APPLYING BEHAVIORAL ECONOMICS TO THE CHALLENGE OF REDUCING COCAINE ABUSE

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of Reducing Cocaine Abuse
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ABSTRACT

This paper focuses on potential contributions of behavioral economics to reducing cocaine abuse. More specifically, this paper underscores the fundamental role of reinforcement in the genesis and maintenance of cocaine use and explores how reinforcement and consumer-demand theory might be translated into effective strategies for reducing cocaine use. A broad range of relevant research findings are discussed, including preclinical studies conducted with laboratory animals, laboratory and treatment-outcome studies conducted with cocaine abusers, and large epidemiological studies conducted with national samples of the U.S. population.

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Cocaine abuse remains a major U.S. public health problem. The number of frequent cocaine users (use ≥ once per week) remains stable at 500,000-7500,000 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), 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 & Wong, in press), 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.

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 & 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 or 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 & Fischman, 1989; Johanson & 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; Bickel et al., 1993; Bickel et al., 1995; Bickel & DeGrandpre, 1996a; Vuchinich & 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.

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 implications of the behavioral economics for policy and other matters regarding drug supply should see Bickel and DeGrandpre (1996a,1996b).

Laboratory Settings

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 (Figure 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% 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 et al. (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-hr 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 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 two-fold 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. Said 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 forego cocaine in order to obtain the alternative. A plausible hypothesis is that simply enriching an environment in which cocaine is available by introducing non-drug 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 3 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 5 consecutive 6-hr 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%), followed by the group with glucose-plus saccharin during initiation sessions

only (25%), and the two groups with water available during initiation sessions had no failures (0%) (Figure 2).

Interestingly, this same group of investigators failed to significantly influence self-administration in monkeys smoking cocaine (Comer et al., 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 that 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 substantially 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 foregoing the cocaine option. Such additional contingencies appear unnecessary to significantly interfere with the initiation of cocaine use.

Studies with humans. A study by Higgins et al. (1994a) 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 as Drug A and Drug B. During a third session, they made a maximum of ten exclusive choices between Drugs A and B. Choices were registered by completion of an FR 10 on either of two concurrently available levers associated with drug and placebo options. Subjects could also forego either option. Session duration was a maximum of 2 hrs. Subjects had to choose cocaine over placebo 7 or more times during that double-blind cocaine vs. placebo choice session in order to participate in the subsequent cocaine vs. money sessions. Subjects were <u>not</u> 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 vs. money sessions were structured like the cocaine vs. placebo session, except that now subjects chose between cocaine and varying amounts of money. Subjects were informed of monetary values prior to each cocaine vs. money session, and values were varied across 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 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 vs. 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

(Figure 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. Subjects were eleven volunteers with the same characteristics as those described above. Nine of the eleven subjects reliably chose cocaine over placebo in the choice session, demonstrating that the drug functioned as a reinforcer and establishing their eligibility for the cocaine vs. money sessions. Two subjects who did not meet the eligibility criterion and two additional subjects who had scheduling conflicts were excluded from the cocaine vs. money sessions. Again, cocaine preference decreased as an orderly function of opportunity cost (Figure 4). However, this study had an additional feature that distinguished it from the prior study. Prior to each cocaine vs. money session, subjects were treated with varying doses of alcohol (placebo, 0.5, & 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 compliments; 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.

Clinical Applications

Contingency management. Contingency-management interventions are commonly used in the treatment of illicit-drug

