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The Influence of Alternative Reinforcers on Cocaine Use and Abuse: A Brief Review

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HIGGINS, S. T. *The influence of alternative reinforcers on cocaine use and abuse: A brief review.* PHARMACOL BIOCHEM BEHAV **57**(3) 419–427, 1997.—This report reviews experimental studies conducted with nonhuman and human subjects demonstrating that: a) cocaine's abuse liability is, in part, a function of its positive reinforcing effects, b) cocaine use is operant behavior, c) the degree of behavioral control that cocaine exerts as a reinforcer is malleable and dependent on environmental context, and d) increasing the availability of alternative, nondrug reinforcers can significantly disrupt the acquisition and maintenance of cocaine use and abuse. Implications of these observations for effective prevention and treatment of cocaine abuse are discussed. © 1997 Elsevier Science Inc.

Cocaine Cocaine abuse Reinforcement Self-administration Alternative reinforcers Incentives Treatment Prevention

THE following four empirical generalizations have the potential to improve our understanding of cocaine abuse and to increase the efficacy of prevention and treatment interventions for that disorder:

1. Cocaine's abuse liability is, in part, a function of its positive reinforcing effects.
2. Cocaine use is an instance of operant behavior.
3. The degree of behavioral control that cocaine exerts as a reinforcer is malleable and dependent on environmental context.
4. Increasing the availability of alternative, nondrug reinforcers is one contextual alteration that can significantly disrupt the acquisition and maintenance of cocaine use and abuse.

The first of these generalizations has garnered an impressive degree of scientific consensus and is familiar to most involved in studying cocaine abuse. Generalizations 2, 3, and 4 may be less familiar, especially to those not trained in the behavioral sciences, and merit some explication. Generalization 2 is a corollary of 1. That is, reinforcement is a behavioral process wherein the future probability of an operant response is increased as a function of having produced a particular consequence (11). Said differently, if cocaine functions as a reinforcer, then cocaine use necessarily stands as an instance of operant behavior. Explicit recognition of generalization 2 is important because it suggests that the extensive knowledge base regarding other forms of operant responding (e.g., responding maintained by food, water, sex, or social attention) might be fruitfully applied to understanding cocaine abuse. One aspect of that knowledge base that is well established, and is the basis for generalization 3, is that the degree of behavioral control that a reinforcer exerts depends on the environmental context in which responding occurs. To take a very simple example, a relatively bland food can exert substantial behavioral control with a food-deprived organism if it is the only food source available. However, introduce a more palatable option as a concurrent alternative to that bland food source and control by the latter will diminish dramatically. Similarly, the degree of behavioral control that cocaine exerts as a reinforcer is influenced by environmental context. Generalization 4 deals with one such contextual factor, namely the presence of alternative reinforcers. As is reviewed below, experimental studies in nonhumans and humans, in laboratory and clinic settings, with different routes of cocaine administration, and with recreational and dependent human cocaine users all demonstrate that cocaine use can be decreased significantly by increasing the availability of alternative reinforcers. Moreover, the continuity of that empirical support across such varied conditions and species suggests that it is a basic characteristic of the manner in which cocaine affects behavior.

STUDIES IN NONHUMANS

A study conducted by Nader and Woolverton (13) illustrates the kind of support that is provided for these four generalizations by experimental studies in nonhuman primates

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responding under controlled laboratory conditions. Subjects were food-deprived rhesus monkeys, each fitted with indwelling venous catheters. Subjects resided in sound-attenuated chambers, each of which was equipped with two response levers, a food pellet dispenser, an infusion pump, and a row of stimulus lights located above the response levers. Responding on one of the levers resulted in the delivery of varying numbers of food pellets or infusions of varying doses of cocaine depending on the color of the stimulus lights and according to a fixed ratio (FR) 30 schedule of reinforcement. By responding on the other lever, the monkey could alternate between cocaine and food reinforcement under an FR 5 schedule. Subjects generally made a maximum of 15 *exclusive* choices between cocaine and food during an experimental session.

Choice of the drug option in this study varied as an orderly function of dose, ranging from few or no choices when saline or low doses of cocaine were available to exclusive choice of that option at the higher doses (Fig. 1). That effect illustrates the potent reinforcing effects of cocaine such that food-deprived subjects would forgo basic sustenance for drug (1). Importantly, however, the curve relating choice of cocaine to dose was shifted significantly to the right and downward by increasing the number of food pellets delivered per ratio completed in the food option. This latter relationship demonstrates how cocaine's behavioral control is dependent on environmental context.

