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A COMPARISON OF FIVE REINFORCEMENT SCHEDULES FOR USE IN CONTINGENCY MANAGEMENT-BASED TREATMENT OF METHAMPHETAMINE ABUSE

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One variation of contingency management involves providing vouchers with monetary value for the provision of a biological sample indicating no recent drug use. These vouchers can be exchanged for goods or services. The schedule with which the vouchers are disbursed has been studied and results suggest that those schedules that incorporate escalating magnitude of reinforcement for consecutive instances of abstinence and a reset contingency, which reduces the value of the vouchers for instances of use, seem to provide the best treatment outcome. In this paper we explore several other scheduling arrangements while using the escalating schedule with a reset contingency as the comparator. The comparator schedule generally outperformed the other schedules in initiating and in maintaining abstinence from methamphetamine.

Methamphetamine abuse is a growing public health and criminal justice problem in much of the Western and Midwestern United States and its use appears to be increasing east of the Mississippi River (CEWG, 2002; OASIS 2003). Methamphetamine use occurs in all types of communities from large cities to rural settings, although often the most severe impact is observed in rural areas and moderately sized urban communities (Rawson, Gonzales, & Brethen, 2002). In 2001, an estimated 9.6 million people in the United States had tried methamphetamine at least once (SAMHSA, 2002). As more Americans abuse this drug, the demand for treatment grows. Research and past experience with other types of stimulant abuse suggest that contingency management represents a promising behavioral therapy for treating methamphetamine use disorders (e.g., Higgins & Silverman, 1999; Huber, Shoptaw, Roll, Ling, & Rawson, 2002; Rawson, Huber, et al., 2002; Roll & Shoptaw, in press).

Contingency management interventions are based on a robust basic-

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science literature supporting a position that drug use is a form of operant behavior (e.g., Bigelow & Silverman, 1999; Higgins, 1997). As such, the probability of using drugs should be influenced by the environmental context in which drug use occurs. More specifically, the availability of alternative non-drug reinforcers should decrease use if they are available in sufficient magnitude and according to a schedule that is incompatible with drug use (Carroll, Lac, & Nygaard, 1989; Higgins, Bickel, & Hughes, 1994; Nader & Woolverton, 1991). These observations form the conceptual basis for the contingency-management approaches to drug abuse treatment, which have proven effective at initiating clinically relevant periods of abstinence (Higgins, Alessi, & Dantona, 2002; Higgins & Silverman, 1999; Magura, Casriel, Goldsmith, Strug, & Lipton, 1988; Rawson, Huber, et al., 2002; Stitzer, Bigelow, Liebson, & Hawthorne, 1982).

A common type of contingency management intervention currently being used to treat substance abuse was popularized by Higgins and colleagues (e.g., Higgins, Budney, et al., 1994; Higgins et al., 1993; Higgins et al., 1991). In this procedure, patients receive "vouchers" for the provision of biological samples (urine or breath) that indicate no recent drug use. Hence, the procedure is often called Voucher Based Reinforcement Therapy (VBRT). These vouchers are withheld when the biological sample indicates recent drug use.

VBRT has proven to be successful at initiating periods of abstinence when compared to standard treatment regimens (e.g., Higgins & Silverman, 1999; Rawson, Huber, et al., 2002) and has been shown to produce relatively long periods of abstinence (Higgins, Badger, & Budney, 2000; Higgins, Wong, Badger, Ogden, & Dantona, 2000). Most individuals initiate some sobriety with this approach.

