RANDOMIZED TRIAL COMPARING TWO TREATMENT STRATEGIES USING PRIZE-BASED REINFORCEMENT OF ABSTINENCE IN COCAINE AND OPIATE USERS

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We compared two strategies of prize-based contingency management (CM) in methadone-maintained outpatients. Urine was tested thrice weekly for 5 weeks pre-CM, 12 weeks CM, and 8 weeks post-CM. Participants were randomly assigned to a cocaine contingency (four prize draws for each cocaine-negative urine, $N = 29$) or an opiate-cocaine contingency (one draw for each urine negative for opiates or cocaine, four draws if negative for both, $N = 38$). There were no group differences in cocaine abstinence during CM or post-CM and no differences in opiate abstinence during CM. Opiate abstinence was greater in the opiate-cocaine group post-CM, and heroin craving was reduced in this group during and post-CM. Draws earned per cocaine-negative urine (four vs. one) did not affect cocaine use.

DESCRIPTORS: cocaine abuse, community settings, contingency management, heroin abuse, opiate

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In spite of recent advances in the treatment of drug dependence, no medications have yet been identified to reliably treat cocaine abuse and dependence (Grabowski, Rhoades, Elk, Schmitz, & Creson, 1993; Rhoades, Creson, Elk, Schmitz, & Grabowski, 1998; Sofuoglu & Kosten, 2006). Fortunately, a set of behavioral techniques known collectively as contingency management (CM) has been shown to be an effective treatment for cocaine dependence (Bigelow, Brooner, & Silverman, 1998; Higgins, Badger, & Budney, 2000; Higgins et al., 1991; Piotrowski et al., 1999; Silverman et al., 1998). In the application of CM in the context of substance abuse treatment, the delivery of a drug-negative biological specimen (usually urine) is the target behavior, and a monetary voucher, opportunity to draw for a prize, or other desired item or privilege is used as the reinforcer (Higgins et al., 2000; Iguchi, Belding, Morral, Lamb, & Husband, 1997; Petry & Martin, 2002; Petry, Martin, & Simcic, 2005; Petry et al., 2006; Silverman et al., 1996; Stitzer & Bigelow, 1978).

Treatment of opiate-dependent patients in methadone maintenance programs remains especially problematic in patients who concurrently use cocaine (Gerada, 2005; Gowing, Ali, & White, 2006; O'Brien, 2005; Runyon & Carroll, 2006). CM may be particularly useful in this relatively treatment-resistant population, although the optimal approach for treating polydrug use with CM has not yet been identified. A meta-analysis suggests that CM is highly effective when targeted toward one drug at a time but less effective when targeted toward multiple drugs simultaneously (Griffith, Rowan-Szal, Roark, & Simpson, 2000); however, no study has directly compared CM targeted toward one drug at a time to CM targeted toward multiple drugs simultaneously. Silverman et al. (1998) showed that targeting vouchers solely toward cocaine abstinence using an escalating schedule of reinforcement promotes cocaine and opiate abstinence in polydrug-using methadone-maintained patients.

Some attempts to target CM with voucher-based reinforcers valued in the range of $755.00 to $1,155.00 toward heroin and cocaine simultaneously have had negative or only modest results (Katz, Chutuape, Jones, & Stitzer, 2002; Piotrowski et al., 1999). A few such studies have yielded positive results in decreasing both cocaine and opiate dependence, but only in the context of an intensive psychosocial intervention, in the absence of a control group, with high-magnitude vouchers ($3,369.00 over 9 weeks), or very long durations of voucher availability ($5,800.00 over 52 weeks; Dallery, Silverman, Chutuape, Bigelow, & Stitzer, 2001; Katz, Gruber, Chutuape, & Stitzer, 2001; Silverman, Robles, Mudric, Bigelow, & Stitzer, 2004; Silverman, Svikis, Robles, Stitzer, & Bigelow, 2001).

Prize-based abstinence reinforcement is another approach to CM. In the prize-based CM procedure developed by Petry and colleagues, the primary reinforcer is the opportunity to draw four prizes, with some prize draws resulting in tangible prizes ranging in values such as $1.00 to $100.00 and other prize draws result in only a verbal message (e.g., ''sorry, try again''). Prize-based CM has been shown to be effective in decreasing use of alcohol, opiates, and cocaine in both research programs and community programs (Peirce et al., 2006; Petry & Martin, 2002; Petry et al., 2005). As with voucher-based CM, if draws and prizes for drug abstinence are to be used with substance-dependent patients who abuse both cocaine and heroin, the question about how limited resources should be allocated arises.

