

Several recent reports based on data from large epidemiological studies support the sensitivity of cocaine use in naturalistic settings to price. Grossman and Chaloupka (1998) studied results from the Monitoring the Future survey, which is conducted annually with a nationally representative sample of high school seniors. A sample of approximately 2,400 individuals in each class is chosen for follow-up, with half of them being followed on even years and the others on odd years. Grossman and Chaloupka used results from 10 consecutive years of follow-up data. Cocaine use was analyzed in terms of frequency of use among those who were already users at baseline, and participation in cocaine use from one follow-up to the next. These two measures of cocaine use were analyzed in relation to cocaine price, which was estimated for the different geographical residences of the survey participants using the System to Retrieve Information from Drug Evidence (STRIDE), a database of cocaine prices throughout the United States maintained by the U.S. Drug Enforcement Agency (DEA). Statistically significant and negative relationships were observed between cocaine price and both measures of cocaine use (i.e., greater price meant less use).

Another study by Saffer and Chaloupka (1997) assessed sensitivity of cocaine use to price using data collected from over 49,000 participants in the National Household Surveys conducted in 1988, 1990, and 1991. The National Household Survey provides information on the use of illicit drugs, alcohol, and tobacco among members of the civilian, noninstitutionalized U.S. population age 12 and older. Saffer and Chaloupka assessed participation in cocaine use as a function of cocaine price, with the latter being estimated based on the STRIDE database. Relationships between cocaine use and price were negative and statistically significant. It merits mention that this study also provided evidence that alcohol and cocaine function as complements, consistent with the results from the laboratory and clinic studies described earlier.

Considering that we know that cocaine use is sensitive to price and other economic factors in laboratory, clinic, and general population studies, it does not seem too large a stretch to speculate about additional ways in which economic factors might be manipulated to reduce cocaine use and abuse in settings other than substance abuse treatment clinics. In the paragraphs that follow I discuss three examples of how these principles might be applied.

First, attempts could be made to intervene in neighborhoods that are at risk for fostering the initiation of cocaine use and abuse (Crum, Lillie-Blanton, and Anthony 1996; Lillie-Blanton, Anthony, and Schuster 1993). A recent study by Crum et al. (1996) provides a nice illustration of the potential impact of neighborhoods on the initiation of cocaine use. Self-reported data on opportunities to use cocaine and other drugs were collected from 1,416 urban-dwelling middle-school participants in a longitudinal field study. The neighborhoods in which these children resided were rated using an 18-item scale that assessed safety (e.g., safe places to walk), neglect (e.g., broken bottles, trash around), and other neighborhood characteristics. Scale scores were used to categorize

neighborhoods into most, middle, and least disadvantaged. After controlling for grade, gender, minority status, and peer drug use, children residing in the most disadvantaged neighborhoods were estimated to be 5.6 times more likely to have been offered the opportunity to use cocaine than those living in relatively advantaged neighborhoods.

Such at-risk neighborhoods could be targeted for programs strategically designed and scheduled to increase the availability of healthy and effective substitutes for cocaine use. Programs in the arts and music, athletics, academics, social relations, and career development are examples of the kinds of programs that might be investigated. The content, scheduling, and location of these programs would have to be carefully planned to substitute for the social, entertainment, and other functions that are often served by cocaine use. Well-conducted basic-science research studies have demonstrated the efficacy of alternative, nondrug substitutes for disrupting the initiation of cocaine use (Carroll, et al. 1989; Carroll and Lac 1993). They can do so in the absence of any explicit contingencies between cocaine use and access to the substitute. The fact that such contingencies are unnecessary is important because it means that the efficacy of such interventions need not depend on objective monitoring of cocaine use (e.g., urinalysis), which is costly and impractical for prevention efforts. Whether disruptions in the initiation of cocaine use comparable to those observed in the laboratory could be caused by systematically programming substitutes for cocaine use in at-risk neighborhoods is an important question that warrants scientific investigation. Such interventions have the potential to contribute to the targeted, theoretically based community interventions that have been called for in prevention research (Institute of Medicine 1996).

Second, cocaine abuse is prevalent at alarming levels in newly arrested and other criminal offenders. It is not uncommon for half or more of newly arrested felons to test positive for recent cocaine use (National Institute of Justice 1996). These individuals contribute directly to the high U.S. incarceration rates and attendant escalating criminal justice costs. A plausible alternative for cases involving nonviolent crimes related to cocaine use are programs similar to the voucher program described earlier. However, instead of vouchers, individuals in these programs might earn progressively greater reductions in their level of criminal justice supervision by continuously abstaining from cocaine. Cocaine use would set supervision back to a stricter level. Important features of such programs would be regular and sensitive monitoring so that cocaine use is readily detected, consistent consequences for drug use and abstinence delivered with minimal delay, and consequences set at an intensity and duration that permit clients to interact repeatedly with the contingencies so that they may contact and learn from the new opportunity costs of continuing to use cocaine. Many states currently have programs that approximate this suggestion, but they generally lack the important contingency-management features just mentioned. I know of no controlled trials examining the efficacy of any such program in reducing cocaine use among criminal offenders, but such studies cer-

tainly appear warranted. Considering the relatively robust evidence supporting the sensitivity of cocaine use to opportunity cost and other economic factors, such programs seem to offer a reasonable and cost-effective alternative to current practices.