The reliability of these results was supported in two subsequent experiments by the same authors demonstrating that increasing the magnitude of an alternative food reinforcer significantly decreased cocaine self-administration in rhesus monkeys (14,15). One of those studies also demonstrated that just as cocaine's behavioral control is dependent on environmental context, so too is the control exerted by the alternative

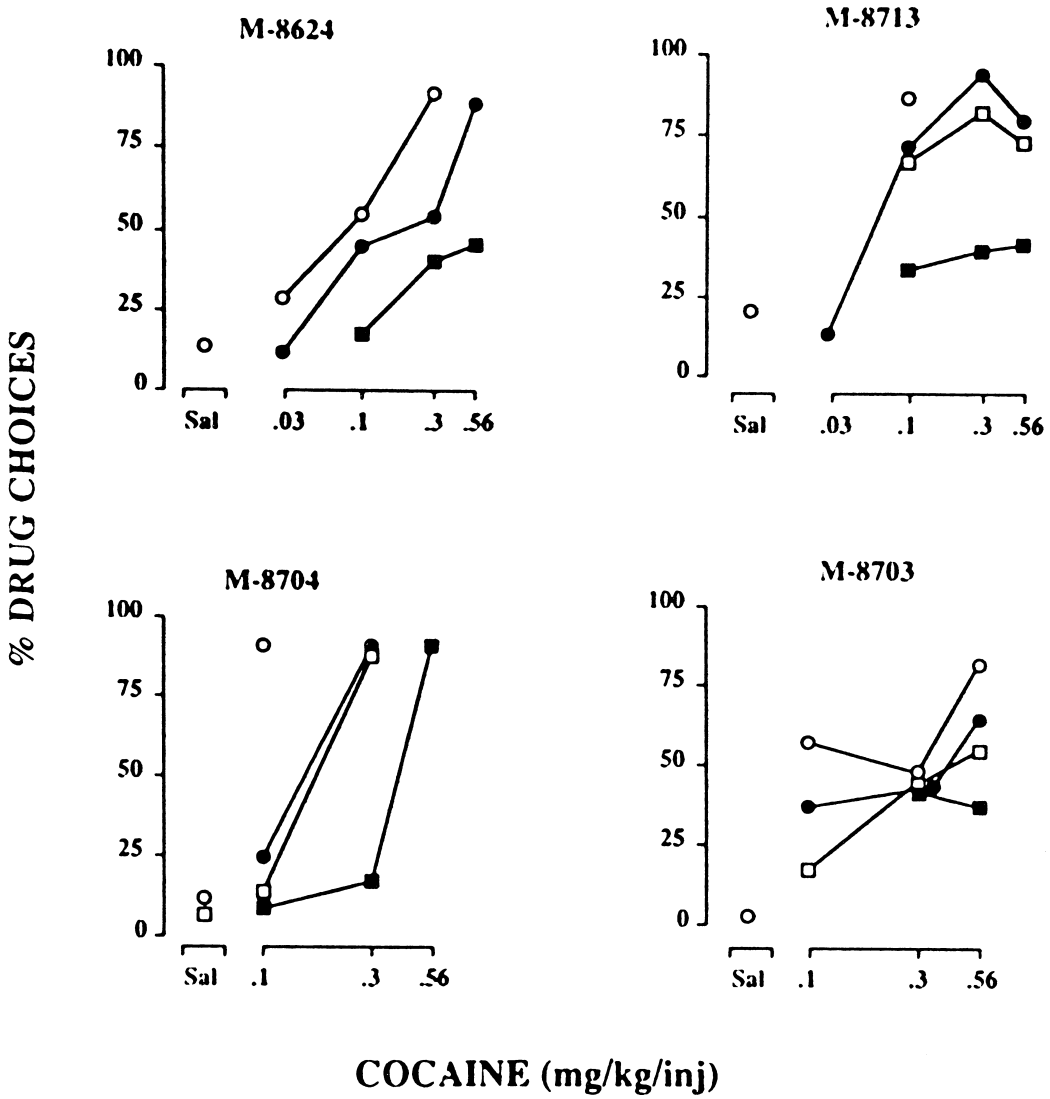

FIG. 1. Percentage of the completed trials in which cocaine was chosen, for each of four monkeys, as a function of cocaine dose (0.03–0.56 mg/kg/injection). Different symbols represent different magnitudes of food reinforcement available (1–16 pellets; 1 g/pellet) as the alternative to cocaine. The last three sessions of a condition were used in data presentation, with each value representing the mean of the last two determinations. Values above "Sal" are from sessions in which saline was available as the drug option. ○, 1 pellet; ●, 4 pellets; □, 8 pellets; ■, 16 pellets. [Adapted from Nader and Woolverton (13) with permission.]

food reinforcer (14). When food supplements were provided at the end of experimental sessions, the ability of the food option to effectively compete with cocaine during sessions was significantly diminished. The bidirectionality of this effect illustrates how contextual control over reinforcing effects is not a unique feature of cocaine, but, rather, a generic characteristic of the manner in which reinforcers control behavior.

A study by Carroll et al. (3) illustrates the ability of alternative reinforcers to influence cocaine self-administration in rats. A total of 55 rats were divided into 11 experimental groups. All subjects were fitted with venous catheters. During fifteen 24-h sessions, the various groups had continuous, concurrent access to intravenous infusions of either cocaine or saline via lever pressing and to either a glucose + saccharin solution or water via tongue-operated drinking devices. Unlike in the Nader and Woolverton studies, 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, thereby providing an opportunity to examine the influence of alternative nondrug reinforcers on the acquisition of cocaine self-administration. As expected, infusion rates were significantly higher in rats given access to cocaine compared with controls given access to saline, demonstrating the reinforcing effects of cocaine. However, the malleability of cocaine's reinforcing effects was also demonstrated. Substitution of water for the glucose + saccharin solution in rats initially exposed to concurrent cocaine and glucose + saccharin availability produced nearly a twofold increase in cocaine self-administration. There was no change in saline self-administration in a control group exposed to the same changes in drinking solutions. Thus, rates of cocaine self-administration when the glucose + saccharin solution was available were substantially below maximal levels; that is, the drinking solution effectively competed with cocaine. Similarly, replacing water with the glucose + 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 demonstrate cocaine's potent reinforcing effects and the malleability of those effects dependent on environmental context.