A number of important factors that may contribute to the success of contingency management have been examined, including: type of drug abuse (e.g., Stitzer & Higgins, 1995), type of reinforcer (e.g., Iguchi, Stitzer, Bigelow, & Liebson, 1988; Petry & Martin, 2002; Schmitz et al., 1998), type of response needed to earn reinforcement (e.g., Petry, 2000; Stitzer & Bigelow, 1985), type of procedure for distributing reinforcers (Petry, 2002), delay to the delivery of reinforcement (Schwartz, Lauderdale, Montgomery, Burch, & Gallant, 1987; Reilly, Roll, & Downey, 2000), magnitude of reinforcement (e.g., Dallery, Silverman, Chutuape, Bigelow, & Stitzer, 2001; Silverman, Chutuape, Bigelow, & Stitzer, 1999; Stitzer & Bigelow, 1985; Roll, Reilly, & Johanson, 2000), population (Corby, Roll, Ledgerwood, & Schuster, 2000; McNamara, Schumacher, Milby, Wallace & Usdan, 2001; Roll, Higgins, Steingard, & McGinley, 1998; Shanner et al., 1997), and schedule with which reinforcement is delivered (Kirby, Marlowe, Festinger, Lamb, & Platt, 1998; Roll, Higgins, & Badger, 1996; Roll & Higgins, 2000).

This last factor, the reinforcement schedule with which vouchers are disbursed, is the topic of the investigation reported on in this paper. Given the incredible sensitivity of behavior to reinforcement schedules we believe this is an important area of study (e.g., Ferster & Skinner, 1957).

The contingency management schedule typically used to reinforce abstinence has the following three key components. First, reinforcer value escalates with consecutive instances of abstinence. Second, consecutive blocks of abstinence earn additional reinforcement. Finally, failure to abstain, results in a reset in reinforcer magnitude. This scheduling arrangement was developed by Higgins, Budney, et al. (1994) and was designed to promote and maintain continuous abstinence. Other arrangements are being investigated (Kirby et al., 1998; Petry, Martin, Cooney, & Kranzler, 2000), but, the arrangements with escalating reinforcer magnitudes and reset contingencies appear to be the most effective to date (Roll & Higgins, 2000; Roll et al., 1996).

In order to gather information about other scheduling arrangements clinical psychologist members of the research team who were experienced in the provision of substance abuse treatment developed several reinforcement schedules, which they believed were representative of schedules that community treatment providers might develop. The impetus for developing these schedules in this fashion was that clinician-generated schedules might be more acceptable to community treatment providers. This strategy also allows us to take results from schedules that the clinicians might consider and show them how they compare with the more typical scheduling arrangement. The types of schedules eventually selected for evaluation yielded similar total earnings and were delivered over similar time frames. Specifically, this project compared the following five types of reinforcement schedules in their abilities to produce initial and sustained abstinence from methamphetamine: (1) a flat magnitude of reinforcement schedule with no bonuses for continuous abstinence or resets for failure to abstain; (2) slowly escalating magnitude of reinforcement with large bonuses for blocks of abstinence and no resets for failure to abstain; (3) high initial magnitude of reinforcement with slow escalation of voucher magnitude and no bonuses for continuous abstinence or resets for failure to abstain; (4) high initial magnitude of reinforcement that decreased rapidly with moderate bonuses for blocks of abstinence and no resets for failure to abstain; (5) low initial magnitude of reinforcement, with moderate escalation, moderate bonuses for continuous abstinence and resets in voucher magnitude for failure to abstain. Based on the previous work showing generally consistent positive results using the escalating schedule with resets, we predicted that this schedule (Number 5) would produce superior outcomes in reductions of methamphetamine use relative to the other schedules.

Methods

Participants

Participants were adults seeking outpatient behavioral treatment for methamphetamine use disorders at a treatment center located in Southern California. Each participant provided voluntary, written informed consent prior to engaging in any research procedures. Participants were

randomly assigned to one of five conditions each of which received VBRT for methamphetamine use. The only difference between conditions was the schedule of reinforcement with which the vouchers were delivered and in the instance of Schedule 1 (see below) the time frame over which the vouchers were delivered. The maximum earnings available from each schedule were approximately the same (i.e., $990.00 - $1,005.00). Four schedules were developed by clinicians experienced in the treatment of substance abuse (Schedules 1-4) and these were compared to the schedule developed by Higgins (Schedule 5) (see Tables 1-5). In all five conditions participants came to the research clinic three times a week. During the first 8-12 weeks of treatment, VBRT procedures were in effect. On every Monday, Wednesday, and Friday participants provided an observed urine specimen, which was immediately analyzed to detect recent (approximately past 48-72 hr) methamphetamine use. If the sample indicated no recent use the participant received a voucher of the specified monetary value. Failure to provide a urine sample was treated the same as the provision of a positive urine sample for reinforcement scheduling purposes.