Third, cocaine and other drug abuse is a serious problem among a subset of individuals receiving Veterans and Social Security Insurance disability income (Satel 1995). A recent study examining the relationship between cocaine use and disability payments among schizophrenics provides an interesting example (Shaner et al. 1995). The severity of psychiatric symptoms, hospitalization rates, and cocaine urine toxicology screens were assessed for 15 consecutive weeks in 105 veterans who met diagnostic criteria for schizophrenia and cocaine dependence. On average, these individuals reported spending half of their total income on illegal drugs. Cocaine use, psychiatric symptoms, and hospital admissions peaked during the first or second week of the month, coincident with delivery of the disability payment. Citing the efficacy of voucher-based incentives in reducing cocaine use, these investigators raised the question of whether similar incentive programs might not be implemented in some manner via use of the disability payments. Obviously, any such program would need to be designed with great sensitivity to individual rights and could not legally involve withholding entitlements. Those concerns notwithstanding, at least two programs for the dually diagnosed are in the process of researching such an approach (Shaner et al. 1995; Ries and Comtois 1997). To assess whether substance use by schizophrenics is sensitive to economic factors, our group recently completed a study in which schizophrenics recruited from a local community mental health center were provided monetary incentives for abstaining from cigarette smoking (i.e., the opportunity cost for smoking was increased) (Roll et al. 1998). Abstinence increased significantly during the incentive phase of the study, demonstrating the sensitivity of substance use by schizophrenics to opportunity cost.

## 6.5 Conclusions

Behavioral economics appears capable of subsuming and organizing empirical observations regarding cocaine use that range from preclinical studies conducted with laboratory animals to epidemiological studies conducted with national samples. Such conceptual breadth is uncommon in the area of drug abuse, and it suggests that behavioral economics incorporates concepts and principles that are fundamental to the initiation and maintenance of cocaine use and abuse. There is also a great deal of potential heuristic value in the conceptual breadth of behavioral economics as it affords cocaine researchers operating in distinctly different settings (lab, clinic, communities) an opportunity to build upon each others' findings. As an investigator who operates mostly in the clinical pharmacology laboratory and treatment clinic, for example, my work has benefited immensely from the research of my colleagues in the basic-

science laboratory and, more recently, from the efforts of those involved in epidemiological research. The history of science is very clear regarding the value of sound theory.

In my opinion, behavioral economics offers more than theory; it also offers very practical strategies for reducing cocaine use and abuse. To the limited extent that those strategies have been investigated, they appear equally or more effective in reducing cocaine abuse than anything else that has been attempted. That is not to say that behavioral economics offers any magic bullets for resolving the challenges presented by cocaine abuse. It does not. However, it does offer scientifically based strategies for improving treatment and prevention efforts that merit further programmatic evaluation. Moreover, many of the strategies suggested by behavioral economics are unconventional in terms of common practices in substance abuse treatment and prevention, which is good. Variety should only be helpful as we attempt to identify and develop more effective interventions. Lastly, behavioral economics offers potential strategies for reducing cocaine use and abuse beyond the formal substance abuse clinic. There is a tremendous need for a broader-based approach to reducing cocaine abuse, which is true for other types of substance abuse as well (e.g., Institute of Medicine 1990). Behavioral economics appears to have the potential to contribute in important and novel ways to those broader efforts.

## References

Bickel, W. K., and R. J. DeGrandpre. 1996a. Modeling drug abuse policy in the behavioral economics laboratory. In *Advances in behavioral economics*, vol. 3, ed. L. Green and J. Kagel, 1–36. New York: Ablex.

———. 1996b. Psychological science and drug policy. In *Drug policy and human nature: Psychological perspectives on the control, prevention, and treatment of illicit drug use*, ed. W. K. Bickel and R. J. DeGrandpre. New York: Plenum.

Bickel, W. K., R. J. DeGrandpre, and S. T. Higgins. 1993. Behavioral economics: A novel experimental approach to the study of drug dependence. *Drug and Alcohol Dependence* 33:173–92.

Bickel, W. K., R. J. DeGrandpre, S. T. Higgins, and J. R. Hughes. 1990. Behavioral economics of drug self-administration. I. Functional equivalence of response requirement and dose. *Life Sciences* 47:1501–10.

Bickel, W. K., R. J. DeGrandpre, S. T. Higgins, J. R. Hughes, and G. J. Badger. 1995. Effects of simulated employment and recreation on cigarette smoking: A behavioral economic analysis. *Experimental and Clinical Psychopharmacology* 3:467–76.

Carroll, M. E., and S. T. Lac. 1993. Autoshaping i.v. cocaine self-administration in rats: Effects of nondrug alternative reinforcers on acquisition. *Psychopharmacology* 110: 5–12.

Carroll, M. E., S. T. Lac, and S. L. Nygaard. 1989. A concurrently available nondrug reinforcer prevents the acquisition or decreases the maintenance of cocaine-reinforced behavior. *Psychopharmacology* 97:23–29.

Comer, S. D., V. R. Hunt, and M. E. Carroll. 1994. Effects of concurrent saccharin

availability and buprenorphine pretreatment on demand for smoked cocaine base in rhesus monkeys. *Psychopharmacology* 115:15–23.