Another point of interest in the Carroll et al. (3) report is that the magnitude of the increase in cocaine self-administration that resulted from replacing the glucose + saccharin solution with water was substantially larger than the decreases in drug ingestion that resulted from replacing water with the glucose + saccharin solution. Said differently, the effect of the palatable alternative reinforcer was greater in attenuating the acquisition of cocaine-reinforced responding than it was in reducing such responding once it 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 + saccharin solution. Unlike the Nader and Woolverton studies, choices between drug and food were not exclusive in this study; that is, there were no contingencies arranged requiring subjects to forgo drug in order to obtain the alternative. A plausible hypothesis is that simply enriching an environment in which cocaine is available by introducing nondrug alternatives without any explicit contingency between their availability and drug use may more effectively interfere with the acquisition than with the maintenance of cocaine self-administration.

Subsequent reports from Carroll and colleagues further support that hypothesis, which, as is discussed below, has important clinical implications. In an elegant experiment, Carroll and Lac (2) studied the acquisition of cocaine self-administration in four groups of 12 rats each; a fifth group was studied as well, but is not directly germane to the present discussion. In a 2×2 experimental design, the four groups were exposed to glucose + saccharin or water for 3 weeks prior to and then during 30 cocaine self-administration acquisition sessions. An acquisition criterion was established to determine whether cocaine self-administration was acquired during the 30-day acquisition period: subjects had to achieve an average of 100 or more drug ingestions per session across five consecutive 6-h sessions. The group that had access to the glucose + saccharin solution before and during acquisition sessions had the greatest number of failures to acquire self-administration (50%), followed by the group with glucose + saccharin during acquisition sessions only (25%); the two groups with water available during acquisition had no failures (0%) (Fig. 2). Thus, these results provided another demonstration that the acquisition of cocaine self-administration could be substantially affected by manipulations in the availability of a palatable alternative reinforcer.

Interestingly, this same group of investigators failed to significantly influence self-administration in monkeys smoking cocaine (4). In that study, a saccharin solution was introduced after cocaine self-administration was already established. Although this manipulation decreased cocaine's behavioral control to a limited extent in several subjects, the effects were unimpressive. There is 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 established may require an arrangement in which access to the alternative nondrug reinforcer is made contingent on forgoing the cocaine option. The other side of that same coin, of course, is that such additional contingencies appear unnecessary to significantly interfere with the acquisition of cocaine self-administration.

STUDIES IN HUMANS

A study examining the influence of an alternative monetary reinforcer on cocaine self-administration in adult volunteers responding under controlled laboratory conditions illustrates the application of these four generalizations to human behavior (7). 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 10 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 forgo either option. Session duration was a maximum of 2 h. Subjects had to choose cocaine over placebo seven 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 *not* informed of