abuse (Stitzer & Higgins, 1995), and can be conceptualized as interventions that directly and systematically increase the opportunity cost of drug use (cf., Bickel & DeGrandpre, 1996). That is, conditions are arranged such that drug use results in the forfeiture of an alternative 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 thirteen controlled trials examining the efficacy of different contingency-management interventions for reducing cocaine use, either alone or as a part of multielement treatment packages (Higgins, 1996). Significant treatment effects supporting the efficacy of the interventions in reducing cocaine use were observed in 11 (85%) 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 a behavioral treatment with or without an added incentive program (Higgins et al., 1994b). 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 two-fold longer durations of continuous cocaine abstinence were documented in the incentive group during the 24-week treatment period than those assigned to the no-incentive group (means were 11.7±2.0 weeks in incentive group vs. 6.0±1.5 in the no-incentive group, see Figure 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 (9 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: (1) 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; (2) 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; (3) how troubled or bothered patients were in the past 30 days by these drug problems (rated from 0-4, with higher scores indicating 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 in clinical populations to opportunity cost was conducted in a methadone-maintenance clinic located in Baltimore, MD (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 above. 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 (Figure 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 $\geq$ 2 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 $\pm$ 0.02 drinking days weekly while taking disulfiram vs. 1.5 $\pm$ 0.4 off the medication. The average number of drinks per drinking occasion while taking disulfiram was 4.7 $\pm$ 2.2 vs. 10.9 $\pm$ 2.6 off 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% ± 3 vs. 25% ± 6 off the medication, a statistically significant difference. In economic terms, cocaine and alcohol appeared to act as compliments. That is, when subjects were off 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).

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 et al. (1996) studied results from the Monitoring the Future survey, which is conducted annually with a nationally representative sample of high school seniors (see Grossman et al., this volume). 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 et al. used results from ten 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 data base of cocaine prices throughout the U.S 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 = less use).

Another study by Safer 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. Safer and Chaloupka assessed participation in cocaine use as a function of cocaine price, with the latter being estimated based on the STRIDE data base. 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 compliments consistent with the results from the laboratory and clinic studies described above.

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. Below I discuss three examples of how these principles might be applied.

First, attempts could be made to intervene in neighborhoods at-risk for fostering the initiation of cocaine use and abuse (Crum et al., 1966; Lillie-Blanton et al., 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-report 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 should be carefully planned to substitute for the

social, entertainment and other functions that are often served by cocaine use. Well-conducted basic-research studies have demonstrated the efficacy of alternative, nondrug substitutes for disrupting the initiation of cocaine use (Carroll et al., 1989; Carroll & 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 non-violent crimes related to cocaine use are programs similar to the voucher program described above. 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 reset 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 new opportunity cost of continuing to use cocaine. Many states currently have programs that approximate this suggestion, but 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 certainly 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 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, 1995 cited in Satel, 1995). 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., opportunity cost for smoking was increased) (Roll et al., 1997). Abstinence increased significantly during the incentive phase of the study demonstrating the sensitivity of substance use by schizophrenics to opportunity cost.

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 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 the 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.

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Figure Legends

Figure 1. 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. From Nader & Woolverton, 1992..

Figure 2. Frequency distributions are presented for groups 1-4. The number of days until the acquisition criterion was met is divided into five 5-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 frames show the two groups that received access to glucose-plus-saccharin in the operant chamber, and the two lower frames indicate that only water was available in the operant chamber. The upper and lower left frames show the two groups that were exposed to glucose-plus-saccharin in the home cage, while the upper and lower right frames show the groups exposed to only water in the home cage. From Carroll & Lac, 1993.