Crum, R. M., M. Lillie-Blanton, and J. C. Anthony. 1996. Neighborhood environment and opportunity to use cocaine and other drugs in late childhood and early adolescence. *Drug and Alcohol Dependence* 43:155–61.

Grossman, M., and F. J. Chaloupka. 1998. The demand for cocaine by young adults: A rational addiction approach. *Journal of Health Economics* 17 (4):427–74.

Higgins, S. T. 1996. Some potential contributions of reinforcement and consumer-demand theory to reducing cocaine use. *Addictive Behaviors* 21:803–16.

Higgins, S. T., W. K. Bickel, and J. R. Hughes. 1994. Influence of an alternative reinforcer on human cocaine self-administration. *Life Science* 55:179–87.

Higgins, S. T., A. J. Budney, and W. K. Bickel. 1994. Applying behavioral concepts and principles to the treatment of cocaine dependence. *Drug and Alcohol Dependence* 34:87–97.

Higgins, S. T., A. J. Budney, W. K. Bickel, G. J. Badger, F. E. Foerg, and D. Ogden. 1995. Outpatient behavioral treatment for cocaine dependence: One-year outcome. *Experimental and Clinical Psychopharmacology* 3:205–12.

Higgins, S. T., A. J. Budney, W. K. Bickel, F. E. Foerg, R. Donham, and G. J. Badger. 1994. Incentives improve outcome in outpatient behavioral treatment of cocaine dependence. *Archives of General Psychiatry* 51:568–76.

Higgins, S. T., A. J. Budney, W. K. Bickel, J. R. Hughes, and F. Foerg. 1993. Disulfiram therapy in patients abusing cocaine and alcohol. *American Journal of Psychiatry* 150:675–76.

Higgins, S. T., J. M. Roll, and W. K. Bickel. 1996. Alcohol pretreatment increases preference for cocaine over monetary reinforcement. *Psychopharmacology* 123:1–8.

Higgins, S. T., and C. J. Wong. 1998. Treating cocaine abuse: What does research tell us? In *Cocaine abuse research: Pharmacology, behavior, and clinical applications*, ed. S. T. Higgins and J. L. Katz, 343–61. San Diego, Calif.: Academic Press.

Institute of Medicine. 1990. *Broadening the base of treatment for alcohol problems*. Washington, D.C.: National Academy Press.

———. 1996. *Pathways of addiction: Opportunities in drug abuse research*. Washington, D.C.: National Academy Press.

Johanson, C. E., and M. W. Fischman. 1989. The pharmacology of cocaine related to its abuse. *Pharmacological Reviews* 41:3–52.

Johanson, C. E., and C. R. Schuster. 1995. Cocaine. In *Psychopharmacology: The fourth generation of progress*, ed. F. E. Bloom and D. J. Kupfer, 1685–97. New York: Raven Press.

Lillie-Blanton, M., J. Anthony, and C. R. Schuster. 1993. Probing the meaning of racial/ethnic group comparisons in crack smoking. *Journal of the American Medical Association* 269:993–97.

Nader, M. A., and W. L. Woolverton. 1992. Effects of increasing response requirement on choice between cocaine and food in rhesus monkeys. *Psychopharmacology* 108: 295–300.

National Association of State Alcohol and Drug Abuse Directors. 1996. *State resources and services related to alcohol and other drug problems for fiscal year 1994: An analysis of state alcohol and drug abuse profile data*. Washington, D.C.: National Association of State Alcohol and Drug Abuse Directors, Inc.

National Institute of Justice. 1996. *1995 Drug use forecasting: Annual report on adult and juvenile arrestees*. Washington, D.C.: U.S. Department of Justice.

Regier, D. A., W. E. Narrow, D. S. Rae, R. W. Manderscheid, B. Z. Locke, and F. K. Goodwin. 1993. The de facto U.S. mental and addictive disorders service system: Epidemiologic catchment area prospective 1-year prevalence rates of disorders and services. *Archives of General Psychiatry* 50:85–107.

Ries, R. K., and K. A. Comtois. 1997. Managing disability benefits as part of treatment for persons with severe mental illness and comorbid drug/alcohol disorders: A comparative study of payees and non-payee participants. *American Journal on Addictions* 6:330–38.

Roll, J. R., S. T. Higgins, S. Steingard, and M. McGinley. 1998. Use of monetary reinforcement to reduce the cigarette smoking of persons with schizophrenia: A feasibility study. *Experimental and Clinical Psychopharmacology* 6:157–61.

Saffer, H., and F. J. Chaloupka. 1997. Demographic differentials in the demand for alcohol and illicit drugs. Paper presented at the National Bureau of Economic Research, Cambridge, Mass., March.

Satel, S. L. 1995. When disability benefits make patients sicker. *New England Journal of Medicine* 333:794–96.

Shaner, A., T. A. Eckman, L. J. Roberts, J. N. Wilkins, D. E. Tucker, J. W. Tsuang, and J. Mintz. 1995. Disability income, cocaine use, and repeated hospitalization among schizophrenic cocaine abusers. *New England Journal of Medicine* 12:777–83.

Silverman, K., S. T. Higgins, R. K. Brooner, I. D. Montoya, E. J. Cone, C. R. Schuster, and K. L. Preston. 1996. Sustained cocaine abstinence in methadone maintenance patients through voucher-based reinforcement therapy. *Archives of General Psychiatry* 53:409–15.

