

CLINICAL IMPLICATIONS OF REINFORCEMENT AS A DETERMINANT OF SUBSTANCE USE DISORDERS

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■ **Abstract** Extensive scientific evidence indicates that reinforcement plays an important role in the genesis, maintenance, and recovery from substance use disorders. In this chapter, we review recent clinical research from laboratory, clinic, and naturalistic settings examining the role of reinforcement in substance use disorders. Well-controlled human laboratory studies are reviewed characterizing orderly interactions between the reinforcing effects of drugs and environmental context that have important implications for understanding risk factors for substance use disorders and for the development of efficacious interventions. Recent treatment-outcome studies on voucher-based contingency management and community reinforcement therapy are reviewed demonstrating how reinforcement and related principles can be used to improve outcomes across a wide range of different substance use disorders and populations. Overall, the chapter characterizes a vigorous area of clinical research that has much to contribute to a scientific analysis of substance use disorders.

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INTRODUCTION

One of the most important advances in the scientific analysis of substance use disorders was the discovery that they were subject to the laws of learning and conditioning. That advance came to the forefront in the 1960s and 1970s based on evidence from studies on drug self-administration in laboratory animals and treatment-outcome and laboratory studies conducted with substance abusers (see Bigelow & Silverman 1999).

The reinforcing effect of drugs in laboratory animals was studied as early as the 1940s (Spragg 1940), but two important developments in the 1960s allowed this research area to flourish. First, a technology was developed to deliver intravenous drug injections to awake laboratory animals able to press a lever or emit other responses (Thompson & Schuster 1964, Weeks 1962). This methodology allowed for the administration of rapidly delivered drug injections as behavioral consequences, which is important to effective operant conditioning. The seminal studies demonstrated that animals readily learned an arbitrary response that led to a drug injection (Thompson & Schuster 1964, Weeks 1962). The animals in these studies were made physically dependent through experimenter-administered drug exposure before commencing with the conditioning aspects of the study. Thus, such learning was interpretable as a product of negative reinforcement; that is, behavior strengthened by avoidance of or escape from an aversive state (i.e., the withdrawal syndrome). While demonstrating a role for conditioning in substance use, the information was also congruent with extant theories of substance use disorders that focused on physical dependence and tolerance as central explanatory factors (see Goldberg 1976). Soon thereafter, though, voluntary drug self-administration was established in laboratory animals that were not physically dependent (Deneau et al. 1969). This advance established that abused drugs functioned as unconditioned positive reinforcers in the same manner as food, water, and sex; that is, they increased the future probability of behavior that immediately preceded their delivery. Perhaps most striking was that positive reinforcement was capable of generating in normal laboratory animals the dangerous extremes in drug consumption characteristic of human substance use disorders. For example, monkeys given unconstrained opportunities to self-administer intravenous injections of cocaine consumed the drug to the exclusion of basic sustenance and, barring experimenter intervention, to the point of death (Aigner & Balster 1978, Johanson et al. 1976). The idea that abused drugs promoted repeated drug use by acting as positive reinforcers was not readily interpretable within extant theories of drug dependence and fostered new models of substance use disorders based on psychological principles coupled with those of general pharmacology (Schuster & Thompson 1969).

In the treatment arena, successful clinical trials with alcoholics and other substance abusers demonstrated the efficacy of interventions based explicitly on reinforcement principles (Hunter & Azrin 1973, Miller 1975, Sobell & Sobell 1973, Winett 1973), and clinical-laboratory studies demonstrated that the substance use

of even severely dependent individuals was modifiable through the systematic use of reinforcement and punishment (e.g., Bigelow & Liebson 1973, Griffiths et al. 1976). Heated controversies emerged in the area of treatment-outcome research with alcoholics, relating mostly to appropriate treatment goals (complete abstinence versus controlled drinking; see Marlatt 1983). However, the empirical evidence that drug use even among severely dependent individuals was sensitive to reinforcement and punishment contingencies was never refuted.

The overarching importance of these scientific advances was that they situated substance use and related disorders within a body of extant psychological principles and processes that accounted for the continuum of substance use ranging from patterns of infrequent use with few problems to patterns of heavy use and many untoward consequences. Stated in its most parsimonious form the advances established that substance use in all its varieties is governed by the Law of Effect (Thorndike 1898), which is a conclusion that remains valid today. These advances also provided principles and methods for a rigorous experimental analysis of substance use disorders. In the animal laboratory, this scientific framework has maintained a central role in substance use research for the past approximately 40 years. The research has evolved to include sophisticated neuroscience, genetic, and pharmacological methods and concepts (Crabbe 2002, Everitt et al. 2001, Platt et al. 2002), but the central role ascribed to reinforcement in accounting for drug use has remained a constant.

The path of clinical research in substance use disorders has been different. For reasons that appear to be unrelated to any specific study or empirical development, explicit recognition and utilization of reinforcement principles in clinical research on substance abuse waned after the 1970s. That was especially true in the alcohol field where clinical studies on topics related to reinforcement principles largely disappeared. Clinical studies on reinforcement principles continued in the area of illicit drug abuse, although there too the scope of the research was more restricted than might have been expected from the advances discussed above. The influence of psychology's cognitive revolution on clinical research in this area is clear, especially in the areas of alcohol and tobacco research, and was no doubt influential in fostering this alternative path (e.g., Donovan & Marlatt 1980, Gottlieb et al. 1987). Another important contributor was the development of effective pharmacotherapies like methadone for heroin dependence and nicotine replacement products for cigarette smoking, although that is less responsible for trends in the alcohol field where efficacious pharmacotherapies are a more recent development.

Whatever the reasons may have been for the waning of clinical research on reinforcement principles, that trend has corrected itself. A vigorous resurgence of clinical research on reinforcement principles in substance use disorders began in the 1990s and continues today. As will be evident from the research described below, research on cocaine dependence has been influential in this development. In many ways, the recalcitrant nature of cocaine dependence created opportunities for the consideration of alternative views. The repeated failures of many different pharmacological and psychosocial treatments for cocaine dependence made it

painfully obvious that no one theoretical camp had a lock on the answers to this problem. When within that context reinforcement-based contingency-management interventions were demonstrated to reliably increase cocaine abstinence in randomized clinical trials, a niche was created for that approach within cocaine and other substance abuse treatment-outcome research (see Higgins & Silverman 1999). Other conceptually related research examining drug reinforcement in the clinical laboratory setting paralleled these developments, including behavioral-economic and other behavioral choice research (see Bickel & Vuchinich 2000). The purpose of this chapter is to review this resurgence of clinical research on reinforcement principles in substance use disorders, including research in laboratory, clinic, and naturalistic settings. Only reports on controlled studies published in peer-reviewed journals since 1990 were included in the review.

CLINICAL RESEARCH ON THE ROLE OF REINFORCEMENT IN SUBSTANCE USE DISORDERS

Much of the research reviewed below can be broadly thought of as examining the influence of environmental context on the reinforcing effects of drugs. The research illustrates two main empirical generalizations about substance use that follow directly from the recognition that abused drugs function as reinforcers. First, drug use is a form of operant behavior that by definition is sensitive to environmental consequences. Second, the degree of control that drugs exert over behavior as reinforcers is malleable and dependent on environmental context. While seemingly simple, we believe the research below will show that understanding the nuances of these empirical generalizations has much to contribute to a scientific analysis of substance use disorders.

Laboratory Settings

DRUG SELF-ADMINISTRATION STUDIES Experiments examining the influence of alternative, nondrug reinforcers on preference for cocaine use have provided helpful insights into the context-dependent nature of the reinforcing effects of drugs. In an initial experiment on this topic in humans, cocaine users made a series of choices between intranasally administered cocaine and placebo and subsequently between cocaine and varying amounts of money (Higgins et al. 1994a). During sessions comparing cocaine with placebo, subjects exclusively chose cocaine and they consumed all of the drug that was available to them. That outcome demonstrated cocaine's ability to function as a robust reinforcer. In subsequent sessions, subjects made exclusive choices between cocaine and varying amounts of money (Figure 1, *upper panel*). Within that context, choice of cocaine decreased as an orderly graded function of increasing value of the monetary option. That outcome demonstrated the malleability of cocaine's reinforcing effects, which were robust when the alternative was a placebo or little money, but relatively weak as the value of the monetary option increased.