Vouchers were delivered immediately after the urinanalysis was conducted. Participants were free to exchange these vouchers for any goods or services they wanted as long as they were deemed appropriate by research and clinical staff. Participants were also free to accumulate vouchers and exchange them for more expensive items once they had accumulated enough to pay for the item. Purchases or transactions were typically carried out within one working day of the participant's request.

During treatment, participants in all five conditions also attended thrice weekly cognitive behavioral therapy group sessions (Matrix Model; Obert et al., 2000). Trained substance abuse counselors delivered these sessions. No attempt was made to avoid mixing participants from the different conditions in the counseling groups.

Data Analysis

Methamphetamine abstinence was documented using urine samples analyzed for metabolites of methamphetamine. SYVA/EMIT methods reliably detect metabolites of methamphetamine for up to 48-72 hours following use of the drug. A negative sample was interpreted to indicate at least 2 days of drug abstinence.

Outcomes over the treatment period were measured in several ways: (1) Total abstinence from methamphetamine was assessed by the mean number of metabolite-free urine samples provided; (2) continuous abstinence was measured as the longest period of uninterrupted abstinence as measured using urine samples (number of tests); (3) the ability to initiate abstinence from methamphetamine was defined as the mean number of tests that occurred in each condition prior to producing the first methamphetamine-negative test result; (4) the ability to protect against relapse following a period of abstinence was assessed by counting the number of participants who relapsed following a 4-week period of abstinence, which, in our opinion, is a clinically significant period

of abstinence. We first assessed the proportion of individuals obtaining at least 4 weeks of continuous abstinence. For individuals able to achieve this criterion, we then measured the number of individuals who relapsed to methamphetamine use after reaching the abstinence criterion (see Roll & Higgins, 2000). Total amount of vouchers earned and attendance at weekly appointments were also analyzed.

Table 1

Week	Monday	Wednesday	Friday	Bonus
1	$25.00	$25.00	$25.00	$50.00
2	$25.00	$25.00	$25.00	$50.00
3	$25.00	$25.00	$25.00	$50.00
4	$25.00	$25.00	$25.00	$50.00
5	$25.00	$25.00	$25.00	$50.00
6	$25.00	$25.00	$25.00	$50.00
7	$25.00	$25.00	$25.00	$50.00
8	$25.00	$25.00	$25.00	$50.00
9	$0.00	$0.00	$0.00	$0.00
10	$0.00	$0.00	$0.00	$0.00
11	$0.00	$0.00	$0.00	$0.00
12	$0.00	$0.00	$0.00	$0.00

Schedule 1. Each instance of abstinence during the first 8 weeks resulted in the delivery of a $25.00 voucher. Additionally, the provision of three consecutive methamphetamine negative urine tests resulted in the delivery of a $50.00 voucher. There were no reset contingencies. The total amount of reinforcement possible from this schedule was $1,000.00.

Table 2

Week	Monday	Wednesday	Friday	Bonus
1	$14.00	$15.00	$16.00	$50.00
2	$17.00	$18.00	$19.00	$50.00
3	$20.00	$21.00	$22.00	$50.00
4	$23.00	$24.00	$25.00	$50.00
5	$26.00	$27.00	$28.00	$50.00
6	$29.00	$30.00	$31.00	$50.00
7	$0.00	$0.00	$0.00	$50.00
8	$0.00	$0.00	$0.00	$50.00
9	$0.00	$0.00	$0.00	$50.00
10	$0.00	$0.00	$0.00	$50.00
11	$0.00	$0.00	$0.00	$50.00
12	$0.00	$0.00	$0.00	$50.00

Schedule 2. Each instance of abstinence during the first 6 weeks resulted in the delivery of a voucher that increased in value by $1.00 for consecutive instances of abstinence. Additionally, during the entire 12-week period, the provision of three consecutive methamphetamine negative urine tests resulted in the delivery of a $50.00 voucher. There were no reset contingencies. The total amount of reinforcement possible from this schedule was $1,005.00.