Stitzer, M. L., and S. T. Higgins. 1995. In *Psychopharmacology: The fourth generation of progress,* ed. F. E. Bloom and D. J. Kupfer, 1807–19. New York: Raven Press.

Substance Abuse and Mental Health Services Administration. 1996a. *Preliminary estimates from the 1995 national household survey on drug abuse.* Rockville, Md.: U.S. Department of Health and Human Services Public Health Service.

———. 1996b. *Preliminary estimates from the drug abuse warning network.* Rockville, Md.: U.S. Department of Health and Human Services Public Health Service.

Vuchinich, R. E., and J. A. Tucker. 1988. Contributions from behavioral theories of choice as a framework to an analysis of alcohol abuse. *Journal of Abnormal Psychology* 97:181–95.

## Comment on Chapters 5 and 6

Jonathan P. Caulkins

Both Chaloupka, Grossman, and Tauras's paper "The Demand for Cocaine and Marijuana by Youth" and Stephen Higgins's "Applying Behavioral Economics to the Challenge of Reducing Cocaine Abuse" address the fundamentally important topic of how substance use and users respond to incentives. Nevertheless, they are quite distinct in their approach and contribution, so I will discuss them sequentially.

Chaloupka et al. examine how responsive demand by U.S. youth for cocaine and marijuana has been to changing circumstances. Their principal contribution is to extend the growing empirical literature on the price elasticity of demand for cocaine. Roughly 70 percent of the $40 billion or so the United States spends annually on drug control is devoted to supply control measures (Office

Jonathan P. Caulkins is professor of operations research and public policy at Carnegie Mellon University's Heinz School of Public Policy and is on the research staff at RAND's Drug Policy Research Center.

of National Drug Control Policy) [ONDCP] 1993). For mass-market drugs such as cocaine, marijuana, and heroin, such enforcement has not been able either to "seal the borders" or to make drugs physically unavailable. Besides increasing "search time" or the nondollar costs of acquiring drugs, the principal effect of these billions of dollars in enforcement spending is to keep prices high. Semiprocessed agricultural products that need not, if they were legal, cost much more than tea or coffee are, instead, worth many times their weight in gold when sold on the streets of cities such as Boston (Caulkins and Reuter 1998). Whether such enforcement has much effect on drug use, therefore, depends directly and heavily on the elasticity of demand. Indeed, the elasticity of demand is perhaps the single most important parameter for evaluating the efficacy of U.S. drug control policy. This new estimate is of great value and makes the paper one worth reading.

The paper, in addition, stimulates four observations. The first concerns the paper's estimates of how various legal sanctions affect drug use. The variables measuring the stringency of enforcement consider only the statutory sentence given conviction, which is very different than the quantity of greatest interest—namely, the expected amount of enforcement or punishment suffered given participation in the activity in question. There can be great disparities between the actual average sanction and the statutory sanction. More important, the analysis does not include any measure of the number of people convicted, let alone the number of people convicted per person selling or using drugs.

Furthermore, we know there are instances when changes in the stringency of laws have been at least partially offset by changes in the number of people arrested and in charging practices. For instance, when certain Australian states introduced the expiation system, a sort of marijuana decriminalization, the number of arrests rose substantially. The usual interpretation is that the police had been reluctant to make low-level marijuana arrests under the old system. Even more surprising, the number of felony convictions for marijuana offenses did not drop because many of those charged did not avail themselves of the opportunity to pay the fine and expiate their sentence.

Finally, inasmuch as supplier sanctions reduce use by driving up price, and as price is included in the cocaine regression, one would not expect the coefficient for supplier sanction to capture sanctions' full contribution to suppressing cocaine use.

The authors acknowledge these issues, but proceed to ignore them when it comes time to draw conclusions; for example, "In general, higher sanctions for the sale of either drug were not found to reduce use of that drug by youths" (section 5.5). I think the variables measuring statutory sanction severity should be included in the regression. As controls, however imperfect, they presumably improve the estimates of the price elasticity of demand. However, I do not think the small magnitude of the coefficients of these variables should be con-

strued as particularly strong evidence of the inability of enforcement sanctions to influence use.

My second observation stems from the cross-sectional nature of the data analysis. Drug prices are consistent with a model of the domestic drug distribution network as following an urban hierarchy. In particular, prices appear to be systematically lower in larger cities than in smaller cities, and lower in areas surrounding larger cities than in areas surrounding smaller cities (Caulkins 1995). If there are factors associated with large cities that promote use apart from these lower prices, then this cross-sectional analysis may overestimate the price elasticity of demand. One obvious potential factor would be the possibility that nondollar costs of purchasing and using drugs ("search times") are lower in cities with larger markets.

A third observation is that although prices influence youth drug use, other factors apparently play an even greater role. Between 1982 and 1989 cocaine prices fell by about 75 percent (Caulkins 1994). Given Chaloupka et al.'s estimate that the price elasticity of cocaine participation is about $-0.95$, one might have expected the prevalence of cocaine use by youth to have increased by 70 to 75 percent. Instead, it fell by about 45 percent (Johnston, O'Malley, and Bachman 1994). These numbers in no way contradict Chaloupka et al.'s elasticity findings. Presumably, if prices had not declined, prevalence rates would have fallen even more dramatically. However, apparently factors other than price overwhelmed the effect of even a dramatic decline in price.