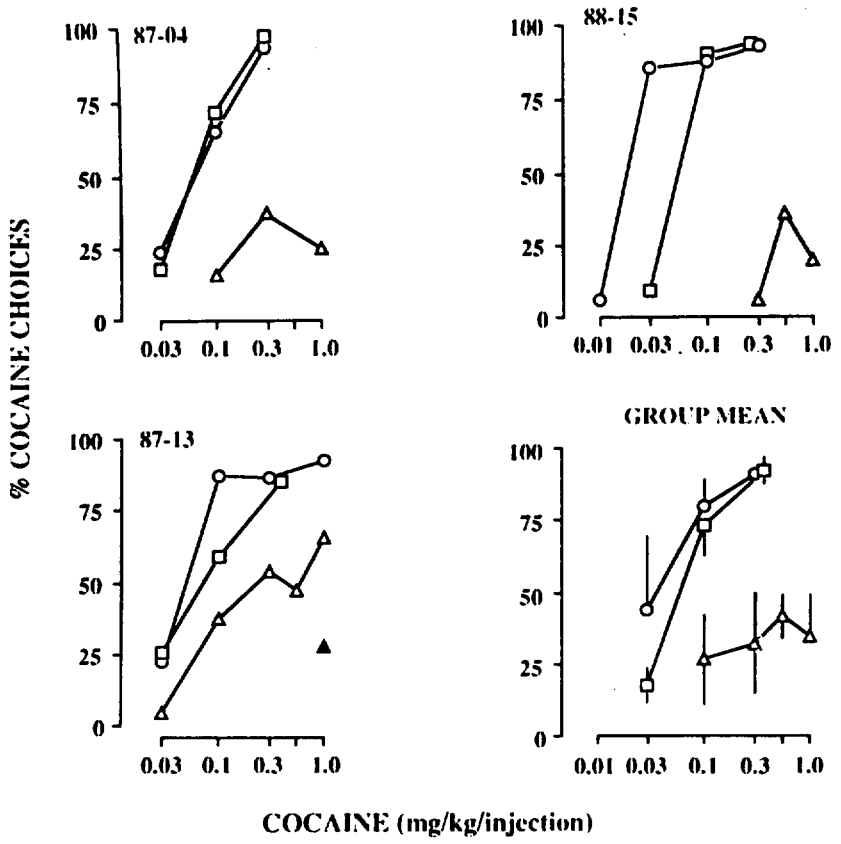
Figure 3. Number of cocaine choices are plotted as a function of the value of money available per choice in the monetary option. Subjects made a maximum of ten choices between cocaine vs. money each session. Data are presented for each of the four individual subjects and as a group average. Results from the first and second exposures to the different monetary values are shown separately. From Higgins et al., 1994a.