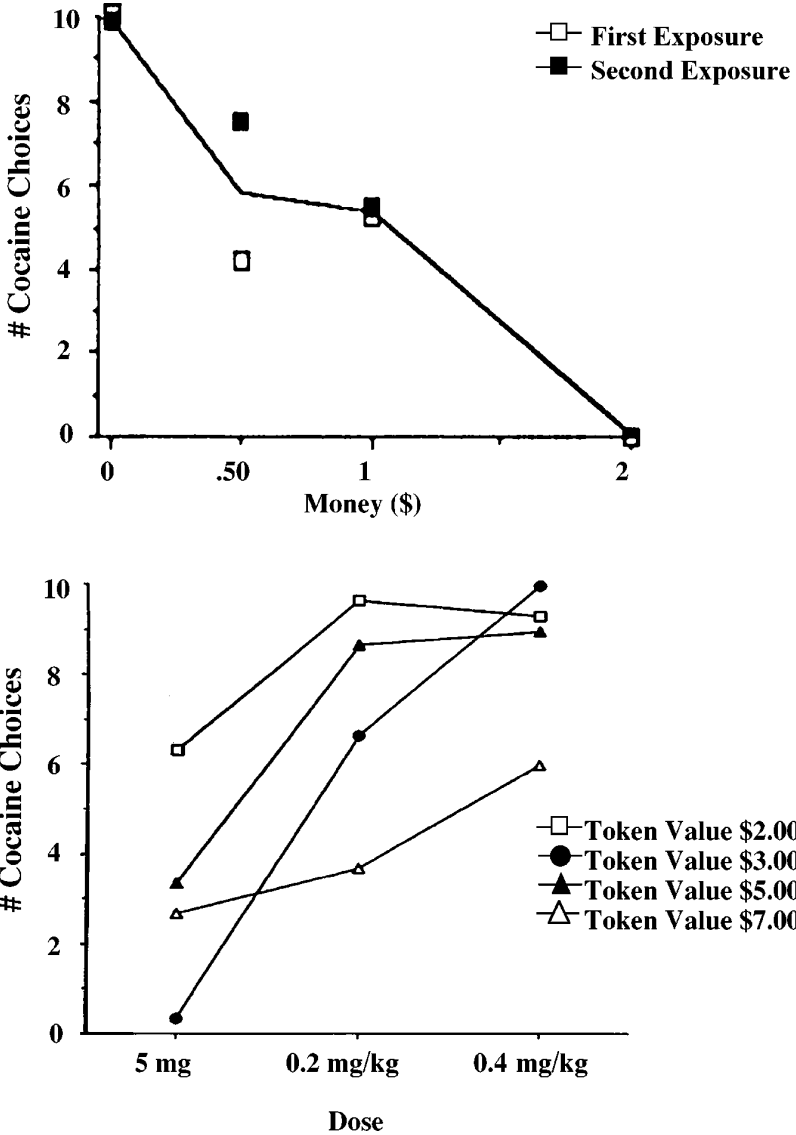


Figure 1 *Upper panel:* Number of cocaine choices as a function of the amount of money offered per choice as an alternative to cocaine. Subjects made a maximum of 10 choices between cocaine and money per session. Each monetary amount was tested twice, with the results from first and second tests shown by separate symbols and the mean of the two tests by the solid line. Reprinted from Higgins et al. 1994a with permission. *Lower panel:* Mean number of cocaine self-administrations per session (maximum = 10) are plotted as a function of cocaine dose for each of four prices of cocaine. Reprinted from Hatsukami et al. 1994 with permission.

This same functional relationship was subsequently demonstrated in studies using smoked and intravenous routes of cocaine administration, larger cocaine doses, and subjects with extensive histories of cocaine abuse and dependence (Donny et al. 2003, Dudish et al. 1996, Foltin & Fischman 1994, Hart et al. 2000, Hatsukami et al. 1994, Walsh et al. 2001). Shown in the lower panel of Figure 1, for example, are results from a study in which crack cocaine users made choices between retaining a token that could later be redeemed for cash or spending the token for an opportunity to smoke cocaine under medical supervision (Hatsukami et al. 1994). Token value (\$2, \$3, \$5, \$7) and cocaine dose (5 mg, 0.2 mg/kg, 0.4 mg/kg) were varied across sessions; the 5 mg dose served as a placebo. At the 5-mg dose, the greatest number of cocaine choices occurred at the lowest price (\$2) token condition. At the 0.2-mg/kg dose the number of cocaine choices increased across all token prices, but the greatest still occurred at the lowest token price, the fewest at the highest (\$7) token price, and intermediate levels at the intermediate (\$3 and \$5) token prices. When the dose was increased to 0.4 mg/kg, subjects chose almost the maximum number of cocaine administrations available at the \$2, \$3, and \$5 token prices, demonstrating the robust reinforcing effects of that dose of smoked cocaine, but did not do so at the \$7 token price. Indeed, the number of choices of the 0.4-mg/kg cocaine dose at the \$7 token price was slightly below the number made for the placebo (5 mg) in the \$2 token price condition. Similar effects also have been demonstrated with heroin in opiate-dependent subjects (Comer et al. 1997, 1998) and cigarette smoking among nicotine-dependent individuals (Bickel et al. 1995, 1997b; Tidey et al. 1999).

Another contextual factor not underscored by those studies but essential to understanding substance use disorders is the role of temporal delays. In naturalistic settings, individuals often make choices between using drugs in the present versus abstaining and experiencing positive consequences in the future. The following laboratory study with cigarette smokers examined how temporal delays influence the relationships between drug preference and alternative reinforcers (Roll et al. 2000). Regular cigarette smokers who had abstained from recent smoking for several hours made repeated choices between puffs on a cigarette available immediately and money that was available at varying values (\$0.10–\$2.00/choice) and after varying delays (end of the session, one week, and three weeks). Preference for the drug option decreased as an orderly, increasing function of the value of the monetary alternative consistent with the studies discussed above (larger values produced larger decreases in smoking), but as the delay interval increased, the influence of each of the alternative monetary values decreased significantly (Figure 2). The fundamental point of this study is that temporal delays diminish the ability of alternative, nondrug reinforcers to compete with the immediate reinforcing consequences of drug use.

Other variables also alter the influence of alternative reinforcers on drug self-administration. For example, an alternative source of nicotine enhances the ability of an alternative monetary reinforcer to decrease smoking (Bickel et al. 1997b), and pretreatment with alcohol (Higgins et al. 1996) diminishes the ability of