The fourth observation concerns what inferences can be drawn about how legalization would affect drug use, which Chaloupka et al. mention as a motivation for this work. Their conclusion that "substantial reductions in illicit drug prices that would almost certainly result from partial or full drug legalization would lead to significant increases in the number of youths consuming illicit drugs" (section 5.5) seems well supported by this work. It is interesting to note, though, how difficult it would be to produce bounds that are much tighter or more specific. Even a completely accurate, highly precise estimate of the price elasticity of demand derived from recent experience would not allow one to predict very accurately by how much drug use would increase if drugs were legalized. One reason is the one just mentioned: Nonprice factors also affect drug use. A second is that the change in consumption one would predict from legalization-induced declines in price depends at least as much on one's model of the shape of the demand curve for prices between the current and postlegalization price as it does on the elasticity or slope of the demand curve near the current price.

Suppose for the sake of argument that the current price and consumption are \$125 per pure gram and 291 pure metric tons of cocaine, respectively. Suppose further that legalization would reduce the price to \$2.50 per gram and that the elasticity of demand estimated here for youth, about $-1.3$, was a point estimate at the current price and that it applied to all users. Then, if one thought the demand curve were linear, this 98 percent decline in price would lead to a 1.3

$\times$ 0.98 = 127 percent increase in consumption.[1] In contrast, if one believed the demand curve had constant elasticity ($Q = \alpha P^{\eta}$), the 98 percent decline in price would lead to a $(0.02)^{-1.3}$ = 16,000 percent increase in consumption (to 47,000 metric tons). I doubt the latter model is correct. Among other reasons, evidence was presented in other papers at this conference (Carroll, chap. 11 in this volume) suggesting that the elasticity of demand might be lower at lower prices. It illustrates clearly, however, that assumptions about the shape or nature of the demand curve have as much impact on numeric estimates of the legalization-induced consumption changes as do estimates of the elasticity around current prices. Estimating elasticities of demand from recent data is enormously valuable for analyzing drug policy reforms within a prohibitionist framework that keeps prices moderately close to their current levels. Likewise, it can provide a caution to the most Pollyanna-ish of legalization advocates who would like to think legalization would not affect use much at all. It cannot, however, provide tight bounds on the likely consumption increase associated with a hypothetical legalization of cocaine.

Higgins's paper, in contrast, reviews clinical and laboratory evidence that supports the notion that cocaine use is an operant behavior that can fruitfully be understood in terms of consumer-demand theory. The theoretical contribution of this paper is its support for taking a behavioral economics approach to understanding drug abuse. Its practical contribution stems from the mechanisms it suggests for controlling substance abuse. For example, interventions based on contingency management have great promise, particularly given that, as Mark Kleiman (1997) points out, (i) the majority of the cocaine and heroin consumed in the United States is used by individuals who are under criminal justice system "supervision," and (ii) such individuals are prime targets for contingency-management interventions.

There seems to me little question about the validity of the experimental results Higgins describes. Many involve classical experimental design with controls, random assignment, and so forth. Indeed, it is a joy for someone accustomed to the social science literature to read such work. There is a delightful rigor that traditional social science rarely, if ever, achieves. The key question is the extent to which the results can be generalized beyond the laboratory or clinical setting. I do not know the answer, but I can offer a few comments.

Thinking about laboratory results can suggest plausible drug control interventions, and Higgins lists several. It cannot, however, determine which of

1. The elasticity estimate of $-1.3$ was produced from years in which prices were generally at least as high as the current price. Hence, I take it as a point estimate at the current price, not as an arc elasticity that would apply over the price change considered in this example. Indeed, if it were viewed as an arc elasticity between the past (higher) price and the current price, the estimated increase in consumption would be smaller. That would increase the difference between the predictors with the two demand models, reinforcing the overall point that uncertainty about the demand model swamps uncertainty about the parameter estimate.

these plausible interventions will prove cost effective in practice. Higgins mentions both alternatives-based drug prevention and coerced-abstinence interventions for drug-involved offenders as programs that are consistent with the concepts of consumer-demand theory that have been demonstrated in the laboratory. Given what we know about conventional treatment's cost efficacy (Rydell and Everingham 1994; Gerstein et al. 1994), I suspect that coerced abstinence will prove cost effective. In contrast, in a recent review of the drug prevention literature, I found no well-designed, controlled studies of alternatives-based prevention interventions that proved cost effective, and the consensus in the prevention literature favors so-called "psychosocial" or "comprehensive" prevention interventions (Institute of Medicine 1996).

Even if laboratory studies cannot prove the cost effectiveness of interventions, they might stimulate ideas for interventions that would not have otherwise been considered. That is certainly a possibility. However, although the interventions Higgins describes might fairly be termed as innovative or progressive relative to the state of the art, the ideas are not entirely novel. They have been proposed in the literature before. (See, e.g., the programs reviewed in Caulkins et al. 1994.)

Paradoxically, when Higgins could present clinical data relevant to evaluating the cost effectiveness of an intervention, he does not do so. The paper stresses the statistical significance of results, not their magnitude or practical significance. For example, Higgins cites a contingency management study for which "32 percent of contingent patients achieved sustained periods of abstinence" averaging 9.4 weeks in length "compared to less than 10 percent in the noncontingent condition" over the course of what I understand to be a six-month study. There seems to be no question as to the statistical significance of the difference in outcomes, but it sounds like contingency management was able to reduce drug use by only a modest proportion. Suppose the individuals whose longest period of abstinence was 9.4 weeks, on average, actually abstained for an average of 18 weeks in total over the six months. Table 6C.1 suggests that contingency management reduced drug use during the trial by about one-sixth, a nontrivial but not overwhelming reduction.