The objective of the present study was to compare the efficacy of two different CM strategies for earning opportunities to draw for prizes to reduce the use of cocaine and illicit opiates in polydrug abusers. This investigation was a feasibility study conducted in preparation for a larger clinical trial (Ghitza et al., 2007); the main goal was to ensure that the prize-based CM procedure would be successful; due to resource limitations, this feasibility study did not include a control group who received noncontingent prize draws. The two response requirements were (a) making some prize draws contingent on abstinence from either cocaine or opiates, with additional prize draws given for simultaneous abstinence from both, and (b) making all of the prize draws contingent on cocaine abstinence. The first strategy in which one prize draw was given for cocaine abstinence, one draw was given for opiate abstinence, and four draws were given for abstinence from both has been shown by Petry and Martin (2002) to be effective in increasing cocaine and opiate abstinence. The second strategy takes advantage of the therapeutic effects of methadone to decrease opiate use while using the entire amount of CM resources to target cocaine abstinence, because cocaine abuse and dependence do not reliably respond to any medications yet tested, including methadone (Grabowski et al., 1993; Rhoades et al., 1998; Sofuoglu & Kosten, 2006). Another rationale for this approach is supported by a previous finding that voucher reinforcement of cocaine abstinence led to a significant increase in opiate abstinence as well (Silverman et al., 1998). In the present study, we compared a strategy targeting prize-based CM exclusively towards cocaine to an opiate-cocaine contingency that independently reinforced abstinence from the use of cocaine and illicit opiates. We hypothesized that targeting prize-based CM toward abstinence from cocaine or opiates one drug at a time would be more effective for decreasing use of both drugs than would targeting cocaine abstinence only.

METHOD

Participants

Participants were selected from 88 patients consecutively admitted for methadone maintenance at the Intramural Research Program of the National Institute on Drug Abuse between October, 2001, and May, 2003. This study was

approved by the local institutional review board for human research. Participants were recruited through advertisements in a variety of local newspapers and television stations selected to ensure exposure to both sexes and all ethnicities. After complete description of the study to each participant, written informed consent was obtained. Eligibility criteria for initial enrollment were age 18 to 65 years, cocaine and opiate use (by self-report and urine screen), and physical dependence on opiates (by self-report). Eligibility for randomization to a group was based on subsequent opiate and cocaine use. At the end of the pre-CM baseline, participants whose urine specimens had tested positive for heroin at least four times and cocaine at least four times (not necessarily on the same days) out of 15 tests were randomized to one of two experimental CM interventions (opiate-cocaine contingent or cocaine contingent, described below). Participants who did not meet these criteria were permitted to remain in the study but were not randomized to an experimental group; their data are not reported here. Participants were not told about the randomization criteria. Diagnoses of heroin or cocaine dependence were not required. Exclusion criteria were current psychotic, bipolar, or major depressive disorders; current physical dependence on alcohol or sedatives; unstable serious medical illness; estimated IQ below 80 (Shipley Institute of Living Scale; Zachary, 1986); and urologic conditions that would preclude urine collection.

Applicants were screened by telephone and in two on-site visits that included medical, psychiatric, and drug use histories; a physical examination; urine and blood screens; and a battery of assessment instruments, including the Addiction Severity Index (McLellan et al., 1985) and the Diagnostic Interview Schedule (Robins, Cottler, Bucholz, & Compton, 1995).

Standard Treatment

All participants received, without charge, daily methadone and weekly individual counseling for 25 weeks. Methadone HCl was administered orally in 35 ml of a cherry-flavored solution. Methadone dose was gradually increased to 100 mg/day over the first 2 weeks and remained constant throughout the rest of the study; doses were adjusted as needed to prevent adverse effects. All subjects reached the 100 mg/day methadone dose by the beginning of the CM intervention period. Take-home doses of methadone were given only for major holidays and for participant emergencies. For individual counseling sessions, counselors completed a semistructured psychosocial assessment and treatment plan for each participant; reduction of drug use was the primary goal. Counseling sessions were problem focused and included both supportive and motivational techniques. Counselors helped patients develop a functional analysis of their substance use, identify and avoid high-risk situations, avoid drug-using friends and acquaintances, cope with urges to use, and examine short- and long-term consequences of use. The counselors were aware of both the outcomes of urine toxicology tests and self-reported drug use. The patients were aware that the counselors knew the outcomes of the tests.

Data Collection

Every Monday, Wednesday, and Friday throughout the study, the urine specimens were collected under observation of a laboratory technician. Urine specimens were analyzed by enzyme-multiplied immunoassay technique (EMIT) system that provided qualitative results for benzoylecgonine equivalents (cocaine) and morphine (opiates) with cutoff concentrations for positive set at 300 ng/ml. The assay was done by a commercial laboratory and had a 24-hr turn-around time, was conducted on all specimens, and was used in the data analysis. Breath alcohol levels were determined with an Alco-Sensor III.

Immediately after each urine collection, participants were asked by a study technician how many times they had used heroin, cocaine,

or other drugs on each day since the previous urine collection. Once every 2 weeks, participants completed a 22-item opiate (withdrawal) symptom checklist derived from the antagonist subscale of the Opiate Adjective Checklist used by Preston, Bigelow, and Liebson (1988). Participants rated each item on a five-point scale (0 = *not at all* to 4 = *extremely*); withdrawal-scale scores were calculated as the sum of the ratings on the 22 withdrawal items. Participants also completed a heroin-craving scale on which they rated how much they had wanted heroin on a five-point scale (0 = *not at all* to 4 = *extremely*; Preston, Umbricht, & Epstein, 2000).