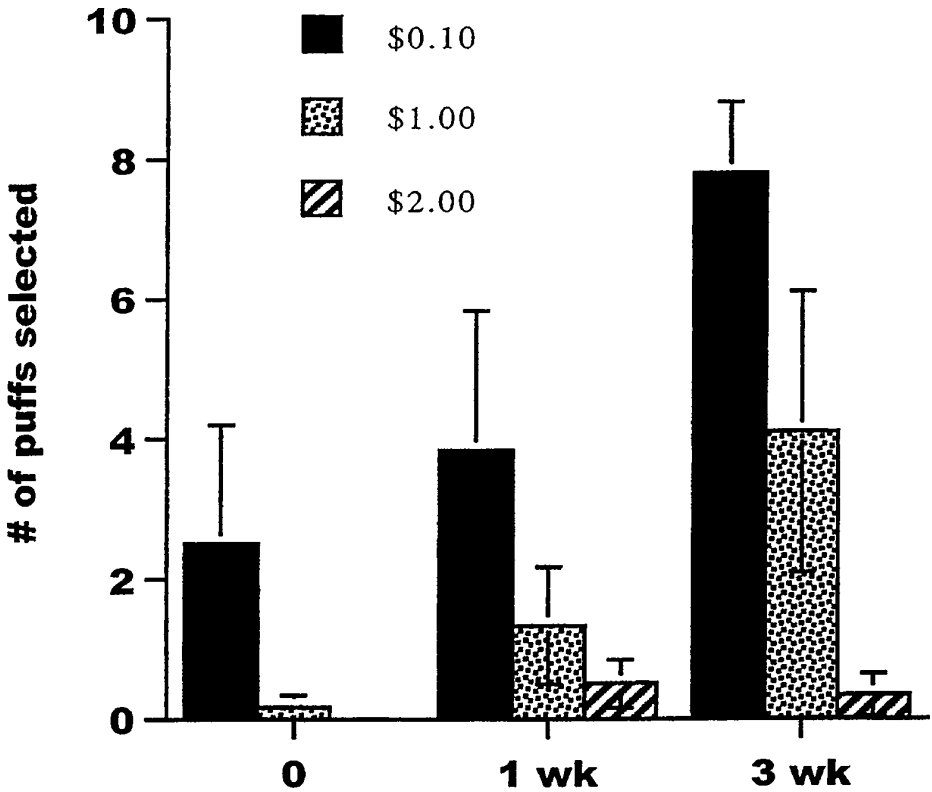


Figure 2 Mean number of choices for cigarette puff versus money in each session (maximum = 10) at one of three monetary values plotted as a function of delay interval between choosing and collecting the monetary option; brackets represent SEMs. Reprinted from Roll et al. 2000 with permission.

monetary reinforcement to decrease preference for cocaine reinforcement. Non-drug reinforcers can influence drug preference in other, less direct ways. For example, when drug use is associated with subsequent increased earnings on a performance task because of experimenter manipulation and not drug-produced enhancement of performance, future preference for drug use increases (see Alessi et al. 2002). Likewise, when drug use is associated with subsequent decreased earnings on the performance task, future preference for drug use decreases. The main point of this research is that not only the direct reinforcing effects of the drug influence the probability of future use, but also environmental consequences that occur while under the influence of the substance.

The studies reviewed thus far have emphasized the influence of alternative reinforcers on preference for drug reinforcement. However, the relationships demonstrated in these studies can be thought of more generally in terms of constraints

on drug use and other available alternatives (Bickel & DeGrandpre 1996). As constraints on drug consumption increase, either in terms of the price or effort required to obtain and use the substance or the quality and magnitude of the alternatives forfeited as a consequence of drug use, drug use decreases. Similarly, as constraints on drug use decrease, either because drugs are readily available at low cost or there is little in the way of alternatives to be forfeited by using drugs, consumption increases. Such sensitivity to price or cost factors is referred to in economic terms as the Law of Demand (Pearce 1986). Behavioral-economics research provides compelling evidence that drug consumption is sensitive to the Law of Demand (Chaloupka et al. 1999). That said, it is also the case that when responding maintained by drug and nondrug reinforcement has been compared in drug-dependent individuals, demand for drug is less sensitive (i.e., more inelastic) than demand for nondrug reinforcement (e.g., Bickel et al. 1997b). In the next section, we review a new area of behavioral-economics research that provides additional insights into these relationships.

DISCOUNTING OF DELAYED CONSEQUENCES An emerging area of behavioral-economics research suggests that individuals with substance use disorders discount the value of delayed reinforcement and the severity of reinforcement losses to a greater extent than individuals without substance use disorders (Bickel & Marsch 2001). This difference can be summarized as substance abusers showing a greater preference for (a) more immediate, smaller magnitude over more delayed, larger magnitude reinforcement, and (b) more delayed, larger magnitude losses (punishment) over more immediate, smaller magnitude losses.

The procedures and findings in this research area are illustrated by the following study comparing delay discounting in 18 opiate-dependent outpatients and 38 community volunteers matched on age, gender, education, and IQ (Madden et al. 1997). Participants made a series of choices between two hypothetical monetary options or hypothetical drug options (patients only). The use of hypothetical events permitted the investigators to examine monetary amounts, drug doses, and temporal delays that otherwise would not be practically or ethically feasible. Monetary values were tested ranging from \$1 to \$1000; a similar number of heroin doses were studied in units comparable to the monetary values. Seven delay intervals were tested, ranging from one week to 25 years. Testing began with a choice between the highest values available immediately or following a one-week delay (e.g., \$1000 now versus \$1000 in one week). As expected, all subjects chose the immediate option. Next, the value of the immediate option was systematically decreased (e.g., \$950 now versus \$1000 in one week, \$900 now versus \$1000 in one week, and so on) until subjects indicated preferences across all monetary values, and then the process was repeated but in an ascending order. A record was made of the value at which a subject's preference switched between the immediate and delayed options in the descending and ascending progressions. An average of those two values was used to represent an indifference point where the immediate and delayed options were equivalent. The same series of descending and ascending

choices was then repeated using another temporal delay (e.g., \$1000 now versus \$1000 in one month) until indifference points were established at all delay intervals.

Indifference points for money decreased in both populations as an orderly function of increasing delay interval, and the shapes of the discounting curves were hyperbolic rather than linear (Figure 3, *upper panel*). Delay discounting and the hyperbolic shape of the functions are basic characteristics of operant behavior that are seen in nonhumans and humans alike (Bickel & Marsch 2001). While both groups exhibited hyperbolic discounting, note that the curve of the opiate-dependent group was significantly steeper than the curve in the control group, especially during the initial 60 months. A comparison of discounting curves for heroin and money within the opiate-dependent group showed steep discounting curves for both types of reinforcement, but significantly more so for heroin than money (Figure 3, *lower panel*).

We identified 14 reports of original studies published in peer-reviewed journals characterizing delay discounting in individuals with substance use disorders. The studies reliably demonstrated greater discounting among substance abusers than controls. The results just outlined were replicated in another group of opiate-dependent outpatients using real rather than hypothetical money (K.N. Kirby et al. 1999), thereby supporting the validity of findings with hypothetical events. Other studies in the opiate-dependent population demonstrated that those who were willing to share needles in a vignette discounted money at higher rates than patients who were unwilling to share needles (Odum et al. 2000). Also, drug deprivation increased discounting of money and drugs compared to nondeprived conditions (Giordano et al. 2002).

These observations have been extended to other substance use disorders as well. With regard to alcohol, college students who reported heavy drinking with or without associated problems discounted hypothetical money more than light drinkers (Vuchinich & Simpson 1998), and actively using alcoholics discounted hypothetical money more than abstinent alcoholics and controls, with the abstinent alcoholics scoring intermediate to the other two groups (Petry 2001a).

Current cigarette smokers have been shown to discount hypothetical money more than never-smokers and ex-smokers, with no differences between the latter two groups (Bickel et al. 1999). Greater discounting occurs in smokers versus never-smokers whether the monetary consequences are hypothetical or real (Baker et al. 2003, Mitchell 1999).

Comorbid problems are also associated with increased discounting rates. Substance abusers (mixed group) with a gambling problem (Petry & Casarella 1999) or antisocial personality disorder (Petry 2002) discounted hypothetical money more than substance abusers without those additional problems. Also, gamblers with substance abuse discounted hypothetical money more than gamblers without substance abuse (Petry 2001b). Several of these reports replicated the finding that substance abusers discount delays involving drugs more than those involving money (e.g., Bickel et al. 1999, Petry 2001a).