My interpretation of those numbers may be way off base, but if so, it just underscores my larger point that it would have been useful if the article had devoted more time to reporting the absolute magnitude of these effects. Likewise, although this intervention may be highly cost effective because it achieved the reduction in use at very low cost, one cannot know that from the article because no cost information is reported.

My final comment concerns just what marriage of disciplines is being contemplated. One of Higgins's principal conclusions is that the application of consumer-demand theory to understanding cocaine abuse is an important advance. That may well be true, but it is interesting that in this article the only concepts borrowed from consumer-demand theory are demand (interpreted as use), price, opportunity cost, and the existence of substitutes and complements (section 6.1). Those concepts are hardly unique to economics. Many fields that

**Table 6C.1** **Hypothetical Illustration of Magnitude of Effect of Contingency-Management Intervention**

| | Noncontingent | Contingent |
|---|---|---|
| Used for almost all of 26 weeks (%) | 90 | 68 |
| Abstained for average of 18 of 26 weeks (%) | 10 | 32 |
| Average number of weeks of use over 6-month treatment regimen | 24.2 | 20.2 |

systematically study decision making have parallel concepts, perhaps masquerading under a different name. So inasmuch as Higgins is enthusiastic about the potential benefit to clinicians and substance abuse professionals of borrowing ideas from different fields, perhaps the relevant field is not so much economics as decision theory or choice modeling more generally.

It is also interesting to think about this marriage of fields from the other side. What do economists and policy analysts gain from these rigorous laboratory and clinical studies? It depends on how full one perceives the glass of experimental results to be. A minimalist would say that the studies Higgins describes have demonstrated that consumption responds to prices, that income affects consumption, and that there exist substances or objects that can serve as either substitutes or complements for drugs. In short, drug users and drug use respond to incentives. None of that is new. Policy analysts are quite familiar with these concepts and have applied them to drug policy analysis. Furthermore, from personal experience, I have not had a great deal of trouble explaining to lay people why drug users should exhibit these behaviors, so the ability to point to laboratory studies demonstrating these behaviors may be helpful but certainly is not invaluable.

Imagine, for a minute, the opposite extreme. Imagine that many additional years of laboratory studies have been pursued and have found evidence of comparable credibility that laboratory animals and clinical subjects fit the consumer-demand model entirely, in the sense that they can be described as rationally maximizing a utility or preference function. Would that be very useful? Not terribly. Analysts and researchers have long been quite willing to apply such rational-actor models to drug use. Experimental confirmation of these prior assumptions of rationality might vindicate certain disciplinary prejudices, but it would not likely generate many new ideas.

Now imagine an intermediate scenario in which laboratory studies validate models of drug use behavior that are more specific than merely "users respond to incentives" but also more subtle than "users optimally maximize their utility functions." Such results could be very useful to anyone trying to develop models of how drug users behave or trying to predict how drug users will respond to various policy interventions.

Perhaps the best example of such an intermediate result discussed at this conference is the idea that future events are discounted hyperbolically, not exponentially (Vuchinich and Simpson, chap. 4 in this volume). That finding does not follow trivially from the notion that drug users respond to incentives.

Nor is it consistent with rational-actor models. It helps explain observed behaviors of drug users, such as impulsiveness and apparently inconsistent discount rates (Kleiman 1992). It may also prove useful for designing interventions, for example, because of what it says about the importance of immediacy of rewards in a contingency-management or coerced-abstinence program.

Unfortunately at present it does not seem that there are many such intermediate results from the laboratory studies. However, I am quite optimistic that more will be forthcoming.

### References

Caulkins, Jonathan P. 1994. *Developing price series for cocaine.* Santa Monica, Calif.: Rand Corporation.

———. 1995. Domestic geographic variation in illicit drug prices. *Journal of Urban Economics* 37:38–56.

Caulkins, Jonathan P., Nora Fitzgerald, Karyn Model, and H. Lamar Willis. 1994. *Youth drug prevention through community outreach: The military's pilot programs.* Santa Monica, Calif.: Rand Corporation.

Caulkins, Jonathan P., and Peter Reuter. 1998. What price data tell us about drug markets. *Journal of Drug Issues* 28 (3): 593–612.

Gerstein, Dean R., Robert A. Johnson, Henrick J. Harwood, Douglas Fontain, Natalie Suter, and Kathryn Malloy. 1994. *Evaluating recovery services: The California Drug and Alcohol Treatment Assessment (CALDATA).* Sacramento, Calif.: California Department of Alcohol and Drug Programs.

Institute of Medicine. 1996. *Pathways of addiction: Opportunities in drug abuse research.* Washington, D.C.: National Academy Press.

Johnston, Lloyd D., Patrick M. O'Malley, and Jerald G. Bachman. 1994. *National survey results on drug abuse from the Monitoring the Future study, 1975–1993.* Washington, D.C.: U.S. Government Printing Office.

Kleiman, Mark A. R. 1992. *Against excess: Drug policy for results.* New York: Basic Books.