Study Timeline and Groups

The study had three consecutive phases: pre-CM baseline treatment (5 weeks or 15 urine specimens collected, whichever occurred first), CM intervention (12 weeks), and post-CM (8 weeks). Pre-CM baseline began at the time of enrollment and continued until the participant had provided 15 urine specimens. The experimental interventions were in place for 12 weeks, after which standard methadone treatment was resumed for 8 weeks (post-CM phase).

Randomization. Participants were randomized to an experimental intervention group by a study technician who used a Microsoft Excel macro that stratified randomization by race, sex, employment status, probation status, and frequency of opiate- and cocaine-positive urine specimens during pre-CM baseline. The dichotomous classification used for stratification by frequency of opiate- and cocaine-positive urines was < 90% urines positive for the respective drugs during pre-CM baseline or not. Group assignment (opiate-cocaine contingent vs. cocaine contingent) was nonblinded due to the nature of the intervention.

Contingent CM intervention. During the CM intervention, in addition to EMIT testing, the urine specimens were also tested on-site for cocaine and opiates with OnTrak Tests immunoassay kits that gave qualitative results for benzoylecgonine equivalents (cutoff 300 ng/ml) and morphine (cutoff 300 ng/ml) within 5 min of specimen provision. In the rare instances when OnTrak and EMIT toxicology results did not agree, we used the EMIT results due to their known lower rate of false positives. (In the clinic, disputed OnTrak positives could be corrected the next day when EMIT results arrived from the offsite laboratory, and prize draws were adjusted accordingly, always in the participants' favor.) Participants in both groups were told the results of both the cocaine and opioid urine tests.

Participants in the opiate-cocaine contingent group ($N = 38$) earned one prize draw if the specimen tested negative for either opiates or cocaine or four prize draws if the specimen tested negative for both. Participants in the cocaine contingent group ($N = 29$) earned four prize draws if the specimen tested negative for cocaine; the opiate urine results did not affect prize draw earnings. On Monday and Wednesday, the maximum number of prize draws that could be earned for a participant in either group was four. On Friday, in addition to their regular prize draws for that day, participants who had met abstinence requirements all week (i.e., opiate-cocaine contingent group negative for opiates and cocaine; cocaine contingent group negative for cocaine) earned bonus prize draws that followed an escalating schedule: five prize draws for the 1st week of abstinence, six for the 2nd, and so on up to 16 for the 12th week. Participants who failed to provide a scheduled urine specimen earned no bonus prize draws for the week, and the next earned bonus prize draw was reset to five. Prize draws were made at the end of the clinic visit.

Prize-drawing procedure. The prize-drawing procedure was modeled after one that had been used successfully by Petry and Martin (2002). Participants drew from a rotating drum that contained 250 wooden balls. Each ball was marked with a symbol that indicated the prize

magnitude: 125 of the balls were marked with a symbol for "sorry, try again"; 109 were redeemable for a small prize worth $1.00 to $5.00, 15 for a large prize worth up to $20.00, and one for a jumbo prize worth up to $100.00. Participants drew the number of balls they had earned (as described above), and the number of prizes won was recorded in a log book. Balls were returned to the bowl after each participant made his or her prize draws.

After the prize drawing was completed, participants chose their prizes, which were kept on site in a locked cabinet that was regularly restocked. Examples of prizes available in each of the three categories were as follows: small—fast food coupon, bus pass, toiletries, or food or drink items; large—portable stereo, watch, clothing item, kitchen implement, or retail gift certificate; jumbo—small television, small stereo, or any five large prizes.

For both groups, 12 weeks of continuous abstinence (i.e., meeting their abstinence target of cocaine or both cocaine and opiates) enabled the participant to make 270 prize draws (4 times 36 regular prize draws, plus 126 bonus prize draws).

Data Analysis

Intake measures were analyzed by analysis of variance (ANOVA) or Pearson χ^2 to test comparability among groups. To address the issue of attrition, study retention as a function of treatment group was analyzed with a log-rank test (SAS LIFETEST procedure) of time until provision of the final urine sample.