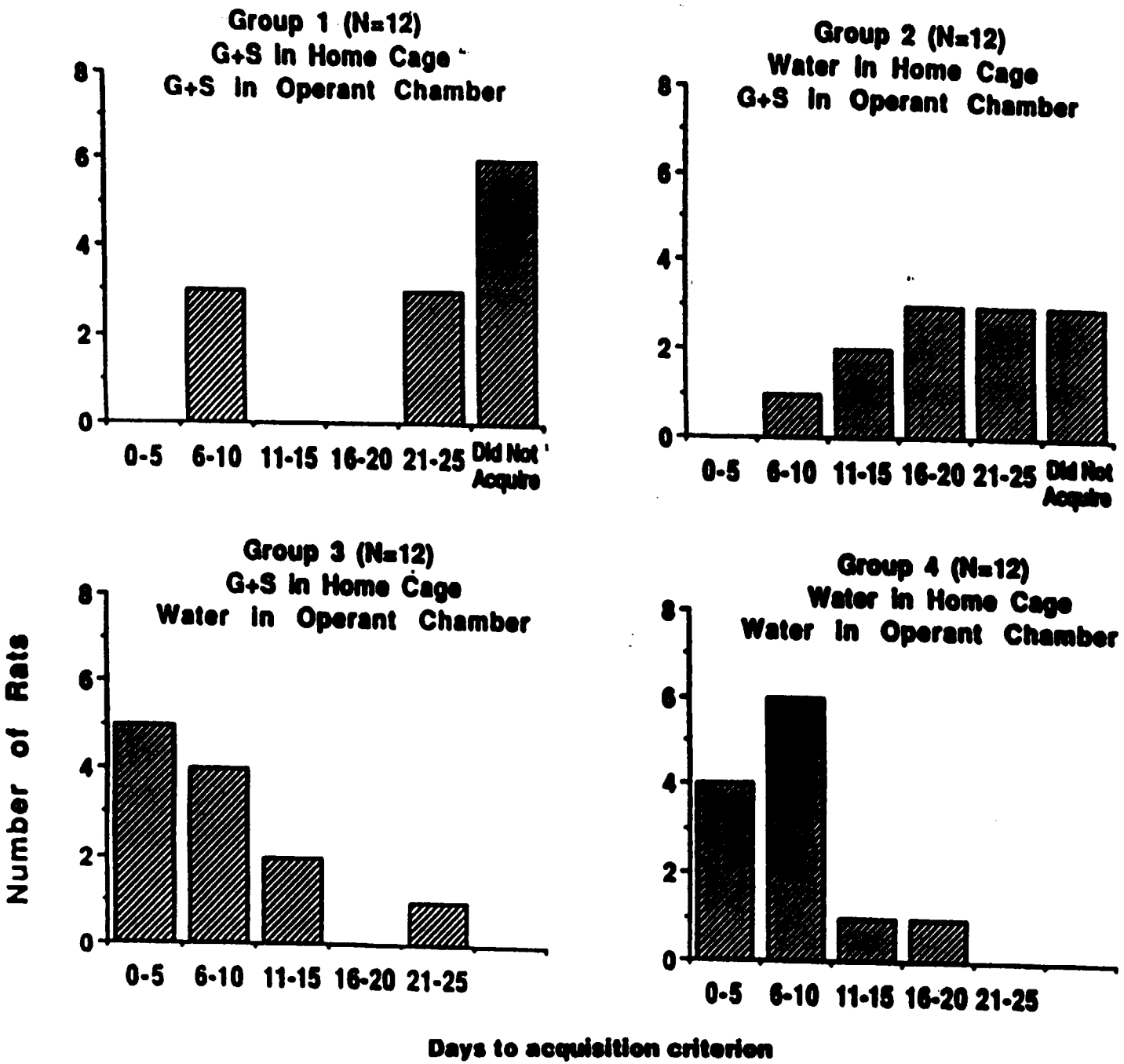
Figure 4. Number of cocaine choices during sessions involving alcohol pretreatment are shown as a function of three money conditions [low (L); medium (M); high (H) monetary values], with separate functions presented for each of the three alcohol doses [placebo (PL), 0.5 g/kg, 1.0 g/kg]. All data points represent means from seven subjects who completed the experiment; brackets represent ± SEM. From Higgins et al., 1996.