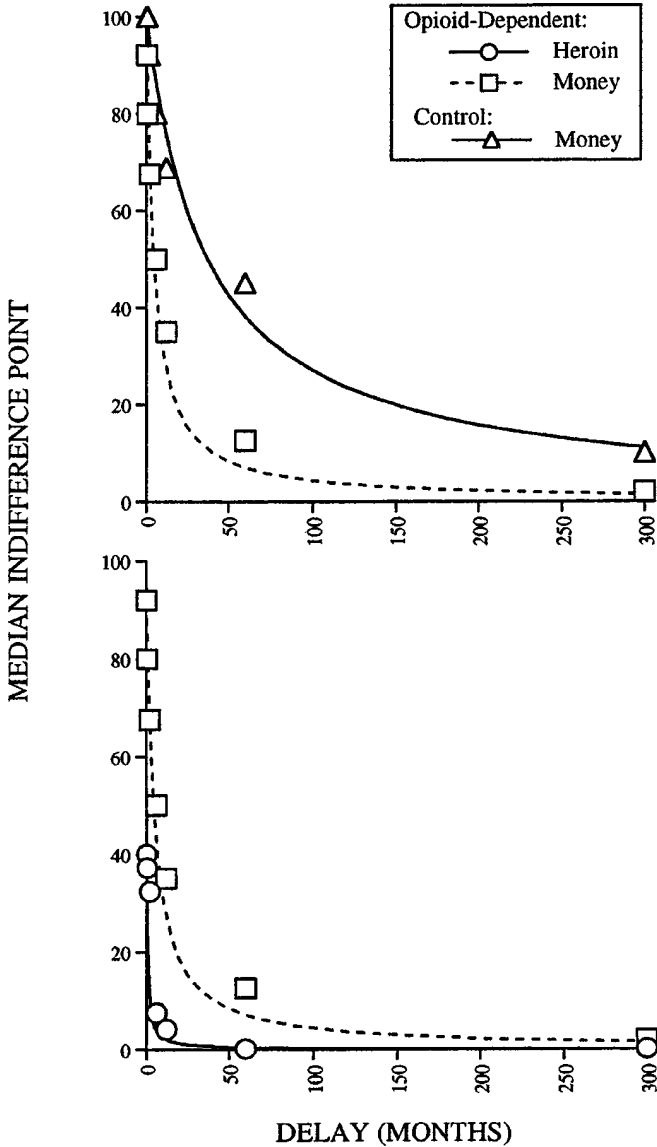


Figure 3 *Upper panel:* Median indifference points between large delayed and small immediate monetary reinforcement are shown as a function of delay duration for opioid-dependent patients and controls as a function of delay interval. *Lower panel:* Median indifference points between large delayed and small immediate monetary and heroin reinforcement for opioid-dependent patients as a function of delay interval. In upper and lower panels, Y axis represents percent choices for the large delayed reinforcer. Reprinted from Madden et al. 1997 with permission.

Whether the greater discounting rates observed among those with substance use disorders represents cause or consequence of the disorders is unknown. The studies showing no difference in discounting between ex-smokers and never-smokers and intermediate levels among abstinent alcoholics compared to active and nonalcoholics could mean that cessation of substance abuse restores discounting closer to normal levels or, alternatively, that recovery from substance use disorders is more likely among those who discount less (Bickel et al. 1999). The findings that substance abusers with antisocial personality disorder or gambling problems had higher discounting rates than substance abusers without those other problems suggest that the measure is capturing a characteristic that extends beyond the substance use disorders. The discounting measure overlaps with scores on impulsivity questionnaires, with modest but significant correlations between them having been noted in most of the above reports. The observation that drug deprivation increases discounting demonstrates that it is not a static phenomenon, as do the observations that drugs and money are discounted differently. This is an emerging area of investigation with many questions remaining to be answered. The studies reviewed provide strong evidence of increased discounting of delayed consequences among individuals with substance use disorders, and they provide potential insights into some reasons why those with more severe dependence or comorbid problems have poorer prognoses. Whether cause or consequence, this characteristic is an important one to consider in efforts to provide a scientific account of substance use disorders, as well as in efforts to treat and prevent them.

INFLUENCE OF ALTERNATIVE REINFORCERS IN NATURALISTIC SETTINGS An emerging body of research focuses on assessing the influence of naturalistic sources of nondrug reinforcement and substance use disorders. These studies use a questionnaire called the Pleasant Events Schedule (PES), which was initially developed to investigate the role of naturalistic reinforcement density in the study of depression (MacPhillamy & Lewinsohn 1976). The PES is a self-rated behavioral inventory comprised of 320 items that are rated on a three-point scale regarding frequency of occurrence and the enjoyability of the activity during the past 30 days. For activities not engaged in during the past 30 days, subjects rate how enjoyable they anticipate it would have been had they engaged in it. Responses are summarized in 10 scales that were developed both rationally and empirically.

A seminal study using the PES with substance abusers involved a comparison of PES scores from 50 individuals enrolled in treatment for cocaine abuse/dependence and 50 community controls matched on sociodemographics (Van Etten et al. 1998). Cocaine abusers reported a lower frequency of specific types of activities compared to controls, including a lower frequency of nonsocial, introverted, and passive activities. Those differences between the scales remained significant even after controlling for demographics and other potential explanatory variables in multivariate analyses. Cocaine abusers generally did not differ significantly from the comparison group in enjoyability ratings, suggesting that the activities on which they differed in frequency had the potential to be reinforcing in the cocaine abusers had

they engaged in them. Within the group of cocaine abusers, cocaine-negative urinalysis results (i.e., abstinence) during a 24-week treatment period were positively correlated with a higher frequency of nonsocial activities even after controlling for the influence of other potential explanatory variables.

The results from this study suggested that it was not the overall frequency of drug-free activities engaged in that differed between cocaine abusers and nonabusers or those with more severe dependence, but the frequency of particular types of activities. Those observations were replicated and extended in a study of binge drinking in 256 college students who completed the PES and other questionnaires regarding recent substance use (Correia et al. 2003). Binge drinkers reported a significantly lower frequency of nonsocial, introverted, and passive outdoor activities than the comparison group.

The PES was used to further examine relationships between substance use and other activities in college students (Correia et al. 1998, 2002) and psychiatric outpatients (Correia & Carey 1999). Subjects in these studies completed the PES twice, once regarding activities they engaged in while under the influence of substances (alcohol and illicit drugs, but excluding nicotine and caffeine) and the other regarding activities engaged in when sober. This permitted the investigators to derive summary measures of frequency and enjoyability ratings for activities engaged in while under the influence of substances (drug-related cross-product) and when sober (drug-free cross-product), and a ratio of the first two measures (drug-related cross-product divided by the sum of the drug-related and drug-free cross-products), resulting in what the investigators termed a reinforcement ratio. This reinforcement ratio was developed to examine predictions from Herrnstein's Matching Law, which is a general law specifying that operant behavior is distributed across multiple sources of reinforcement in proportion to the amount of reinforcement received from each option (Herrnstein 1970). Drug-related cross product and reinforcement ratio were significant predictors of the frequency of substance use in both studies involving college undergraduates (Correia et al. 1998, 2002) and the study in psychiatric outpatients (Correia & Carey 1999).

Considering results across all five studies, they suggest that a relatively low frequency of nonsocial activities and a greater ratio of drug-derived reinforcement as a proportion of all reinforcing activities predict greater substance use in those with substance use disorders as well as in heterogeneous samples of college students. The consistency of these observations across studies, substances, and populations, as well as the connection with a general law of operant conditioning and reinforcement theory, suggests that they may be important to understanding the determinants of substance use in clinic and other naturalistic settings.

EPIDEMIOLOGICAL EVIDENCE

The research reviewed above underscores a robust influence of environmental context on the reinforcing effects of drugs. An obvious question that follows from those observations is whether the epidemiological evidence on prevalence of

substance use and related disorders is consistent with the empirical generalizations noted. Certainly, the laboratory studies would predict greater substance use among those with greater constraints on access to alternative, non-drug reinforcers. While surely open to alternative explanations, low socioeconomic status, low educational achievement, and unemployment are reliably associated with increased substance use, abuse, and dependence in the epidemiological literature, consistent with predictions of a reinforcement model.