Urine results, our primary outcome measures, were analyzed by random-effects mixed-regression models (SAS GLIMMIX macro). Random-effects mixed-regression models have been widely accepted in the CM literature as appropriate analytical tools for longitudinal data since they were introduced in the late 1980s. They have been shown to compare favorably with traditional repeated measures approaches (Nich & Carroll, 1997). These likelihood-based models use iterative methods that utilize all of the existing data, both on an individual and on a group level, to estimate treatment outcomes over time. They facilitate intent-to-treat analyses by interpolating missing values (with appropriate penalties reflected in larger standard errors) rather than deleting participants with missing values or coding all missing values identically. They also allow correlations between repeated measurements to be specified; in our case a first order autoregressive covariance structure was used. This covariance structure allows the correlations of measurements taken further apart to be less than those taken closer to one another, a reasonable assumption for most clinical trials. The repeated outcome measures in our models were (a) urines negative for opiates over time and (b) urines negative for cocaine over time. The independent variables were group (opiate-cocaine contingent, cocaine contingent), a covariate for pre-CM baseline drug use (expressed as the percentage of urine specimens negative for the drug being analyzed, arcsine transformed; the arcsine transformation was used to correct for heterogeneity of variance; Hogg & Craig, 1995), treatment phase, and a covariate for dropout (number of last urine specimen collected during the study). Pre-CM baseline drug use was included as a covariate because, although pre-CM baseline drug use was not significantly different across the groups, earlier work has shown that pre-CM baseline drug use is a major predictor of treatment response (Preston et al., 1998). The nonrandomness of the missing data was addressed by including a term for dropout; inclusion of a term for dropout was based on the pattern-mixture approach to controlling for the non-random nature of missing data (i.e., for the possibility that dropouts differed in some systematic way from study completers; Hedeker & Gibbons, 1997).

The longest duration (in weeks) of abstinence from opiate or cocaine use was analyzed with a

nonparametric median two-sample test (SAS NPAR1WAY procedure) due to the skewed distribution of these data.

To assess whether cocaine abstinence predicted opiate abstinence (and vice versa), we ran two GLIMMIX models in which each urine result for cocaine (or opiates) was used as a time-varying predictor of the same day's urine results for opiates (or cocaine); in each of these two models, we tested for an interaction with treatment group. We controlled for the same covariates as listed above.

Group differences in opiate withdrawal symptoms or heroin craving by treatment week were analyzed in mixed-regression models (SAS Proc Mixed), with Week as a within-participant factor and Group as a between-participants factor, controlling for each participant's mean pre-CM baseline opiate withdrawal and heroin craving rating. A first order autoregressive error structure was used. Total prizes and prize draws as a function of contingency group were analyzed with two-sample t tests.

The alpha level for all data analyses was $p \leq .05$. All analyses were two tailed. Analyses were conducted on an intent-to-treat basis. We restricted our analyses to assessing our primary and secondary outcome measures and did not conduct ancillary exploratory analyses.

RESULTS

Participant Characteristics and Retention

Of the 88 individuals enrolled, 67 were randomized to a contingent group (cocaine $N = 29$; opiate-cocaine $N = 38$); 13 dropped out of the study before being randomized, and 8 completed the pre-CM baseline phase but did not meet criteria for randomization. Data from the 67 randomized participants are reported here; their demographic characteristics are listed in Table 1.

Mean (SD) study retention in the overall sample was 22 (6) weeks and did not differ across groups (log-rank $\chi^2 = 0.19$, $df = 1$, $p > .05$). The number of missing urines did not

Table 1

Demographic Characteristics and Retention Rates by Group

	Group	
	Opiate-cocaine contingent ($N = 38$)	Cocaine contingent ($N = 29$)
Variable	$M \pm SD$	$M \pm SD$
Sex (% male)	50	65.5
Race: % white	39.5	37.9
% African American	57.9	58.6
Age (years)	40.5 ± 8.0	37.8 ± 6.5
Marital status:		
married (%)	15.8	17.9
never married (%)	55.3	46.4
other[a] (%)	29.0	35.7
Education (years completed)	11.4 ± 1.8	11.3 ± 1.1
Employment:		
full time (%)	23.7	38.0
part time (%)	21.0	24.1
unemployed (%)	47.4	34.5
other (disability, jailed, etc.)	7.9	3.4
Income: legal ($)	$1,036 \pm 1,424$	$1,132 \pm 1,066$
illegal[b] ($)	$1,170 \pm 1,171$	609 ± 829
$ spent on drugs in past 30 days	$1,921 \pm 1,079$	$1,589 \pm 1,017$
Alcohol use:		
days in last 30	4.8 ± 8.0	7.4 ± 10.8
years	3.9 ± 8.0	5.5 ± 7.5
Cannabis use:		
days in last 30	0.9 ± 1.2	1.1 ± 3.2
years	4.4 ± 4.3	4.9 ± 6.5
Cocaine use:		
days in last 30	13.9 ± 8.6	12.7 ± 9.2
years	9.0 ± 6.2	11.0 ± 7.0
IV route (%)	55.3	39.3
smoked route (%)	39.5	57.1
other (%)	5.2	3.6
Heroin use:		
days in last 30	28.0 ± 6.2	28.6 ± 5.4
years	13.9 ± 9.2	13.14 ± 7.5
IV route (%)	76.3	55.2
nasal route (%)	21.1	44.8
Polydrug use:		
days in last 30	14.4 ± 8.6	12.2 ± 10.2
years	7.5 ± 4.9	8.0 ± 7.0

[a] Divorced, separated, widowed.
[b] $F(1, 65) = 4.81$, $p = .0320$.