Table 3

Week	Monday	Wednesday	Friday	Bonus
1	$10.00	$11.00	$12.00	$0.00
2	$13.00	$14.00	$15.00	$0.00
3	$16.00	$17.00	$18.00	$0.00
4	$19.00	$20.00	$21.00	$0.00
5	$22.00	$23.00	$24.00	$0.00
6	$25.00	$26.00	$27.00	$0.00
7	$28.00	$29.00	$30.00	$0.00
8	$31.00	$32.00	$33.00	$0.00
9	$34.00	$35.00	$36.00	$0.00
10	$37.00	$38.00	$39.00	$0.00
11	$40.00	$41.00	$42.00	$0.00
12	$43.00	$44.00	$45.00	$0.00

Schedule 3. Each instance of abstinence during the 12-week period resulted in the delivery of a voucher, the value of which escalated by $1.00 for consecutive abstinences. There were no bonuses or reset contingencies. The total amount of reinforcement possible from this schedule was $990.00.

Table 4

Week	Monday	Wednesday	Friday	Bonus
1	$75.00	$70.00	$65.00	$20.00
2	$60.00	$55.00	$50.00	$20.00
3	$45.00	$40.00	$35.00	$20.00
4	$10.00	$10.00	$10.00	$20.00
5	$10.00	$10.00	$10.00	$20.00
6	$10.00	$10.00	$10.00	$20.00
7	$10.00	$10.00	$10.00	$20.00
8	$10.00	$10.00	$10.00	$20.00
9	$10.00	$10.00	$10.00	$20.00
10	$10.00	$10.00	$10.00	$20.00
11	$10.00	$10.00	$10.00	$20.00
12	$10.00	$10.00	$10.00	$20.00

Schedule 4. The magnitude of reinforcement started high and decreased by $5.00 for the first 3 weeks for each consecutive instance of abstinence. Following that all remaining abstinences earned vouchers worth $10.00. Throughout the entire 12-week period three consecutive instances of abstinence resulted in the delivery of a $20.00 bonus. There were no reset contingencies. The total amount of reinforcement available was $1,005.00.

The main effect of schedules for producing differences in abstinence outcomes was tested using analysis of variance. When main effects were detected, post hoc analyses were conducted to identify differences between schedules using Tukey-Kramer tests. All tests were conducted using an alpha level of $p < 0.05$, two-tailed.

Table 5

Week	Monday	Wednesday	Friday	Bonus
1	$2.50	$3.75	$5.00	$10.00
2	$6.25	$7.50	$8.75	$10.00
3	$10.00	$11.25	$12.50	$10.00
4	$13.75	$15.00	$16.25	$10.00
5	$17.50	$18.75	$20.00	$10.00
6	$21.25	$22.50	$23.75	$10.00
7	$25.00	$26.25	$27.50	$10.00
8	$28.75	$30.00	$31.25	$10.00
9	$32.50	$33.75	$35.00	$10.00
10	$36.25	$37.50	$38.75	$10.00
11	$40.00	$41.25	$42.50	$10.00
12	$43.75	$45.00	$46.25	$10.00

Schedule 5. This schedule was based on that developed by Higgins and colleagues (e.g., Higgins, Budney, et al., 1994). During the 12-week period each instance of abstinence resulted in the delivery of a reinforcer, which increased for consecutive abstinences by $1.25. Additionally, each block of three consecutive abstinences resulted in the delivery of a $10.00 bonus. Finally, failure to abstain resulted in a rest in voucher value to the initial value from whence the escalation could begin again. The total amount of reinforcement available from this schedule was $997.50.

Results

Participants were 50 males and 33 females seeking treatment for methamphetamine use disorders. The mean age was 31.4 (*SEM* 0.8) years. Fifty-two (62.7%) were Caucasian, 25 (30.1%) were Hispanic, 2 were African American, 2 (2.4%) were American Indian, and 2 (2.4%) were Pacific Islander. Thirty-seven (44.8%) were employed full time and the rest (55.2%) were not. Nineteen (22.9%) were married, 23 (27.7%) were separated or divorced, and the remainder was never married. None of these demographics significantly differed among the participants assigned to the five schedules.