———. 1997. Managing drug-involved offenders. *Drug Policy Analysis Bulletin,* no. 1:3–4.

Office of National Drug Control Policy. 1993. *State and local spending on drug control activities.* Washington, D.C.: The White House.

Rydell, C. Peter, and Susan S. Everingham. 1994. *Controlling cocaine: Supply vs. demand programs.* Santa Monica, Calif.: Rand Corporation.

## Comment on Chapters 5 and 6

David Shurtleff

Chaloupka et al. provide an econometric analysis of the impact of drug prices and drug control policies on youth drug abuse. Econometric approaches are appealing because they provide us with important real-world information about

David Shurtleff is acting deputy director of the Division of Basic Research at the National Institute on Drug Abuse, National Institutes of Health.

the relationships between economic fluctuations and the consumption of commodities (i.e., goods). In order to describe these relationships (demand functions), econometric approaches factor in variables such as uncontrollable price changes, consumed quantities, and other outside forces such as the availability of alternative substitutable commodities and income effects. While Chaloupka et al.'s approach is based on existing data sets, possible relationships among variables can provide important insights for later manipulation and study under controlled conditions.

The authors have made an impressive effort in coordinating data from various data sets, such as Monitoring the Future; STRIDE (System to Retrieve Information from Drug Evidence); and monetary fines and prison terms for the sale, manufacture, and distribution of cocaine and marijuana. From these data sets they have constructed measures that do not determine actual amounts consumed but that are useful in estimating demand elasticities for cocaine and marijuana. Their conclusions are compelling, and suggest that among youth, cocaine demand is inversely related to price. Furthermore, the data suggest that increasing the penalties for the possession of cocaine and marijuana would significantly reduce use, but such increases would need to be large to have a significant impact. Also, youth demand for licit and illicit drugs is more sensitive to price than adult demand. Research will be needed to determine why such differences exist and to identify the economic or other variables that underlie them. With regard to the effect of price manipulation on illicit drug consumption, research from behavioral economics suggests that the "total price" of a commodity may include many and diverse behavioral elements such as the amount of effort or force needed to make a response, the number of responses required per unit of commodity, or the amount of time needed to obtain a commodity. Such elements have not only been shown in the laboratory to be important determinants of the total price of commodities (e.g., Hursh et al. 1988) but may also be operating in the "natural world." For example, enforced drug-free school and neighborhood "watch" zones may increase the total price of illicit drugs by increasing the effort and travel time needed to obtain them. By identifying the various components of total price and their relative contribution to total price, more effective drug prevention strategies and drug policies can then be developed.

Dr. Higgins's paper provides an excellent overview of the application of economic theory to the treatment of drug abuse by highlighting the usefulness of contingency management as a treatment approach within a context of economic concepts. Higgins describes how the concept of opportunity cost (forfeiture of alternative commodities for using an illicit drug) and price can guide the development of drug treatment strategies. He supports this claim by describing a study in which cocaine-dependent subjects were given vouchers for clean urine (Higgins et al. 1995): "Approximately twofold longer durations of continuous cocaine abstinence were documented in the incentive group during the 24-week treatment period than in the no-treatment group. . . . Additionally,

those assigned to the incentive group evidenced greater reductions in the Addiction Severity Index (ASI) Composite Drug Scale one year after treatment entry (nine months after cessation of vouchers) compared to those assigned to the no-incentive group. . . ." (section 6.3). This experiment demonstrates both the short- and long-term efficacy of contingency management in reducing cocaine abuse after cessation. Additional research needs to compare contingency management with pharmacotherapy to determine their relative long-lasting effects in reducing drug abuse. Importantly, the paper by Higgins identifies a variety of contingency-management techniques for treating drug abuse and addiction. Typically, addicts are provided with alternatives that are both reinforcing and that substitute for drug-related behaviors. In some cases, access to alternative reinforcers or behaviors (such as vouchers and vocational training) is dependent on drug abstinence. Higgins explains that these methods can and should be applied to situations beyond laboratory and treatment settings. That such alternative-choice approaches may be useful as prevention strategies in neighborhoods with a high prevalence of illicit drug abuse, in the criminal justice system, and in conjunction with social entitlement programs seems a reasonable extension of the treatment- and laboratory-based research. Strategies for testing and evaluating these interventions will be needed to assess their efficacy in families, schools, and community settings.

Contingency management is designed explicitly to treat one of the seven DSM-IV (American Psychiatric Association 1994) symptoms for drug dependence; that is, cessation or reduction in important social, occupational, or recreational activities because of substance use. Contingency management attempts to restore these activities with the use of economic and behavior-analysis principles. From an economic perspective, contingency management increases the proportion of an individual's income through the receipt of vouchers that are exchangeable for commodities and services, and through increased savings from not purchasing drugs. Increased income, it is thought, increases an individual's choices. If an individual's income is not sufficiently increased—for example, because of low voucher values or insignificant increases in income from foregoing drug purchases—contingency management may fail. In addition, the economic concept of substitution plays a role in determining the success of contingency management. If earned activities are substitutable for drug-related behaviors, contingency management should decrease the likelihood of drug use. Thus, the availability of substitutable alternatives to drug use and the proportional or marginal increase in income are at least two important variables that will determine the success of contingency management in treating drug dependence.