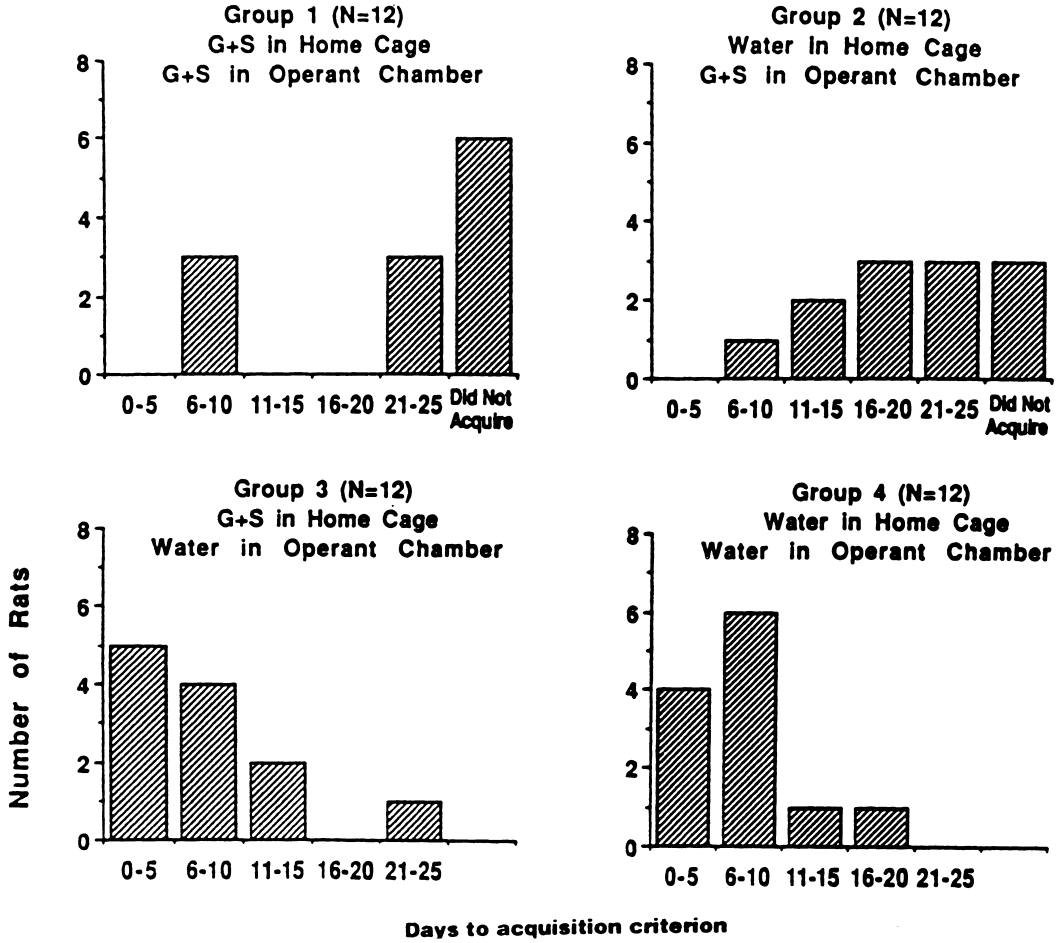

FIG. 2. Frequency distributions for groups 1–4. The number of days until the acquisition criterion was met is divided into five 5-day intervals, and the number of rats that acquired within each interval is represented by the height of the bar. No rats met the criterion between 26 and 30 days. The last bar 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 + saccharin in the operant chamber, and the two lower frames show results when only water was available in the operant chamber. The upper and lower left frames show the two groups that were exposed to glucose + saccharin in the home cage, and the upper and lower right frames show the groups exposed to only water in the home cage. [Adapted from Carroll and Lac (2) with permission.]

that criterion. The reason for the criterion was that we wanted to study subjects for whom cocaine functioned as a reinforcer, because 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 sessions. Values varied from zero to $2.00 per choice or, in total, 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 (Fig. 3). These results demonstrated the malleability of cocaine preference in human volunteers, thereby systematically replicating and extending to humans the findings of Nader and Woolverton (13–15) in monkeys and Carroll et al. (2,3) in rats.

A second study following the same procedures as outlined above further illustrates these points (12). Subjects were 11 volunteers with the same characteristics as those described above. Nine of the 11 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 increasing value in the monetary option (Fig. 4, leftmost function). However, this study had an additional feature that distinguished it from the previous study. Prior to each cocaine vs. money session, subjects were treated with varying doses of alcohol (placebo, 0.5 g/kg, and 1.0 g/kg). Pretreatment with the active doses of alcohol increased prefer-