All five reinforcement schedules engendered considerable abstinence. One-way analysis of variance (ANOVA) suggests that there was no statistically significant difference between the groups in either mean total number of abstinences during treatment nor in terms of the mean longest period of continuous abstinence, $F(4, 78) = 0.4696$, $p > 0.05$; $F(4, 78) = 0.7551$, $p > 0.05$ respectively, (see Figures 1 and 2). It should be noted that we calculated both of these variables for a 12- week period, even though Schedule 1 was in effect for only 8 weeks. Although this may underestimate Schedule 1's utility in producing abstinence we believe this analysis decision is correct because we are most interested in comparing the clinician-generated schedules to Schedule 5, which was in effect for 12 weeks. Participants in the different schedule conditions (1-5) earned on average: $589.06, $476.08, $451.41, $614.17, and $402.09 respectively. These differences were not statistically significant, $F(4, 78) = 1.007$, $p > 0.05$.

One-way ANOVA indicated that there were significant between-group differences, $F(4, 78) = 4.590$, $p < 0.05$, in the relative efficacy of the

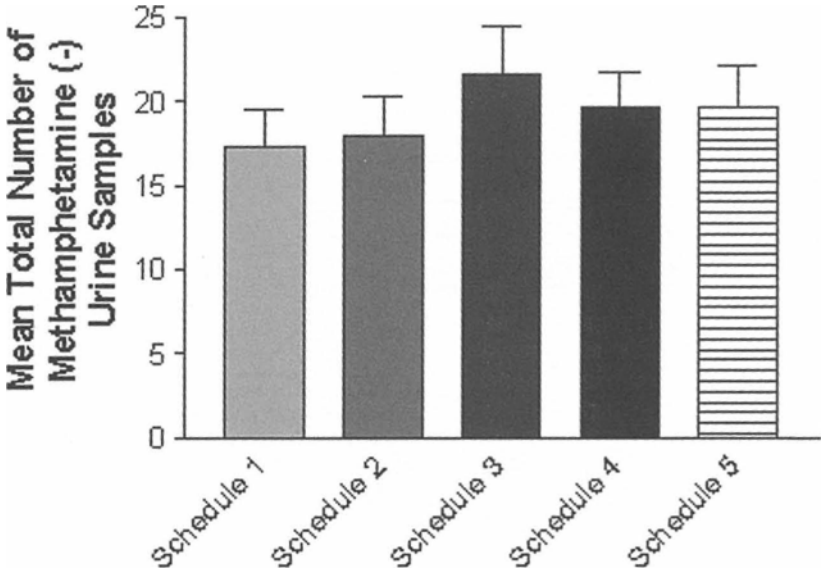

Figure 1. Number of urine tests indicating no recent methamphetamine use (± *SEM*) during the intervention period. Missed tests were counted as positive.