differ between groups in the pre-CM baseline phase ($t = -0.52$, $df = 65$, $p > .05$), CM intervention phase ($t = 0.33$, $df = 65$, $p > .05$), or post-CM phase ($t = 1.32$, $df = 53$, $p > .05$), nor across the whole study ($t = 0.59$, $df = 65$, $p > .05$). The total number of missing urine

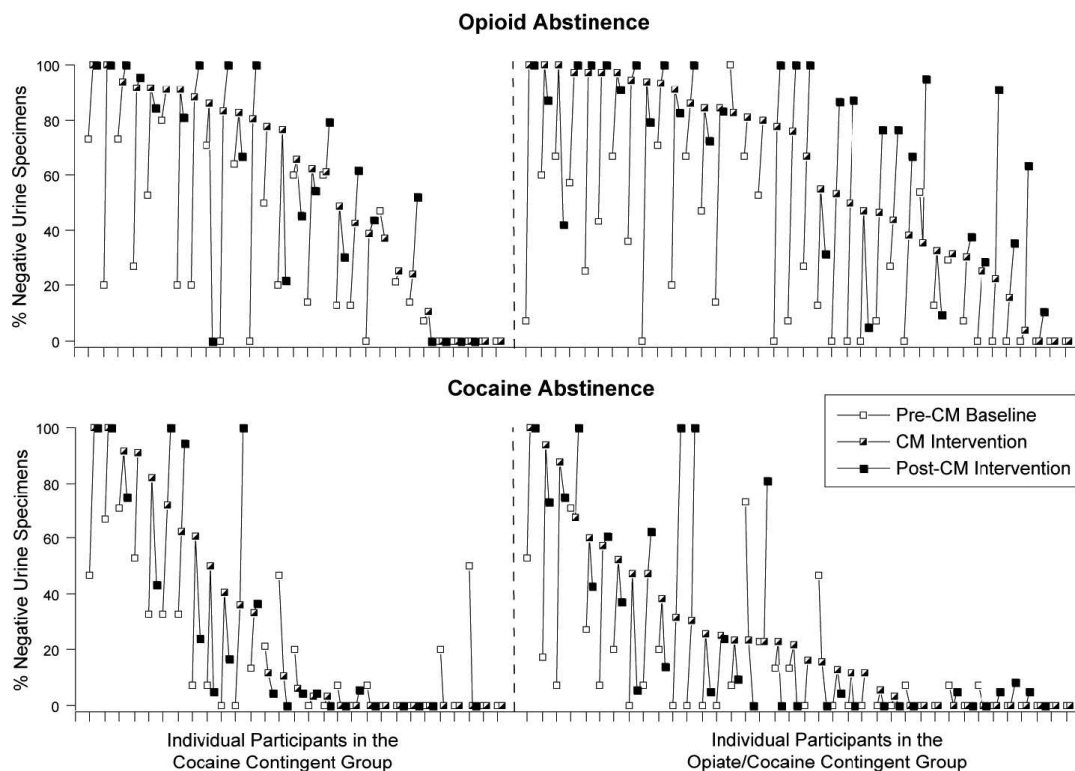**Opioid Abstinence**

Cocaine Abstinence

Figure 1. Percentages of urine specimens negative for opiates (top) and cocaine (bottom) during pre-CM baseline, CM intervention, and post-CM intervention in the cocaine contingent and opiate-cocaine contingent groups. Each set of symbols connected by lines represents data from an individual participant. No solid squares are shown for participants who dropped out before the post-CM intervention phase of the study. Vertical dashed lines separate the two groups. The preponderance of solid squares with high values in the upper right panel illustrates the tendency toward opioid abstinence post-CM in the opiate-cocaine contingent group, a pattern suggesting a delayed emergent benefit of CM.

specimens in the study was 921 (481 in the opiate-cocaine group and 440 in the cocaine group); the total number of urines collected in the study was 4,104. Seventy-nine percent (30 of 38) of participants in the opiate-cocaine group and 66% (19 of 29) of participants in the cocaine group completed the post-CM phase of the study.

Drug Use: Urine Screen

The results of opioid urinalyses are shown for individual participants in Figure 1 (top); unadjusted (raw) group means are shown in Figure 2 (top). A random-effects mixed-regression analysis assessing opiate abstinence revealed a significant interaction between Group and Treatment Phase, $F(2, 118) = 3.88$, $p < .05$.