An important economic concept that emerges from both the Chaloupka et al. and the Higgins papers is that elasticity of demand may determine changes in drug use. Elasticity of demand is a concept that indicates the degree of responsiveness of the commodity demanded to changes in its price. If demand is inelastic, a large percentage increase in price will produce a smaller percentage

decrease in consumption. Conversely, demand is characterized as elastic if a percentage increase in price leads to a larger percentage decrease in consumption. Unitary elasticity refers to the condition in which a percentage increase in price results in an equivalent percentage decrease in consumption. Dr. Higgins describes an animal study from Nader and Woolverton (1992) showing that rhesus monkeys, given the opportunity to self-administer cocaine, initially show inelastic demand at low prices (i.e., few responses per unit dose) but will show greater elastic demand as the price for cocaine continues to increase. Also, Bickel et al. (1990) have shown similar demand functions in a review of laboratory studies across a variety of animal subjects and drugs of abuse. Among youth, Chaloupka, et al. demonstrated that demand elasticity for cocaine increases with price. It is clear from both these papers, and from much of the extant behavioral and economic literature, that illicit drug use is sensitive to price manipulations in much the same way as more conventional commodities such as food (Hursh 1984; Hursh et al. 1988), and consumption of licit drugs such as nicotine (Bickel et al. 1991) and alcohol (Babor et al. 1978; Bigelow and Liebson 1972) in laboratory settings. This research further suggests that studying demand for more conventional commodities could contribute to the development of behavioral economic principles and concepts applicable to drug abuse and addiction. Demand curve analysis can be used in a variety of settings in which drug dependence will need to be evaluated. For example, demand curve analysis has been recently used to compare abuse potential across drug classes (Hursh and Winger 1995). Also, demand curve analysis can be used to characterize the degree of dependence in individual drug users. Such information could be used to tailor a contingency-management treatment approach based on an individual's demand elasticity. That is, those individuals who are highly dependent on a particular drug may demonstrate inelastic demand compared with recreational users. By using this approach in the assessment of drug dependence, along with other existing diagnostic tools (e.g., Addiction Severity Index; McLellan et al. 1985), one could then determine the severity of the addiction in order to develop more targeted drug treatment regimens.

In conclusion, both papers contribute significantly to our understanding of both licit and illicit drug abuse and addiction by showing the application of behavioral and economic approaches to this public health problem. As economists and behavior analysts continue to collaborate, the potential for improved interventions for drug prevention and treatment will grow. From a broader perspective, this conference has shown that drug abuse and the demand for drugs can, in part, be explained within a behavioral economic framework. These papers effectively show how illicit drug use, in terms of the principle of demand elasticity, is not different from more conventional commodities, and certainly is not different from demand for licit drugs such as alcohol and nicotine (tobacco). Improved and refined data collection and development of data sets explicitly designed for the economic analysis of drug abuse will provide further

impetus to the search for environmental and economic factors responsible for drug abuse, thus informing the debate on national drug policy, drug treatment strategies, and prevention.

## References

American Psychiatric Association. 1994. *Diagnostic and statistical manual of mental disorders: DSM-IV,* 4th ed. Washington, D.C.: American Psychiatric Association.

Babor, Thomas F., Jack H. Mendelson, Isacc Greenberg, and John Kuehnle. 1978. Experimental analysis of the "happy hour": Effects of purchase price on alcohol. *Psychopharmacology* 58:35–41.

Bickel, Warren K., R. J. DeGrandpre, Stephen T. Higgins, and John R. Hughes. 1990. Behavioral economics of drug self-administration. I. Functional equivalence of response requirement and drug dose. *Life Sciences* 47:1501–10.

Bickel, Warren K., R. J. DeGrandpre, John R. Hughes, and Stephen T. Higgins. 1991. Behavioral economics of drug self-administration. II. A unit price analysis of cigarette smoking. *Journal of the Experimental Analysis of Behavior* 55:145–54.

Bigelow, George, and Ira Liebson. 1972. Cost factors in controlling alcoholic drinking. *Psychological Record* 22:305–14.

Higgins, S. T., A. J. Budney, W. K. Bickel, G. J. Badger, F. E. Foerg, and D. Ogden. 1995. Outpatient behavioral treatment for cocaine dependence: One-year outcome. *Experimental and Clinical Psychopharmacology* 3:205–12.

Hursh, Steven R. 1984. Behavioral economics. *Journal of the Experimental Analysis of Behavior* 42:435–52.

Hursh, Steven R., Thomas G. Raslear, David Shurtleff, Richard Bauman, and Lawrence Simmons. 1988. A cost benefit analysis of demand for food. *Journal of the Experimental Analysis of Behavior* 50:419–40.

Hursh, Steven R., and Gail Winger. 1995. Normalized demand for drugs and other reinforcers. *Journal of the Experimental Analysis of Behavior* 64:373–84.

McLellan, A. Thomas, Lester Lubrosky, John Cacciola, J. Griffith, Peter McGahan, and Charles P. O'Brien. 1985. *Guide to addiction Severity Index: Background, administration and field testing results.* Rockville, Md.: U.S. Department of Health and Human Services.

Nader, Michael A., and William L. Woolverton. 1992. Effects of increasing response requirement on choice between cocaine and food in rhesus monkeys. *Psychopharmacology* 108:295–300.

# IV Polydrug Use