Consider results from the most recent annual U.S. National Household Survey on Drug Abuse (NHSDA), which is conducted annually and assesses the prevalence of illicit and licit substance use and related disorders among a nationally representative sample of individuals aged 12 years and older (Substance Abuse & Mental Health Services Administration 2002). The survey does not examine socioeconomic status per se, but does examine associations between education and employment status and substance use. Regarding illicit drug use among adults (≥ 18 years), 4.3% of college graduates reported current use compared to 7.6% of those with less than a high school education. That difference is especially notable considering that lifetime prevalence of illicit drug use is higher in the college graduates (47.2% versus 32.0%). Similar patterns are observed with licit substances. With cigarette smoking, 13.8% of college graduates are current cigarette smokers compared to 33.8% of those with less than a high school education. Alcohol use is a bit more complicated, with 65.2% of college graduates versus 33.4% of those with less than high school being current drinkers. Among current drinkers, though, only 33% of college graduates report recent binge or heavy drinking compared to 66% of those with less than a high school education. If one considers education as a conduit to the monetary wealth necessary to access certain material alternatives and the skills needed to appreciate others (e.g., literature), then the results seem quite consistent with those from the laboratory studies described above.

The NHSDA evidence on associations between employment and substance use parallels that of education, and other epidemiological evidence is also consistent with the NHSDA findings. For example, risk for alcohol, tobacco, and other drug dependence is associated with lower annual income, educational level, and unemployment in the U.S. National Comorbidity Study (Anthony et al. 1994). Epidemiological research from outside of the United States has shown similar relationships between socioeconomic status and risk for substance use disorders (e.g., Poulton et al. 2002).

Treatment Settings

The largest area of investigation in this resurgence of research on reinforcement principles has involved their application to the treatment of substance use disorders. Treatment interventions based on reinforcement principles seek to (a) increase availability and reduce constraints on reinforcement derived from healthy alternatives to substance use, (b) increase constraints on reinforcement derived

from substance use and the substance abusing lifestyle, and (c) configure these efforts to accommodate the shortened temporal horizons characteristic of substance use disorders. In this section, we discuss two types of efficacious interventions explicitly designed to accomplish those goals.

Contingency Management

Contingency management (CM) involves the systematic delivery of reinforcing or punishing consequences contingent on the occurrence of a target response, and the withholding of those consequences in the absence of the target response (Higgins & Silverman 1999). The CM intervention that has garnered the most research attention is one in which patients earn vouchers exchangeable for retail items contingent on recent drug abstinence. This treatment approach was initially developed as a novel method to manage cocaine dependence in outpatient settings (Higgins et al. 1991, 1993). A search of the literature from 1991 (publication of first voucher report) through March 2003 identified 55 reports of controlled studies published in peer-reviewed journals where vouchers or related monetary-based CM interventions were used to promote behavior change in persons with substance use disorders (Table 1). As is described in detail below, 85% (47/55) of the reports noted significant changes in at least one of the behaviors targeted by the CM intervention.

REINFORCING ABSTINENCE FROM COCAINE USE We introduce the voucher intervention by briefly describing the initial randomized trial conducted with it (Higgins et al. 1993). In that study, vouchers were combined with intensive counseling based on the community reinforcement approach (CRA) (see below). The study involved a comparison of CRA plus vouchers versus standard care. The voucher program was implemented around a fixed schedule of urine-toxicology monitoring. Cocaine-negative specimens earned points that were recorded on vouchers and provided to patients. Points began at a low value (\$2.50) and increased with each consecutive negative test result. A cocaine-positive result or failure to provide a scheduled specimen reset the voucher value back to the initial low value from which it could escalate again. No money was ever given to patients. Instead, points were used to purchase retail items, with clinic staff making all purchases. Maximum earnings possible across 12 weeks was \$997.50 in purchasing power, with average earnings being approximately 60% of maximum.

Thirty-eight cocaine-dependent outpatients were randomized to one of the two treatments. As shown in Figure 4, cocaine abstinence levels in the two treatments were comparable at the start of treatment, but those receiving standard care soon either dropped out of treatment or continued using cocaine, while the majority of those assigned to CRA plus vouchers abstained from cocaine use. These results replicated those from an earlier nonrandomized trial (Higgins et al. 1991), and created considerable interest in dissociating the efficacy of vouchers from CRA. Two

TABLE 1 Voucher-based contingency management studies

Study	N	Gender	Voucher duration (weeks)	Setting	Design	Total possible earnings during voucher intervention	Voucher delivery	Positive outcome ($p \leq .05$)
COCAINE AND OPIATES								
Cocaine								
Higgins et al. 1991	25	M,F	12	DF	1 ^{a,b}	\$1038.00	I	Y
Higgins et al. 1993	38	M,F	12	DF	1 ^b	\$997.50	I	Y
Higgins et al. 1994b	40	M,F	12	DF	1	\$997.50	I	Y
Silverman et al. 1996b	37	M,F	12	M	2	\$1155.00	I	Y
Shaner et al. 1997	2	M ^c	8	DF	4	\$1000.00	I	Y
Silverman et al. 1998	59	M,F	12	M	2	\$1950.00	I	Y
Elk et al. 1998	12	F	≥4	DF	1	≥\$296.00	—	N
Kirby et al. 1998	23	M,F	12	DF	3	\$420.00(CV1), \$570.00(CV2)	I	Y
Silverman et al. 1999	29	M,F	9	M	4	\$382.00(CV1), \$3480.00(CV2)	I	Y
Higgins et al. 2000	70	M,F	12	DF	2	\$997.50	I	Y
Robles et al. 2000	72	M,F	0.29	M	4	\$100.00	D	Y
Jones et al. 2001	80	F	1	M	1	\$385.00	I	Y
Preston et al. 2001	95	M,F	8	M	3	\$554.00	D	Y
Rawson et al. 2002	120	M,F	16	M	1	\$1277.50	I	Y
Katz et al. 2002b	40	M,F	1.57	M	4	\$400.00	D	Y
Epstein et al. 2003	193	M,F	12	M	2	\$1155.00	I	Y
Opiates								
Silverman et al. 1996c	13	M,F	12	M	4	\$1155.00	I	Y
Bickel et al. 1997a	39	M,F	23	M	1 ^b	\$658.38	I	Y
Preston et al. 2000	120	M,F	8	M	2	\$554.00	D	Y
Preston et al. 2002	110	M,F	12	M	2 ^b	\$360.00	D	Y ^d
Robles et al. 2002	48	M,F	22	M	2	\$2232.00	I	Y
Cocaine and opiates								
Gruber et al. 2000	52	M,F	4	DF	1 ^b	\$320.00	I	Y
Jones et al. 2000	25	F	1	M	1	\$85.00	I	N

(Continued)

TABLE 1 (Continued)