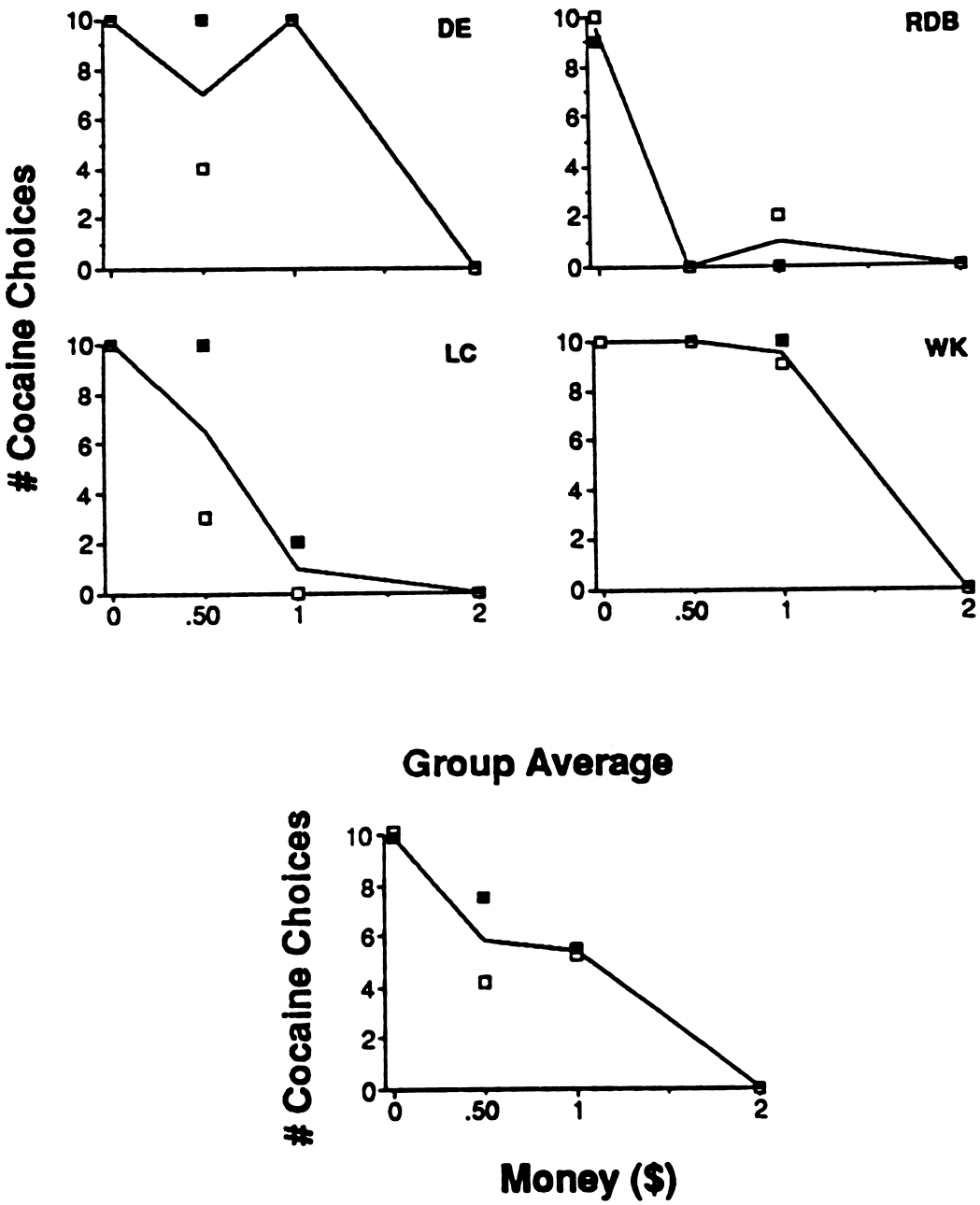

FIG. 3. Number of cocaine choices plotted as a function of the value of money available per choice in the monetary option. Subjects made a maximum of 10 choices between cocaine vs. money during each session. Data are presented for each of the four individual subjects and as a group average. Results from the first and second exposures to the different monetary values are shown separately.

ence for cocaine over the monetary reinforcer, with the effect being most discernible in the high-money condition (Fig. 4, middle and rightmost functions). Note that on average, alcohol pretreatment did not eliminate the ability of the monetary reinforcer to effectively compete with cocaine (it did in some individuals), but it diminished that effect in the high-money condition. These results demonstrate further the malleability of cocaine's reinforcing effects in humans as a function of the availability of alternative reinforcers while also demonstrating how that relationship is dependent on environmental context. That is, alcohol consumption in this study created a context in which preference for cocaine over monetary reinforcement was enhanced.

These two experiments are not the only ones to demonstrate the influence of alternative, nondrug reinforcers on human cocaine self-administration under controlled laboratory conditions. Similar effects have been reported in subjects making exclusive choices between smoked (6) or intravenous (5) cocaine and alternative, nondrug reinforcers. Thus, there is experimental evidence supporting this effect in humans

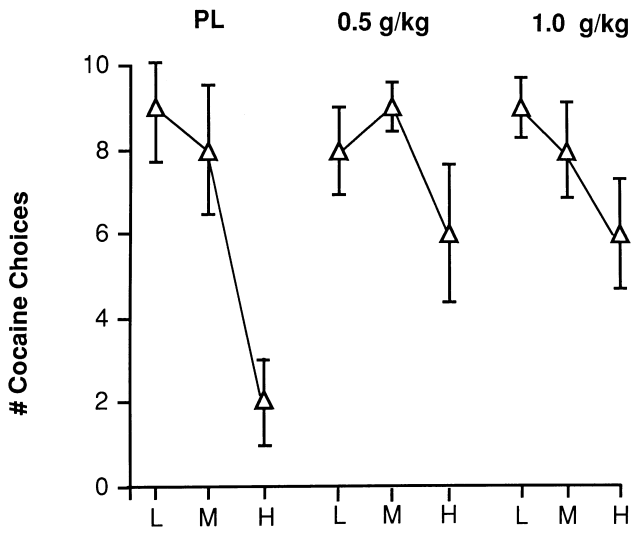

FIG. 4. Number of cocaine choices during sessions involving alcohol pretreatment shown as a function of three money conditions [low (L), medium (M), and high (H) monetary values], with separate functions presented for each of the three alcohol doses [placebo (PL), 0.5 g/kg, 1.0 g/kg]. All data points represent means from seven subjects who completed the experiment; brackets represent ±SEM. [Adapted from Higgins et al. (12) with permission.]

across different laboratories, different experimental arrangements, and with each of the most common routes of cocaine self-administration used in the United States.