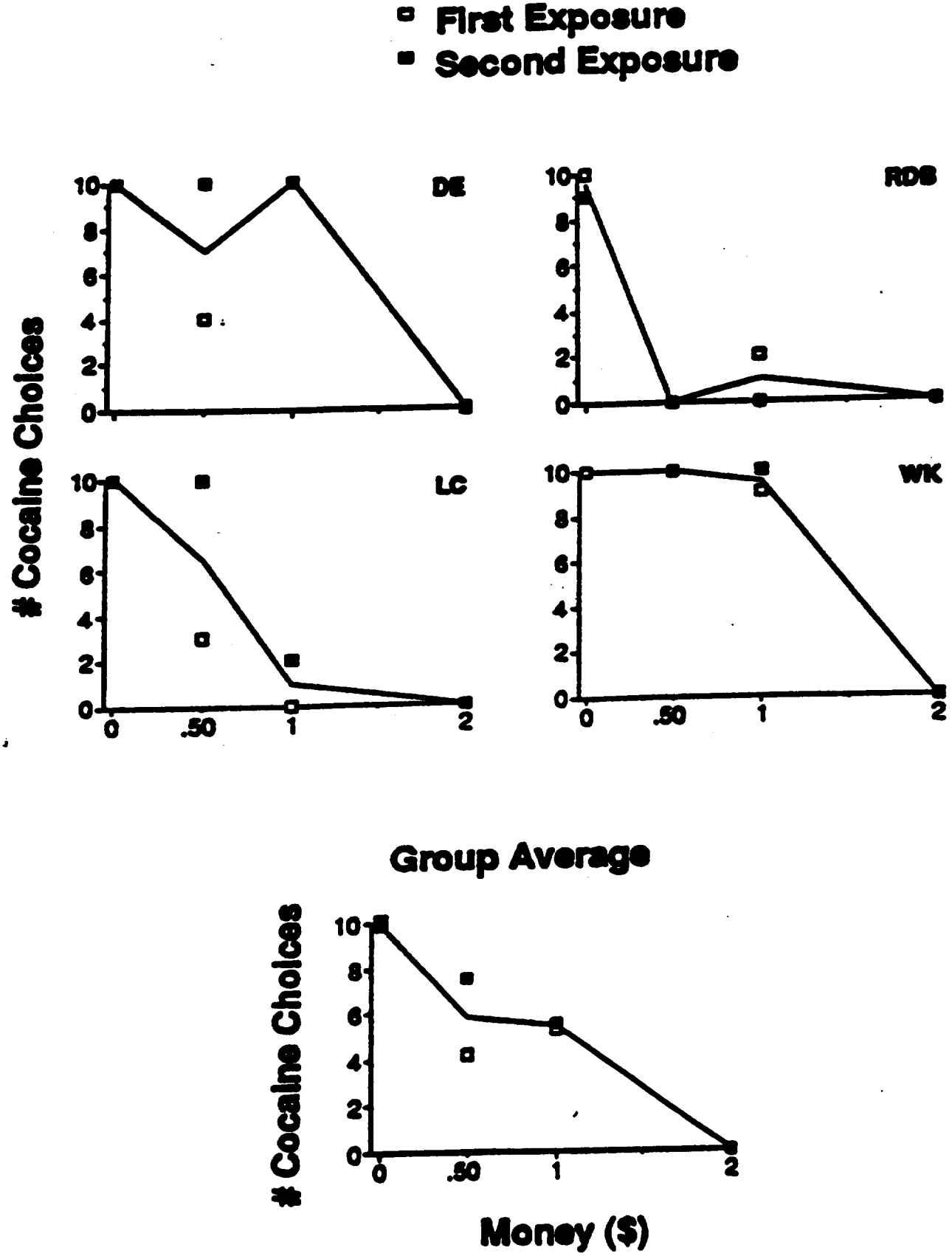
Figure 5. Mean durations of continuous abstinence achieved in each treatment group during weeks 1 through 24 (left panel), 1 through 12 (center panel), and 13-24 (right panel) weeks of treatment. Closed bars represent the incentive group and open bars the no-incentive group. From Higgins et al., 1994b.