Study	N	Gender	Voucher duration (weeks)	Setting	Design	Total possible earnings during voucher intervention	Voucher delivery	Positive outcome ($p \leq .05$)
Dallery et al. 2001	15	M,F	9	M	4	\$374.40(CV1), \$3369.60(CV2)	I	Y
Silverman et al. 2001	40	F	24	M	1 ^b	\$283.00	I	Y
Katz et al. 2002a	52	M,F	12	DF	1	\$1087.50	I	N
Petry & Martin 2002	42	M,F	12	M	1	—	I	Y
Silverman et al. 2002	40	F	78	M	1 ^b	\$9197.50	I	Y
Polydrug								
Chang et al. 1992	12	F	≥9	M	1 ^{a,b}	≥\$135.00	—	N
Carroll et al. 1995	14	F	≥13	M	1 ^b	≥\$195.00	—	N
Iguchi et al. 1997	103	M,F	12	M	1	\$180.00	D	Y ^e
Chutuape et al. 1999	14	M,F	12	M	1 ^b	\$900.00	I	Y
Piotrowski et al. 1999	102	M,F	17	M	1	\$755.00	D	Y
Downey et al. 2000	41	M,F	12	M	2	\$997.50	D	N
Carroll et al. 2001	127	M,F	12	M	1	\$280.50	I	Y
Carroll et al. 2002	55	M,F	12	M	1	\$280.80(CV1), \$576.00(CV2)	I	N
Cigarette smoking								
Schmitz et al. 1995	5	M,F	2	M	5	\$20.00	I	N
Roll et al. 1996	60	M,F	0.71	NTS	2	\$147.50	I	Y
Roll et al. 1998	11	M,F ^e	0.71	NTS	2	\$147.50	I	Y
Donatelle et al. 2000	220	F	≥20	DF	1	≥\$250.00	D	Y
Roll & Higgins 2000	18	M,F	0.71	NTS	4	\$147.00	I	Y
Corby et al. 2000	8	M,F ^f	0.71	NTS	4	\$40.00	I	Y
Shoptaw et al. 2002	175	M,F	12	M	1	\$447.50	I	Y
Tidey et al. 2002	14	M,F ^e	0.71	NTS	4	\$147.50	I	Y
Heil et al. 2003	54	M,F	0.71	NTS	2	\$147.50(CV1), \$295.00(CV2)	I	Y
Alcohol and marijuana								
Alcohol								
Petry et al. 2000	42	M	8	DF	1	—	I	Y
Marijuana								
Budney et al. 1991	2	M	12	DF	4	\$1038.24	I	Y

Budney et al. 2000	60	M,F	12	DF	1	\$570.00	I	Y
Sigmon et al. 2000	18	M ^c	5	NTS	5	\$250.00(CV1), \$500.00(CV2), \$1000.00(CV3)	I	Y
OTHER TARGETS								
Attendance								
Silverman et al. 1996a	7	M, F	6	M	6	\$631.00(CV1)	I	Y
Svikis et al. 1997	142	F	1	M/DF	1	\$7.00(CV1), \$35.00(CV2), \$70.00(CV3)	D	Y
Jones et al. 2000	68	F	1	DF	1	\$85.00	I	N
Jones et al. 2001	80	F	1	M	1	\$140.00	I	Y
Petry et al. 2001	43	M,F	7	DF	4	—	I	Y
Medication compliance								
Preston et al. 1999	58	M,F	12	M	2	\$1155.00	I	Y
Rigsby et al. 2000	55	M,F	4	M	1 ^b	\$280.00	D	Y
Carroll et al. 2001	127	M,F	12	M	1	\$280.50	I	N
Carroll et al. 2002	55	M,F	12	M	1	\$280.80(CV1), \$576.00(CV2)	I	N
Productivity								
Wong et al. 2003	6	F	14	M	6 ^b	—	I	Y

N = sample size, all groups combined. Gender: M = male, F = female. All participants in female-only studies are pregnant and postpartum. Voucher duration = number of weeks voucher intervention was in place. Setting = setting in which study occurred: DF = drug-free clinic, M = medication clinic, NTS = nontreatment setting. Medication clinics breakdown: 79% methadone (n = 27), 9% naltrexone (n = 3), 6% buprenorphine (n = 2), 3% antiretrovirals (n = 1), 3% antipsychotics (n = 1). Design = experimental design: 1 = contingent vouchers versus no voucher control, parallel groups; 2 = contingent vouchers versus noncontingent voucher control, parallel groups; 3 = contingent vouchers, different magnitudes or schedules, parallel groups; 4 = contingent vouchers versus no voucher control, within subject; 5 = contingent vouchers versus noncontingent voucher control, within subject; 6 = contingent vouchers, different magnitudes or schedules, within subject. Total possible earnings during voucher intervention = maximum monetary value that could be earned by the contingent voucher condition. If more than one contingent voucher (CV) schedule was used, total possible earnings of all the schedules equals the amount shown unless otherwise noted [i.e., \$420 (CV1), \$570 (CV2)]. Voucher delivery: I = immediate (at the same visit that a specimen was provided), D = delayed (at a visit after the specimen was provided). A dash (—) indicates insufficient information to determine. Positive outcome = a significant change was reported for the behavior targeted by the contingency management intervention: Y = yes, N = no.

^aNonrandom condition assignment.
^bThe effect of vouchers cannot be dissociated from other interventions.
^cMentally ill/schizophrenic.
^dBased on induction × maintenance phase analyses.
^eBased on the significant effect of increased treatment plan compliance on urinalysis results.
^fAdolescents.

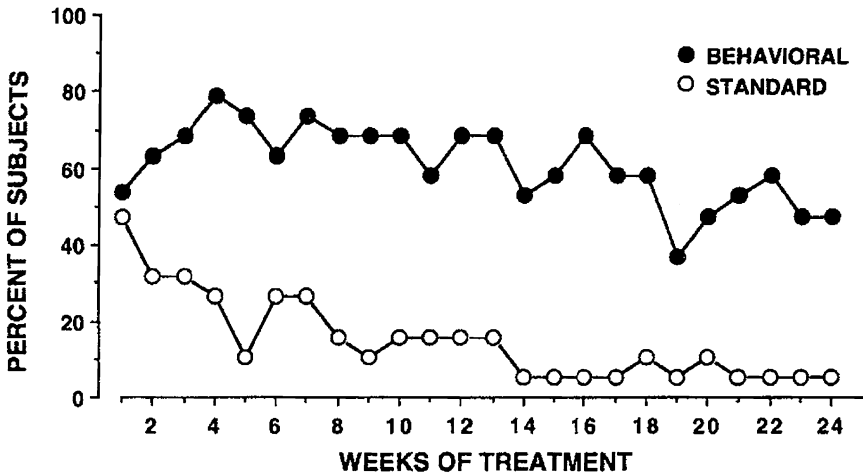


Figure 4 Percent of subjects abstinent from cocaine use in CRA + vouchers (behavioral) and standard (drug abuse counseling) conditions plotted as a function of consecutive treatment weeks. Reprinted from Higgins et al. 1993 with permission.

additional randomized trials by the same group isolated the efficacy of vouchers (Higgins et al. 1994b, 2000), and demonstrated that their effects could be discerned for at least 15 months after the end of the 12-week intervention.

A program of research by Silverman and colleagues replicated and extended those results to cocaine abuse among patients enrolled in methadone-maintenance treatment for opiate dependence (Silverman et al. 1996b, 1998, 1999). Results from the seminal randomized trial by this group comparing contingent voucher-based reinforcement to a noncontingent control condition are shown in Figure 5. Patients in both conditions tested positive for cocaine throughout a five-week baseline. Following implementation of the 12-week voucher intervention, cocaine abstinence increased substantially among those who received them contingent on abstinence, but not those who received them noncontingently. Abstinence decreased in the contingent group during a four-week postintervention period, although a treatment effect remained discernible.

Overall, our literature search identified 16 reports of controlled studies examining the efficacy of voucher-based interventions for increasing cocaine abstinence (Table 1). In 15 of the 16 studies (94%), the investigators reported significant increases in cocaine abstinence. In two trials, the effects of vouchers were not dissociated from CRA (Higgins et al. 1991, 1993), but in each of the other studies, the effects of vouchers on cocaine abstinence were experimentally demonstrated. An important current focus in this area of investigation is the development of less costly voucher models for use in community clinics, about which we say more below.