Another important issue regarding the four generalizations under discussion is whether they extend to clinical settings and populations. A clinical trial conducted in an outpatient clinic for the treatment of cocaine dependence located in Burlington, Vermont, addresses that issue (10). Forty adults who met diagnostic criteria for cocaine dependence were randomly assigned to a behavioral treatment with or without an added incentive program. The incentive program was designed to function in the same manner as the food reinforcers in the Nader and Woolverton (13–15) studies and the monetary and other alternative reinforcers in the studies conducted with humans (5–7,12). That is, the program was designed to provide subjects an exclusive choice between cocaine use and an alternative, nondrug reinforcer. Subjects in the group with incentives earned points recorded on vouchers that were exchangeable for retail items. Points were earned for 12 weeks by submitting urine specimens that tested negative for benzoylecgonine (a cocaine metabolite) during thrice-weekly urinalysis testing. Points were worth the equivalent of $0.25 each in purchasing power. The first negative specimen earned 10 points or $2.50. The value of vouchers for each subsequent consecutive negative specimen increased by 5 points (e.g., 15 points for the second, 20 points for the third, etc.). To further increase the likelihood of continuous cocaine abstinence, the

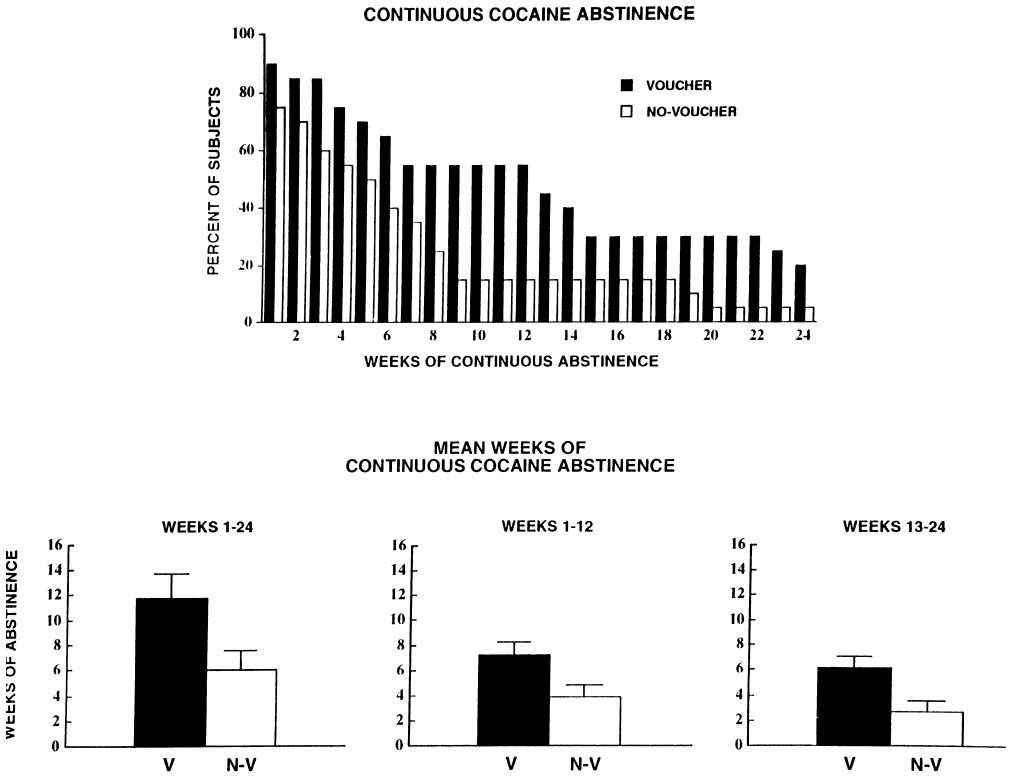

FIG. 5. Top: Distribution of documented continuous cocaine abstinence observed in the voucher (V) and no-voucher (N-V) groups. The height of each bar represents the percentage of patients achieving a duration of abstinence greater than or equal to the number of weeks indicated. Note that the *x*-axis shows weeks of continuous abstinence and not consecutive treatment weeks. Bottom: Mean durations of continuous abstinence achieved in each treatment group during weeks 1–24, 1–12, and 13–24 of treatment. Closed bars represent the voucher group, and open bars represent the no-voucher group. [Adapted from Higgins et al. (10) with permission.]