Opiate abstinence significantly increased from pre-CM baseline to CM intervention in both groups: cocaine contingent was $t = 7.95$, $p < .01$; opiate-cocaine contingent was $t = 10.58$, $p < .01$. Opiate abstinence was also significantly higher during post-CM compared to pre-CM baseline in both groups: cocaine contingent was $t = 7.32$, $p < .01$; opiate-cocaine contingent was $t = 11.99$, $p < .01$. Between-groups comparisons showed that opiate abstinence was significantly greater in the opiate-cocaine group during the post-CM phase, $t = 3.21$, $p < .01$ (Figure 2). This overall better outcome shown in the group mean opiate use in the opiate-cocaine group is reflected in the individual data shown in Figure 1. Opiate use did not differ between the groups in the pre-CM baseline and
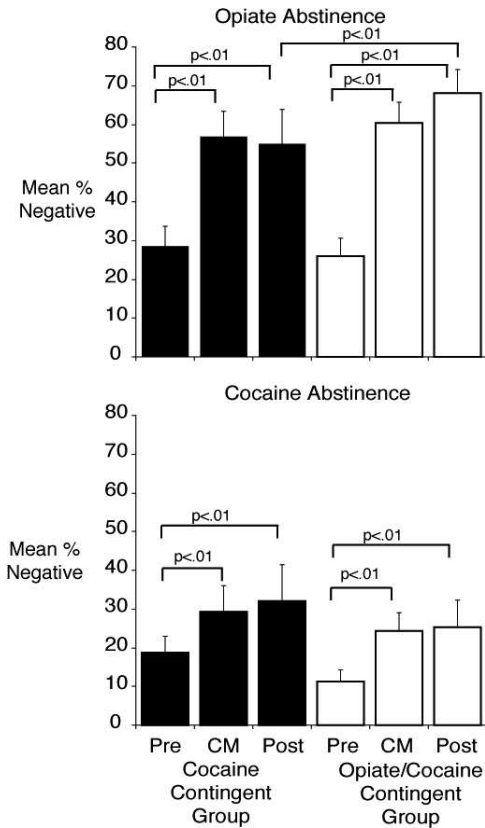
Figure 2. Mean unadjusted percentages of participants by treatment group who were abstinent from opiate use (top) and cocaine use (bottom) in the pre-CM baseline phase (B, first 5 weeks), prize-drawing CM intervention phase (I, 12 weeks), and post-CM (M, return to pre-CM baseline) phase (8 weeks). *p* values denote statistically significant differences.

CM intervention phases (Figure 2, CM intervention phase).

Similarly, the longest duration of continuous abstinence from opiates during the post-CM phase was significantly greater in the opiate-cocaine group (median = 3.3 weeks) than in the cocaine group (median = 1.0 weeks; nonparametric median test: $Z = -1.97$, $p < .05$). No between-groups differences occurred in the CM intervention phase.

The results of cocaine urinalyses are shown for individual participants in Figure 1 (bottom); unadjusted group means are shown in Figure 2 (bottom). A random-effects mixed-regression model assessing cocaine abstinence revealed a significant main effect of Treatment Phase, $F(2, 118) = 24.40$, $p < .01$; there was no significant effect of Group, $F(1, 63) = 1.49$, $p > .05$, or Group by Treatment Phase interaction, $F(2, 118) = 0.13$, $p > .05$. Cocaine abstinence significantly increased from pre-CM baseline to CM intervention in both groups: cocaine contingent was $t = 4.13$, $p < .01$, $df = 118$; opiate-cocaine contingent was $t = 5.49$, $p < .01$, $df = 118$. Cocaine abstinence was also significantly higher during post-CM compared to pre-CM baseline in both groups: cocaine contingent was $t = 3.69$, $p < .01$, $df = 118$; opiate-cocaine contingent was $t = 5.07$, $p < .01$, $df = 118$. There were no significant between-groups differences with respect to cocaine abstinence (Figure 2). Unlike for opiate use in the post-CM phase compared to CM intervention, cocaine abstinence continued to increase in few individual participants post-CM (Figure 1). No between-groups differences were found in the longest duration of continuous abstinence from cocaine.

Opiate use as a predictor of cocaine use. There was no interaction between opiate use and treatment group, $F(1, 43) = 0.98$, $p > .05$. Rather, in both groups, opiate use significantly predicted cocaine use: occasions of opiate abstinence tended to be occasions of cocaine abstinence during the treatment period encompassing CM intervention and post-CM, $F(1, 43) = 72.62$, $p < .0001$. Specifically, during instances of opiate-negative urines, 39.5% of those urines also tested negative for cocaine. By contrast, during instances of opiate-positive urines, only 10.1% of those urines tested negative for cocaine.