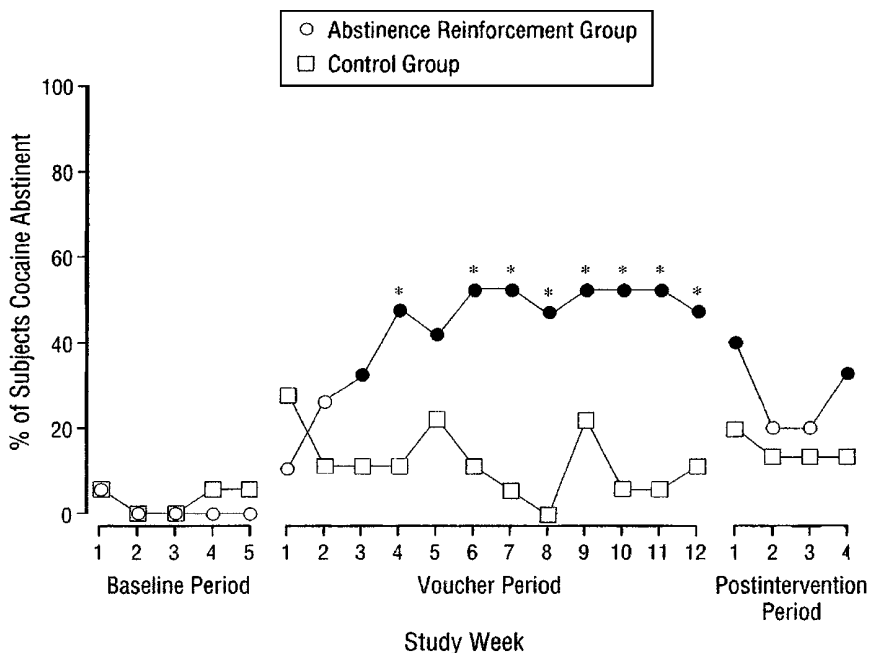


Figure 5 Percentage of patients abstinent from cocaine use in abstinence reinforcement and control groups during 21 consecutive study weeks. Abstinence-based reinforcement was available only during middle voucher period. Reprinted from Silverman et al. 1996b with permission.

REINFORCING OPIATE ABSTINENCE IN OPIATE-DEPENDENT OUTPATIENTS Ongoing illicit opiate abuse is a problem in a subset of patients enrolled in methadone and buprenorphine (medication comparable to methadone) therapy. In three voucher trials conducted with patients enrolled in methadone-maintenance treatment (Preston et al. 2000, 2002; Silverman et al. 1996c) and two trials conducted with patients undergoing methadone (Robles et al. 2002) or buprenorphine (Bickel et al. 1997a) detoxification, opiate abstinence was significantly increased in the voucher condition (Table 1). In two trials, effects of vouchers were not dissociated from other interventions (Bickel et al. 1997a, Preston et al. 2002), but in each of the others the increases in abstinence were directly attributable to the vouchers.

REINFORCING ABSTINENCE FROM MULTIPLE DRUGS IN OPIATE-DEPENDENT OUTPATIENTS We identified 15 reports involving studies on the efficacy of voucher-based contingencies targeting abstinence from two or more substances. Five of the seven (71%) studies targeting abstinence from cocaine and opiates produced positive outcomes. In at least one of the studies with negative outcomes, the

reason appeared to be an insufficient magnitude of reinforcement for the amount of behavior change targeted (Jones et al. 2000). That study involved pregnant methadone-maintenance patients who could earn \$5/day in vouchers by attending a comprehensive day program and providing cocaine- and opiate-negative urine specimens. Another study involving women from this same comprehensive clinic produced significant increases in cocaine and opiate abstinence, but the women could earn up to \$27/day in vouchers by abstaining from cocaine and opiate use and completing a three-hour vocational training session (Silverman et al. 2001). In an interesting innovation, women in the experimental condition in this later study continued to earn vouchers for abstinence and completing vocational tasks for three years, and those in the control group continued to be followed as well (Silverman et al. 2002). Significant increases in cocaine and opiate abstinence were sustained across the three-year period, which is a substantial accomplishment in this population of severely dependent women.

One of the other reports of a positive outcome in this group of studies targeting cocaine and opiate abstinence also merits comment (Petry & Martin 2002). The purpose of this study was to examine whether cocaine and opiate abstinence could be achieved using an overall lower value voucher system. Contingent on submitting cocaine and opiate-negative specimens, patients earned opportunities to make draws from a fishbowl containing slips of paper with values listed on them ranging from no value to \$100 by abstaining from cocaine and opiates. Slips of paper that had monetary value were exchanged for retail items kept onsite at the clinic. The cost was kept low by including a larger number of slips with no and low value than slips with high value. Compared to a no-incentive control condition, subjects randomized to the incentive condition achieved significantly longer durations of continuous abstinence from cocaine and opiates during treatment and six months of follow-up. Total value of earnings in the incentive condition was \$137 or approximately one fifth of the usual voucher earnings. This creative variation is now undergoing multisite testing in the National Institute on Drug Abuse's Clinical Trials Network.

Among the eight studies targeting simultaneous abstinence from three or more drugs, only four (50%) produced positive outcomes (Table 1). This inverse, graded relationship between the number of drugs targeted by the contingency and the number of trials achieving positive outcomes is not likely a chance phenomenon. There is little question that the value of vouchers is a relevant factor in CM interventions (Dallery et al. 2001, Silverman et al. 1999; but see Carroll et al. 2001). Those studies in which simultaneous abstinence from multiple substances has been achieved involved relatively large voucher values (Silverman et al. 2001, 2002), a combination of incentives for abstinence and compliance with medication to increase abstinence (Carroll et al. 2001), or a creative reinforcement schedule (Petry & Martin 2002, Piotrowski et al. 1999). There is no evidence that the higher rates of success in studies targeting single substances is accounted for by patients substituting other drug use to compensate for giving up the targeted drug.

REINFORCING ABSTINENCE FROM CIGARETTE SMOKING We identified nine voucher-based CM studies focused on abstinence from cigarette smoking, with eight of the studies reporting positive outcomes (Table 1). Studies in this area can be divided into (a) treatment-outcome studies, (b) studies conducted with smokers not seeking treatment to assess the feasibility of the approach to a new population or questions about the scheduling of vouchers, and (c) studies where CM was used as a tool to examine another topic (e.g., nicotine withdrawal).

An important treatment-outcome study on smoking cessation involved the use of voucher-based contingencies to increase cigarette smoking abstinence during pregnancy and postpartum (Donatelle et al. 2000). There has been a long-standing ceiling in the cessation rates achieved in this population at between 12% and 18%. In the Donatelle et al. trial, 220 pregnant smokers were randomly assigned to receive a smoking-cessation self-help kit only or the kit plus vouchers contingent on biochemically verified smoking abstinence. Those in the voucher condition had a significant other (SO) participate with them as a support person. Costs for the vouchers (\$50.00 per monthly test for smokers and \$25.00 for SOs) were covered through donations from community businesses and organizations. Smoking cessation rates at end of pregnancy were 32% versus 9% in the voucher and control conditions and 21% versus 6% at the two-month postpartum assessment. The other treatment-outcome trial also produced positive outcomes in a difficult-to-treat subset of smokers, opiate-dependent patients (Shoptaw et al. 2002).

Two of the feasibility studies demonstrated the efficacy of CM for increasing brief smoking abstinence (five days) in schizophrenic cigarette smokers (Roll et al. 1998, Tidey et al. 2002), and a third study did so in adolescent smokers (Corby et al. 2000). Similar brief smoking abstinence studies demonstrated the greater efficacy of the escalating schedule of reinforcement with a rest contingency used in the majority of voucher studies reviewed above compared to a fixed rate of reinforcement (Roll & Higgins 2000, Roll et al. 1996). A final study using the same general approach demonstrated the value of CM as a research tool for investigating nicotine withdrawal in outpatients (Heil et al. 2003). Studies characterizing the nicotine withdrawal syndrome without the use of CM often require participants to reside on a residential research ward to prevent smoking.

REINFORCING ABSTINENCE FROM ALCOHOL OR MARIJUANA USE The fishbowl procedure described above was first reported as an efficacious intervention for increasing treatment retention and alcohol abstinence in the only voucher-based study on that substance (Petry et al. 2000). Each of the trials examining the efficacy of voucher-based CM for increasing marijuana abstinence produced positive outcomes (Budney et al. 1991, 2000; Sigmon et al. 2000).