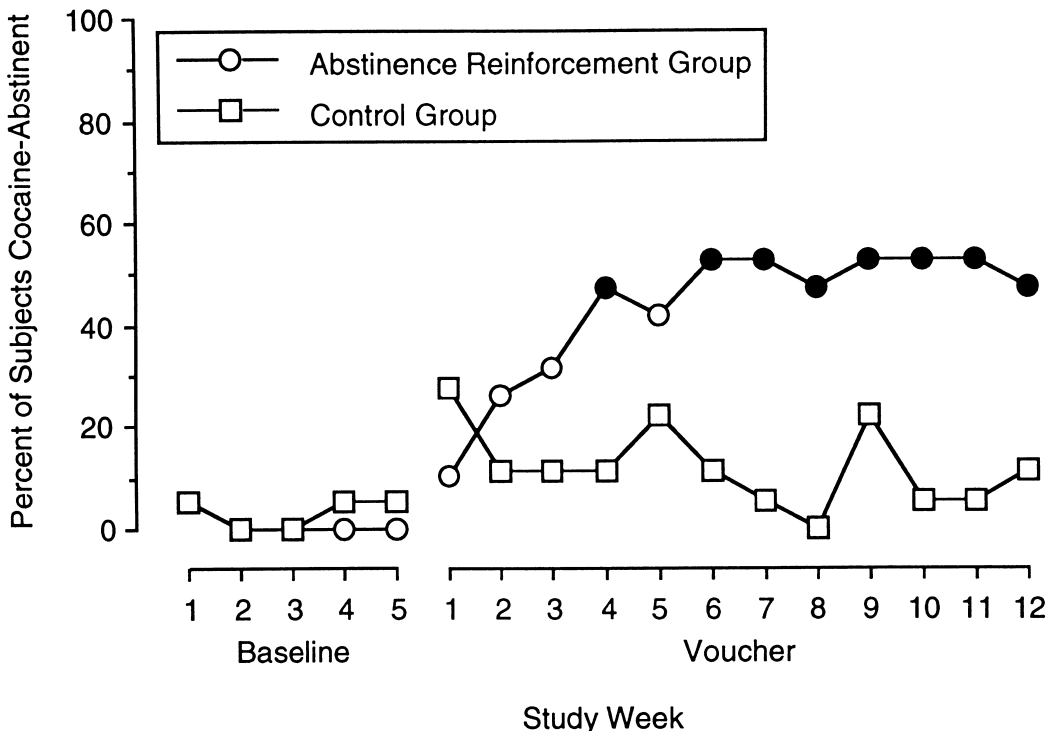

FIG. 6. Percentage of patients abstinent during 17 successive study weeks. Circles represent data from the abstinence reinforcement group, and squares represent the control group. A patient was considered cocaine abstinent for a given week if all three urine samples collected that week were negative for cocaine. Filled points indicate the weeks in which the abstinence reinforcement group value differed significantly from control values ($p \leq 0.05$). [Adapted from Silverman et al. (21) with permission.]

equivalent of a $10.00 bonus was earned for each set of three consecutive negative tests. Specimens that were cocaine-positive or failure to submit a scheduled specimen reset the value of the vouchers back to their initial level. Subjects assigned to the no-incentives group received slips of paper after each urinalysis test, but those vouchers had no monetary value. All other aspects of the treatment were identical for the two treatment groups. Vouchers were discontinued after week 12 of the 24-week treatment program.

With regard to treatment retention, significantly more subjects in the voucher group than in the no-voucher group were retained in treatment: 90% and 75% of subjects assigned to the voucher group completed 12 and 24 weeks of treatment, respectively, compared with 65% and 40% in the no-voucher group, respectively. With regard to the amount of continuous cocaine abstinence documented via urinalysis testing in the two groups, the voucher group achieved significantly longer durations (Fig. 5). Thus, these results demonstrated that one could effectively extend the concept of using alternative reinforcers to compete with cocaine to a clinical setting and population. The incentives effectively retained subjects in outpatient treatment, which is a significant challenge in this population (8), and the durations of continuous cocaine abstinence that were documented in the incentive group equaled or exceeded any reported previously in controlled clinical trials with cocaine-dependent patients.

Another question of generality is whether these generalizations apply to what might be deemed a more difficult-to-treat, inner-city population of cocaine abusers. A study conducted in Baltimore, Maryland, addresses that question (21). Subjects were 37 intravenous cocaine abusers enrolled in outpatient methadone maintenance treatment for opioid dependence. Individuals 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 with monetary value, 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 more weeks of cocaine abstinence (Fig. 6) and greater durations of continuous cocaine abstinence (Fig. 7) than those assigned to the control group. The control group evidenced little discernible benefit from the alternative reinforcers in terms of reducing their cocaine use. Other clinical studies have also demonstrated significant decreases in cocaine use by providing alternative, nondrug reinforcers contingent on abstinence from cocaine and other abused substances [e.g., (18,19,21–24)].

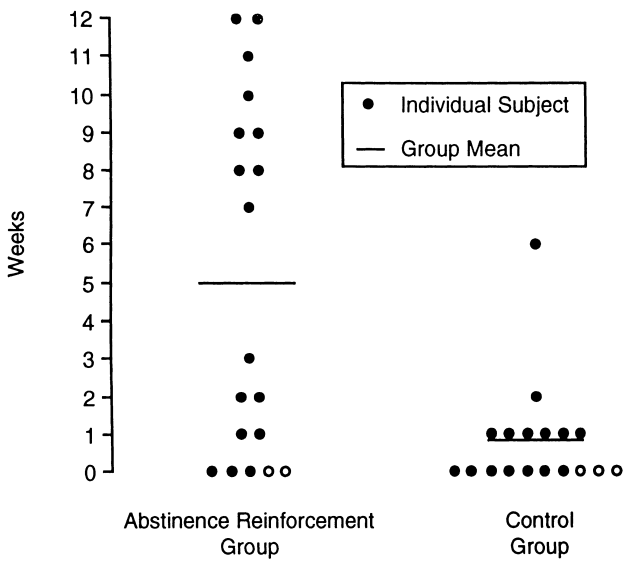

FIG. 7. Longest duration of continuous cocaine abstinence achieved during the 12-week voucher condition. Each point represents data for an individual patient, and the lines represent group means. The 19 abstinence reinforcement patients are displayed in the left column and the 18 control patients in the right. [Adapted from Silverman et al. (21) with permission.] 0 = patients who dropped out of the study.