Cocaine use as a predictor of opiate use. Cocaine use significantly predicted opiate use during the treatment period encompassing CM intervention and post-CM, $F(1, 43) = 120.64$, $p < .0001$, but there was an important significant interaction between Group and Cocaine, $F(1, 43) = 4.51$, $p < .05$; occasions
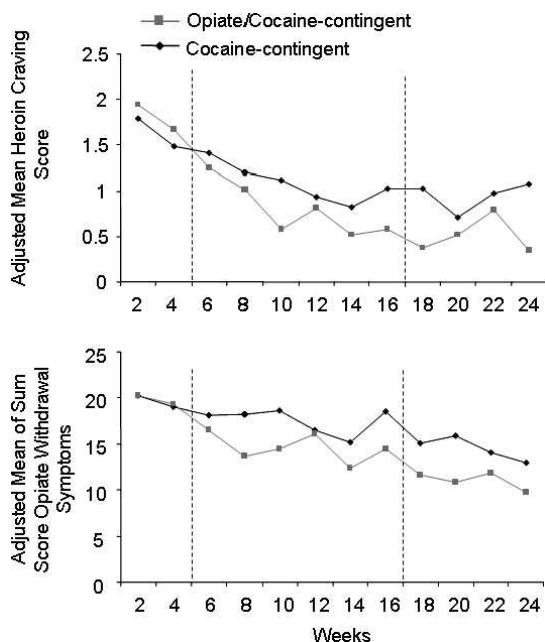
Figure 3.   Adjusted means of heroin craving scores (top) and summary scores for opiate- withdrawal symptoms (bottom) by treatment group and week. Each adjusted mean is from a random-effects mixed-regression model (SAS Proc Mixed procedure), controlling for pre-CM baseline heroin craving and opiate withdrawal symptoms.

of couse of cocaine and opiates were significantly more common in the cocaine group than in the opiate-cocaine group during the treatment period encompassing CM intervention and post-CM. Controlling for pre-CM baseline drug use and dropouts, in the cocaine group, 53.8% of urine specimens negative for cocaine were also negative for opiates, whereas in the opiate-cocaine group, 69.9% of urine specimens negative for cocaine were also negative for opiates.

Heroin Craving and Opiate Withdrawal Symptoms

In two separate mixed-regression models, each controlling for mean pre-CM baseline ratings of opiate withdrawal or heroin craving as appropriate, there were significant interactions between Group and Treatment Week on heroin craving, $F(22, 593) = 5.38$, $p < .01$, and on

opiate withdrawal symptoms, $F(22, 612) = 1.6$, $p < .05$. The opiate-cocaine group exhibited a significantly greater reduction across time than the cocaine group on both heroin craving and opiate withdrawal symptoms (Figure 3).

Prizes

Two-sample t tests showed no differences between the opiate-cocaine and cocaine groups in the total number of prize draws earned, $t(65) = 0.22$, $p > .05$, or prizes won, $t(65) = 0.07$, $p > .05$. The groups won a comparable number of prizes per draw (group means of 32 prizes per 58 draws for the cocaine group and 31 prizes per 55 draws for the opiate-cocaine group). In addition, the groups won a comparable mean number of small prizes (26 and 25 in the cocaine and opiate-cocaine groups, respectively), large prizes (6 and 6), and jumbo prizes (0.6 and 0.2). The cocaine group received a greater number of bonus draws than the opiate-cocaine group ($M \pm SEM$ of 19.1 ± 6.2 vs. 13.2 ± 4.6), but this difference was not statistically significant, $t = 0.8$, $p > .05$, $df = 52$. The ranges of prize draws earned (0 to 270) and prizes received (0 to 137) were the same for both groups. The percentage of participants earning any prize draws was 65.5% (19 of 29) for the cocaine group and 92.1% (35 of 38) for the opiate-cocaine group; this difference was not statistically significant, $t = 1.3$, $p > .05$, $df = 52$. The overall cost of prizes in the 12-week CM intervention was $177.00 per participant.

DISCUSSION

The primary goal of the present study was to determine whether targeting prize-based CM toward abstinence from cocaine or opiates individually would be more effective for decreasing use of both drugs than targeting only cocaine abstinence. In the current study, we evaluated two treatment strategies. One strategy reinforced abstinence from either drug, with a bonus each time the participant tested negative for both. That is, one prize draw was

given for cocaine- or opiate-negative urines, and four prize draws were given for both cocaine- and opiate-negative urines. Petry and Martin (2002) have shown that this strategy reduces concurrent use of cocaine and opioids. The second strategy reinforced only abstinence from cocaine use (i.e., four prize draws contingent on cocaine-negative urines). The rationale for the second strategy was to use the CM resources exclusively toward abstinence from cocaine use because cocaine abuse and dependence, unlike opiate abuse and dependence, do not reliably respond to any medications yet tested, including methadone (Grabowski et al., 1993; Rhoades et al., 1998; Sofuoglu & Kosten, 2006). An additional rationale for the second strategy was that Silverman et al. (1998) had shown that increasing cocaine abstinence through voucher-based CM resulted in concurrent increases in opiate abstinence. However, these two treatment strategies have not been directly compared in terms of their efficacy in promoting cocaine and opiate abstinence.

The clinical significance of the outcome differences in drug use, heroin craving, and opiate withdrawal symptoms observed across treatment groups warrants comment. The dual contingency of reinforcing both cocaine and opiate abstinence produced better treatment outcome by the time that the post-CM phase ended than solely reinforcing abstinence from cocaine. It is important to note that the dual contingency also reduced couse of opiates and cocaine to a greater extent than solely reinforcing abstinence from cocaine use. Although the improvement in opiate abstinence from pre-CM baseline to CM intervention was undoubtedly due to the continuing effects of methadone, the opiate-cocaine contingent group exhibited enhanced opiate abstinence during the 8-week post-CM phase after the CM intervention had ended. The time course of this effect—its greater prominence after discontinuation of the CM intervention—is not one that is typically associated with CM.