REINFORCING OTHER THERAPEUTIC GOALS In addition to reinforcing abstinence, voucher-based CM has been utilized to enhance medication compliance and other outcomes among individuals with substance use disorders. We identified ten reports; seven of the ten studies (70%) resulted in positive outcomes. Vouchers

were efficacious for increased compliance with naltrexone therapy in one trial (Preston et al. 1999) and antiretroviral therapy in another (Rigsby et al. 2000). In two additional trials, voucher-based increases in naltrexone compliance approached statistical ($p < 0.10$) significance (Carroll et al. 2001, 2002). Other applications have involved increasing clinic attendance among pregnant substance abusers (Svikis et al. 1997), attendance at an HIV drop-in center (Petry et al. 2001), and attendance (Silverman et al. 1996a) and productivity (Wong et al. 2003) at vocational training in methadone-maintenance patients. Other instances of negative outcomes involved clinic attendance in the comprehensive care clinic for pregnant abusers mentioned above, where vouchers appeared to be too low and the schedule too simplistic relative to the therapeutic target (Jones et al. 2000, Svikis et al. 1997).

Community Reinforcement Approach

CRA was first developed for treatment of alcoholism (Hunt & Azrin 1973) and later adapted for use with cocaine-dependent (Higgins et al. 1991) and opiate-dependent (Bickel et al. 1997a) outpatients. CRA seeks to facilitate therapeutic change by manipulating naturalistic reinforcement contingencies. The specific content of CRA varies depending on the clinical population and individual patient needs, but usually has several key components. (a) Barriers to treatment engagement such as pending legal matters, homelessness, or other crises are addressed in the initial sessions. (b) Unemployed individuals or those with jobs that put them at risk for substance abuse are provided vocational counseling (e.g., Job Club, see Azrin & Besalel 1980). (c) Patients are taught how to identify antecedents and consequences of substance abuse, and how to minimize contact with the antecedents of substance use and find healthy substitutes for the positive consequences derived from substance use. (d) Behavioral therapy for couples is often provided. (e) Individualized skills training is provided to remedy deficits that either interfere with achieving abstinence or increase relapse risk (e.g., drug refusal, social skills, and mood management training). (f) Disulfiram therapy is used for those with alcohol problems along with a protocol to monitor and support medication compliance. CRA therapist manuals are available for cocaine (Budney & Higgins 1998) and alcohol (Meyers & Smith 1995) dependence.

CRA has also been adapted for use with SOs of treatment-resistant substance abusers (K.C. Kirby et al. 1999, Meyers et al. 2002, Miller et al. 1999). In those applications, CRA includes education about substance use disorders, information and discussion of the positive consequences of not drinking, assistance with engaging the designated patient and the SO in healthy recreational and social activities, and training in how to manage instances of substance use by the designated patient and how to recommend treatment entry.

We are aware of 11 controlled studies published in peer-reviewed journals since 1990 on the use of CRA, 8 involving treatment of patients with substance use disorders and 3 with SOs of treatment-resistant patients. Six of the trials with patients involved CRA combined with vouchers, five with cocaine-dependent outpatients

(Higgins et al. 1991, 1993, 1994b, 2000, 2003), and one with opiate-dependent outpatients (Bickel et al. 1997a). Each of those trials produced significantly better treatment outcomes than the comparison conditions (drug abuse counseling or CRA without contingent vouchers) (e.g., see Figure 4).

Only one of the CRA plus vouchers trials involved an experimental design that isolated the contribution of CRA to outcome (Higgins et al. 2003). In that trial with 100 cocaine-dependent outpatients, combining CRA with vouchers increased treatment retention, increased cocaine abstinence during treatment but not follow-up, decreased drinking to intoxication during treatment and posttreatment follow-up, and improved employment and other measures of psychosocial functioning during treatment and follow-up compared to vouchers only.

CRA alone was shown to increase opiate abstinence in methadone-maintenance patients (Abbott et al. 1998). As noted above, the original series of studies on CRA were conducted with alcoholics. A more recent study extended the efficacy of CRA to the treatment of homeless alcohol-dependent men and women (Smith et al. 1998). In that study, CRA produced greater reductions in drinking throughout a one-year study period compared to standard care. Each of the three trials examining the efficacy of CRA for assisting SOs facilitate treatment entry in treatment-resistant individuals with substance use disorders have produced positive results (K.C. Kirby et al. 1999, Meyers et al. 2002, Miller et al. 1999).

SUMMARY/CONCLUSIONS

An extensive body of empirical evidence has accumulated over more than 40 years that reinforcement processes play a central role in the genesis, maintenance, and recovery from substance use disorders. In the animal laboratory, there has been a productive program of uninterrupted research examining the influence of reinforcement on various aspects of substance use and related disorders. In the clinical arena, research on the role of reinforcement principles in substance use and related disorders has had a less continuous path, but has again been vigorously and productively pursued during the past decade or so.

Research in the clinical laboratory has outlined relationships between drug use and environmental context that we believe are critical to understanding risk factors for substance use disorders. The research demonstrates that human substance use, even in the most virulent forms such as smoked or intravenous cocaine and heroin use by dependent individuals conforms to predictions of reinforcement theory. Research on the influence of alternative, nondrug reinforcers on drug use, temporal delays and temporal discounting, and molar relations between the reinforcement obtained through substance use as a proportion of overall reinforcement rates offers new insights into how abused substances control human behavior. Additionally, the observations are framed in terms of principles and concepts that have continuity across species and most can be modeled in the animal laboratory. To be sure, there may be some features of substance use disorders that are uniquely human, but probably not the core controlling principles and processes.

The treatment-outcome research reviewed in this chapter outlines how reinforcement principles can be effectively applied to improve clinical outcomes. CM and CRA have been demonstrated to be reliably efficacious across a broad array of different types of substance use disorders and populations, including some of the most treatment-refractory subgroups. This research, particularly the studies with pregnant women, also provides an interesting opportunity for some theoretical considerations. The fact that a pregnant woman would discontinue substance use when offered a voucher for doing so, but not to improve the health of her fetus is perplexing. After all, the vouchers are worth a pittance relative to the value of a healthy baby. Yet, when considered in light of the information covered in this chapter the behavior becomes more understandable. First, consider the fact that the women in question are overwhelmingly of lower socioeconomic status. As such, they likely have relatively fewer healthy sources of alternative reinforcement competing for their behavior compared to women that are more affluent. Second, the benefits to the health of the fetus of quitting substance use are not going to be experienced by the mother in any direct way for several months. Temporal delays weaken the influence of behavioral consequences. Third, the women are drug dependent, which is associated with increased discounting of delayed consequences. Thus, the weakening of delayed consequences is going to be greater than average in these women. Fourth, initial cessation of drug use will increase physical discomfort within several hours or days due to nicotine or other drug withdrawal. Not only does the woman have to forgo substance-produced reinforcement, she also has to make herself physically uncomfortable. Fifth, drug use will result in positive reinforcement within seconds, compounded by similarly rapid-onset relief from withdrawal if in the early stages of a cessation effort. When looked at in this way, rather than perplexing, the efficacy of vouchers seems reasonable and predictable. The vouchers likely provide a bridge of smaller, immediate reinforcers to the larger, delayed reinforcer of a healthy baby, while also changing the ratio of reinforcement derived from drug versus nondrug activities. The fact that reinforcement theory can offer a conceptual framework for understanding a perplexing phenomenon like substance abuse by pregnant women along with a practical intervention for treating the problem is a strong testimonial to the utility of the theory.

In closing, we think this chapter outlines some important recent developments in the area of clinical research on substance use disorders. The research reviewed suggests to us that continuing to examine how reinforcement principles and related processes operate in all aspects of human substance use has much to contribute to a scientific analysis of substance use disorders.

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