CONCLUSIONS

The first point to be emphasized regarding the generalizations under discussion in this review is the impressive degree of consistency that exists across species, settings, and experimental arrangements in support of them. As was noted above, such order suggests we are dealing with a fundamental feature of cocaine's behavioral pharmacology.

Second, the studies reviewed provide compelling evidence that making alternative reinforcers available contingent on forgoing cocaine use can produce substantial reductions in ongoing rates of cocaine self-administration. Moreover, the clinical studies reviewed illustrate that this concept can be translated into clinical interventions that are effective in increasing retention in outpatient treatment and supporting clinically significant durations of continuous cocaine abstinence. Considering how early we are into the development of effective treatments for cocaine abuse, this stands as an important advance. Whether vouchers or some of the other types of incentives that have been explored thus far are practical in today's health care system is not so important. Of greater importance are the concepts and principles involved. If current interventions are not a good fit to the current milieu, then others should be devised and tested. I know of no scientific reason to think that any one form of incentive is somehow necessary. Policy makers, behavioral scientists, and clinicians invested in resolving the public health problems of cocaine abuse should think seriously and creatively about how the presence and absence of alternative, nondrug reinforcers is involved in the genesis and maintenance of this disorder and what kinds of creative interventions might be devised to curtail it. The extant scientific evidence suggests that an open and creative approach to these concepts and principles could result in some important gains.

Third, an issue sometimes raised regarding this concept of alternative reinforcers and cocaine use is why individuals experience such terrible losses due to their cocaine use in naturalistic settings but persist in that behavior nevertheless. The first thing to note about this matter is that only 5% or so of those who use cocaine go on to become regular users or abusers (16). Additionally, many who do become regular cocaine users resolve their problem without professional help (17). Thus, it is quite likely that these concepts and principles, among others, operate naturalistically to deter the acquisition and maintenance of regular cocaine use. Another matter to be noted is that many of the adverse effects of cocaine use do not manifest themselves until after the behavior is well established, and then they generally do so on an intermittent basis. As the data reviewed above illustrate, cocaine self-administration becomes more resistant to change once it is well established and thereafter appears to require carefully implemented contingencies to engender change. Perhaps for some individuals the losses associated with cocaine use, as terrible as they may be, are too intermittent and temporally removed from the act of using to effectively suppress drug use. Lastly, there are individual differences in how environmental manipulations of the sort under discussion here influence cocaine use in clinical settings. What those differences are is an empirical matter that is not well understood and needs further study.

Fourth, the question of what happens when the incentives are removed must be raised. This has not been well examined. Follow-up data have been reported from two trials in which voucher-based reinforcement was used as a component of a comprehensive behavioral intervention (9). Both were small trials (i.e., 18–20 subjects per treatment group) and thus not well suited for assessing long-term treatment effects. Nevertheless, no precipitous decreases in cocaine abstinence were observed after the incentives were discontinued, and differences favoring the groups that received incentives were found in both trials 9 months after the incentives were discontinued. Thus, when used as part of a larger intervention, there is evidence that incentives can produce effects that persist for some time after they are discontinued. Consider also the fact that in some situations (e.g., pregnant abusers) achieving even short-term abstinence is important and potentially cost-effective. Lastly, some cocaine abusers may require a long-term incentive program in order to avoid relapse in the same manner that many opioid abusers require methadone maintenance. How a long-term incentive program should be structured for both patient acceptability and efficacy is unclear at this time. However, it is an idea that should not be hastily dismissed. For example, the matter of schizophrenic patients using their disability benefits to support cocaine abuse is a very serious and costly clinical and policy problem that has received recent attention (20). A viable possibility under consideration to address that problem is whether an incentive program similar to the voucher program described above could be devised and implemented with that population (20). In this instance, the potential mechanism for supporting an incentive program on a long-term basis, should that be necessary, is already in place.

Fifth, the findings of Carroll et al. (2,3) have potentially profound implications for prevention efforts. They suggest that introducing reinforcing, nondrug alternatives into environments that under normal circumstances readily support the acquisition of cocaine-reinforced responding can effectively retard the development of that behavior. Moreover, the alternatives are effective in the absence of any explicit contingency between their availability and cocaine use. The reason that is so important is that implementation of such contingencies requires regular monitoring of individual drug use via uri-

nalysis or other means, which, when contemplated on a large scale, raises enormous questions about logistics, costs, and individual privacy. The findings of Carroll and colleagues suggest that regular monitoring of that sort is probably unnecessary for effective use of alternative reinforcers in prevention efforts. For obvious ethical reasons, the findings of Carroll and colleagues cannot be replicated in humans responding under controlled laboratory conditions. Thus, those findings would need to be extended directly into prevention trials. However, considering the continuity demonstrated for the effects of alternative reinforcers, that does not seem like a radical proposition.

Sixth and last, cocaine abuse and other forms of drug abuse result from a complex interplay of many factors. Emphasizing any one aspect, be it behavioral, neurobiological, or sociological, cannot explain the totality of cocaine abuse. Thus, this alternative reinforcer account is not offered as an explanation of or solution to cocaine abuse. Rather, it is offered as one aspect of this complex problem that has the potential to make a significant contribution.

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