Before examining the individual data in Figure 1, we postulated that the atypical time course of observed effects did not actually represent a delayed emergence of the benefits of CM, but instead reflected a difference in the mechanisms through which opiate abstinence initially occurred. Participants in the opiate-cocaine group received direct reinforcement for opiate abstinence during the CM intervention by obtaining prize drawings for even one opiate-free sample. Participants in the cocaine group may have achieved comparable opiate abstinence indirectly due to their discontinuation of cocaine use: Users often purchase both drugs at the same time, and decreasing use of cocaine may have led to a reduction in opportunities to purchase opiates and a reduction in exposure to relapse-facilitating contextual stimuli common to cocaine and opiate use. Thus, participants in the cocaine group may have temporarily had little reason to go out to purchase heroin (especially given that physical withdrawal symptoms were being minimized by methadone maintenance). We reasoned that when the CM intervention was discontinued, those participants may have relapsed to opiate use more readily because of their not having learned a direct association between opiate abstinence and reinforcement.

Such an interpretation suggests that opiate use across the two phases would be more closely coupled in the opiate-cocaine group (who experienced the abstinence reinforcement association for both drugs) than in the cocaine group (who experienced the abstinence reinforcement association only for cocaine). The data in Figure 1 suggest the reverse. Opiate use in the opiate-cocaine group (upper right panel of Figure 1) differed more across phases than opiate use in the cocaine group (upper left panel of Figure 1) with a greater tendency toward abstinence in post-CM (solid squares in upper right panel). This pattern of results suggests a delayed emergent benefit of CM. In the two published studies in which the effects of CM seemed to follow such a time course, the delayed

benefit could be attributed to reinforcement of generalizable skills (Iguchi et al., 1997) or to a rarely used shaping procedure (Preston, Umbricht, Wong, & Epstein, 2001). Alternatively, we postulate that the increased abstinence in the opiate-cocaine group may have resulted from an abstinence-induced increase in the likelihood of contacting alternative sources of reinforcement. There is some evidence for this in the smoking abstinence literature (Glenn & Dallery, 2007; Lussier, Higgins, & Badger, 2005). More work is needed to explain the atypical time course of CM effects seen in this study and to ensure that the finding can be replicated.

Participants in the opiate-cocaine group also reported significantly greater reductions in opiate withdrawal symptoms and heroin craving across the duration of the study than did patients in the cocaine group. These group differences became statistically significant earlier in treatment (during CM intervention) than did the difference in opiate-positive urines. Whatever the causal relation (if any) among the outcomes, the findings as a whole suggest that resource allocation for prize-based CM procedures with dual cocaine and opiate users who have high rates of cocaine and opioid abuse when beginning methadone treatment is likely to be more effective with an opiate-cocaine contingency strategy than with a strategy that targets cocaine exclusively.

One limitation of this study is the relatively small sample size. Another is that we cannot be certain that the findings are generalizable to CM based on other types of reinforcers, such as vouchers. In fact, in a separate study using vouchers (Epstein, Schmittner, Schroeder, & Preston, 2003), we found that splitting the vouchers between reinforcement of cocaine and opiate abstinence without a bonus element for simultaneous abstinence appeared to enhance opiate abstinence at the expense of cocaine abstinence. Direct comparison in a single randomized trial would be necessary to resolve this seeming discrepancy and determine the role of the bonus contingency. The absolute cocaine abstinence rates were relatively modest during the CM intervention phase, and we attribute this relatively modest effect to the high levels of pre-CM baseline cocaine and opiate use in our sample. We have previously shown that the degree of pre-CM baseline drug use is a robust predictor of treatment response during the CM intervention (Preston et al., 1998). Therefore, these data may more readily generalize to a population of relatively heavy polydrug users. Finally, although the present study design allowed a comparison between the two CM strategies and against drug use early in treatment, the inclusion of a noncontingent control group would have provided additional comparative information on the overall effect sizes of the CM interventions. A noncontingent group in the larger clinical trial (Ghitza et al., 2007) that we conducted immediately after this pilot study appeared to show less abstinence than was seen here, though of course the groups cannot be directly compared.

In summary, the results of this study support the efficacy of a prize-based CM procedure to promote abstinence from cocaine and opiate use. The present study is the first to show that in the context of methadone maintenance, targeting prize-based CM toward abstinence from both cocaine and opiates is more effective for decreasing use of both drugs than targeting only cocaine abstinence. The strategy that provides all reinforcement contingent on cocaine abstinence is equally effective in promoting cocaine abstinence, but not as effective in decreasing craving and promoting abstinence from opiate use. These findings may have important implications for community treatment programs that seek to implement a cost-effective prize-based CM approach toward reducing both cocaine and opiate use in dual-using methadone-maintained patients.

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