Figure 6. 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

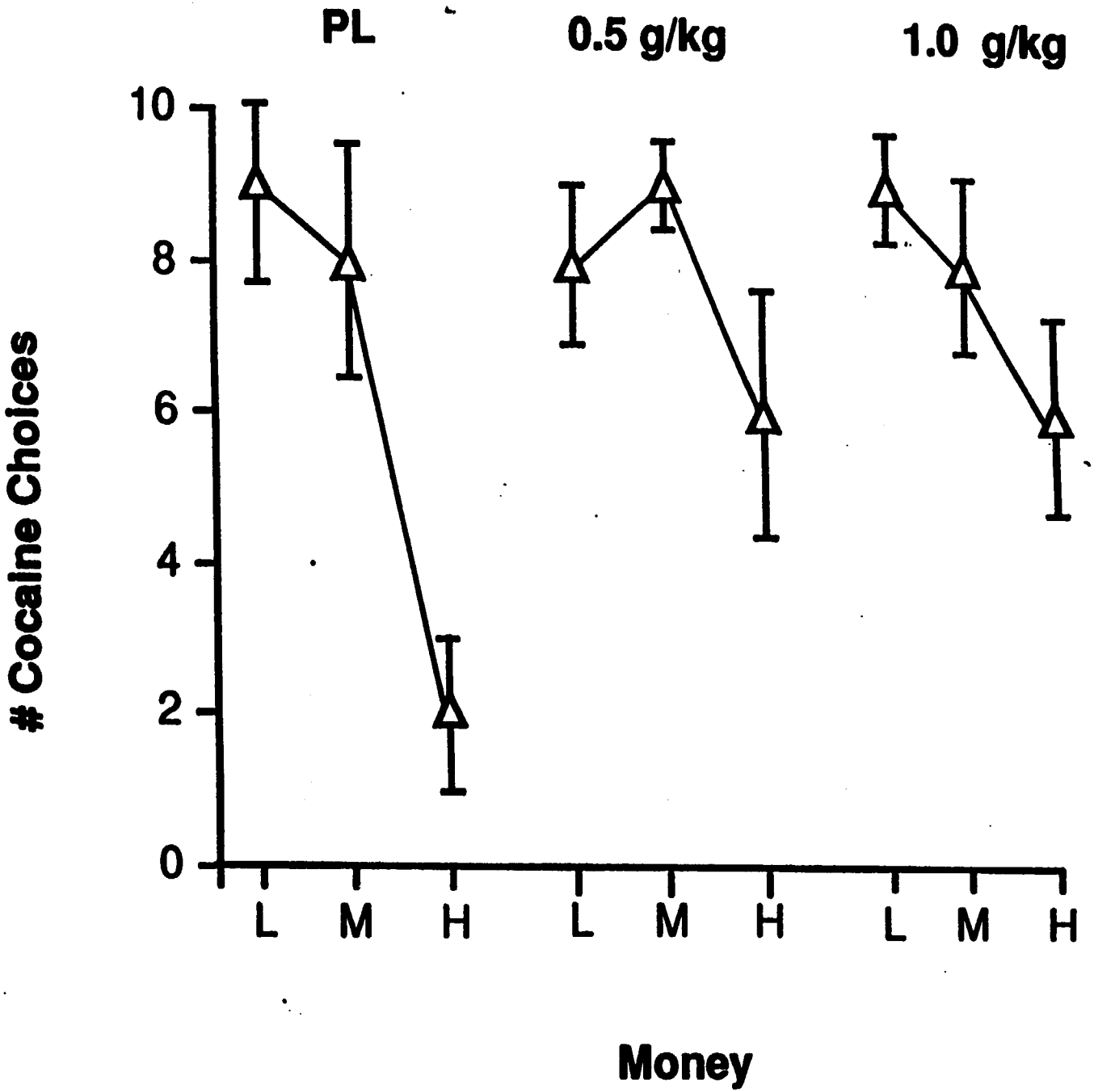
in the left column and the 18 control patients in the right. From Silverman et al., 1996.


87-04
88-15
87-13
GROUP MEAN
100
75
50
25
0
0.01
0.03
0.1
0.3
1.0
% COCAINE CHOICES
COCAINE (mg/kg/injection)


Group 1 (N=12)
G+S in Home Cage
G+S in Operant Chamber
Group 2 (N=12)
Water in Home Cage
G+S in Operant Chamber
Group 3 (N=12)
G+S in Home Cage
Water in Operant Chamber
Group 4 (N=12)
Water in Home Cage
Water in Operant Chamber
Number of Rats
0
2
4
6
8
0-5
6-10
11-15
16-20
21-25
Did Not Acquire
Days to acquisition criterion



Group Average


PL
0.5 g/kg
1.0 g/kg
Cocaine Choices
10
8
6
4
2
0
L
M
H
L
M
H
L
M
H
Money

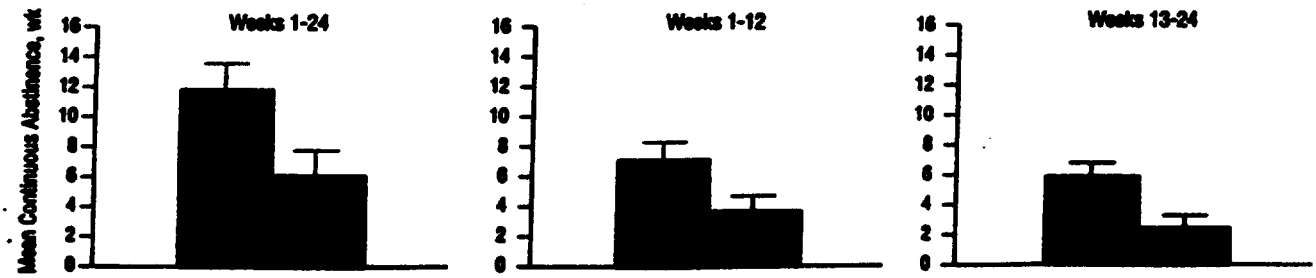
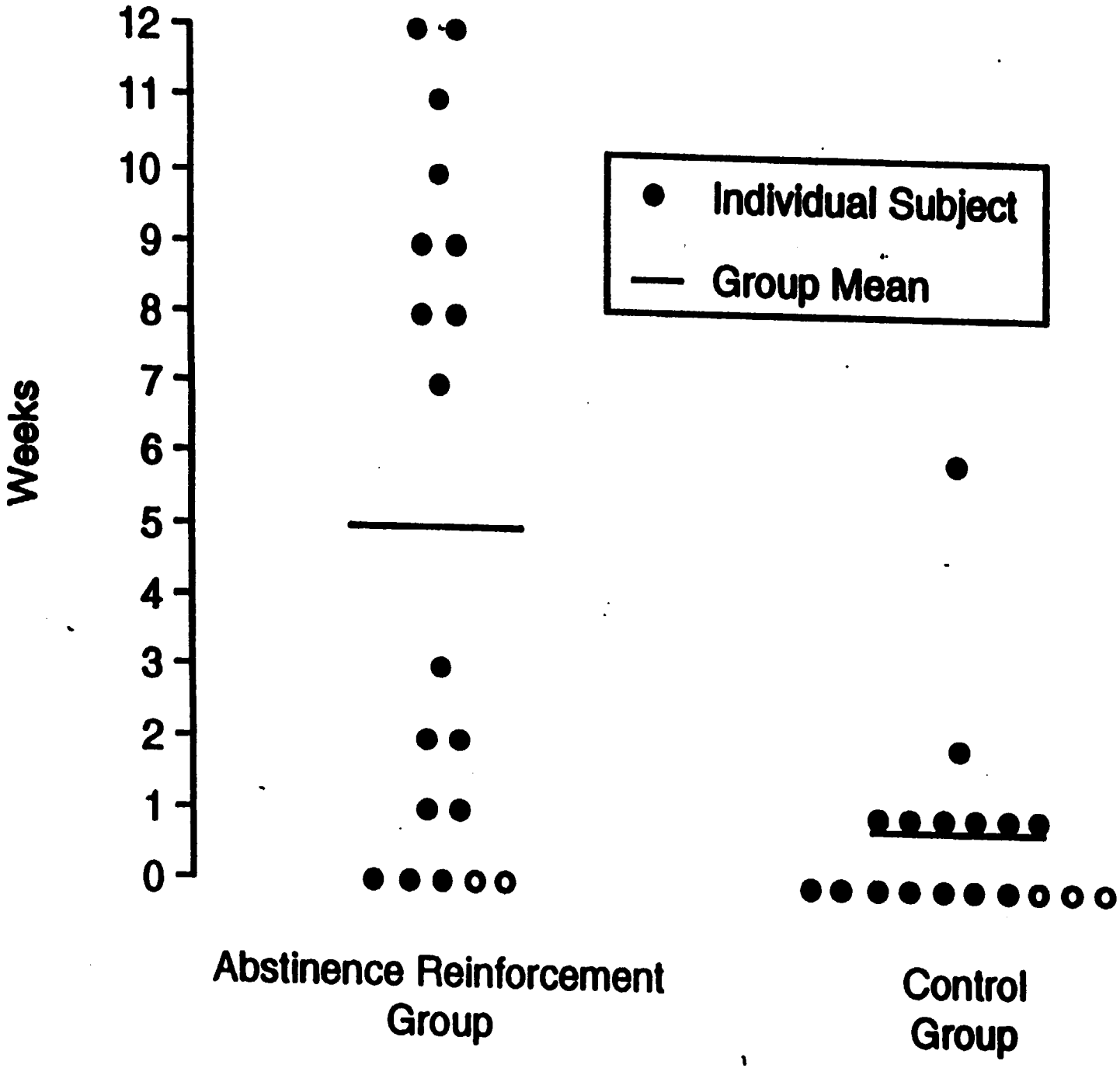

Mean Continuous Abstinence, wk
16
14
12
10
8
6
4
2
0
Weeks 1-24
Weeks 1-12
Weeks 13-24

Fig 4


12
11
10
9
8
7
6
5
4
3
2
1
0
Weeks
Individual Subject
Group Mean
Abstinence Reinforcement Group
Control Group