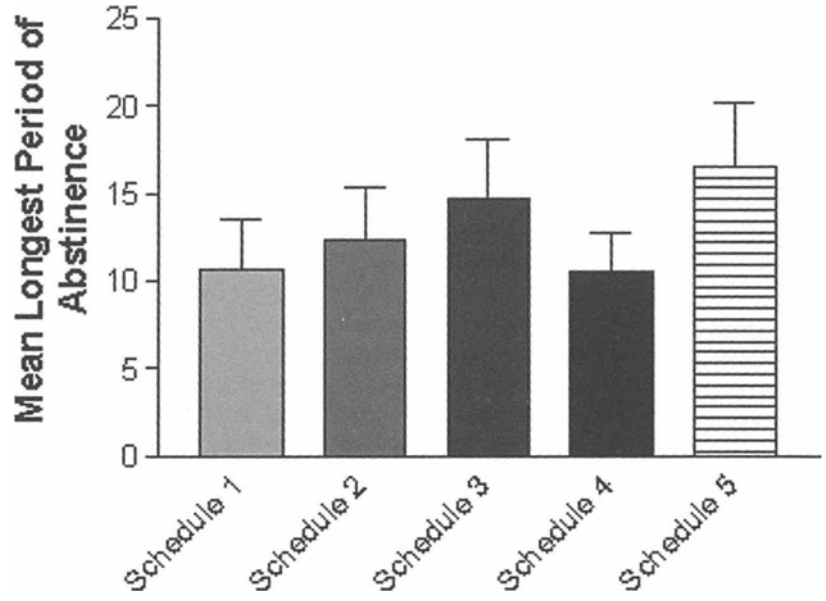

Figure 2. Mean consecutive number of methamphetamine negative urine tests (± *SEM*). Testing was conducted three times per week. Missed tests were counted as positive.

schedules for initiating abstinence. Tukey-Kramer multiple comparison tests revealed the significant differences were between Schedule 5 and Schedules 1 and 3, with Schedule 5 initiating abstinence quicker than the other two ($q = 4.492$; $q = 5.241$, respectively). None of the other between-group differences was significant (see Figure 3).

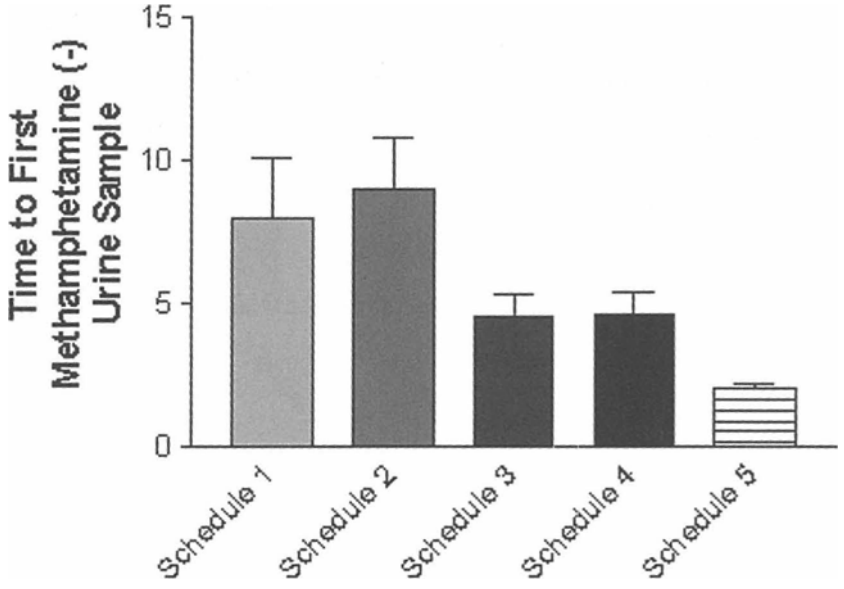

Figure 3. Mean number of urine tests produced prior to producing a urine test that indicated no recent methamphetamine use (± *SEM*)

Analyses showed that approximately half as many individuals in the group receiving reinforcement according to Schedule 1 obtained a 4-week period of abstinence relative to the other four reinforcement schedules (see Figure 4). We therefore excluded those individuals in the Schedule 1 condition from the next analysis which assessed the likelihood of relapse to drug use following 4 weeks of abstinence. This analysis revealed Schedule 5 to be superior in protecting against relapse with those individuals receiving reinforcement according to Schedule 5 being less likely to relapse after 4 weeks of abstinence (Chi-square = 8.084 (3), $p < .05$) (see Figure 5).

In order to assess the degree to which each schedule influenced attendance, we compared attendance at weekly sessions across the five schedules with a one-way ANOVA. Results revealed a significant effect, $F(4, 78) = 3.846$, $p < 0.05$, such that Schedules 5 and 3 promoted greater amounts than were promoted by Schedule 1 (Tukey-Kramer, $q = 4.264$, $q = 4.478$). None of the other comparisons were significant.

It should be noted that we included the 8-week schedule (#1) in our analysis with the other 12-week schedules. We did this because the standard time frame (e.g., Schedule 5) is 12 weeks and our primary

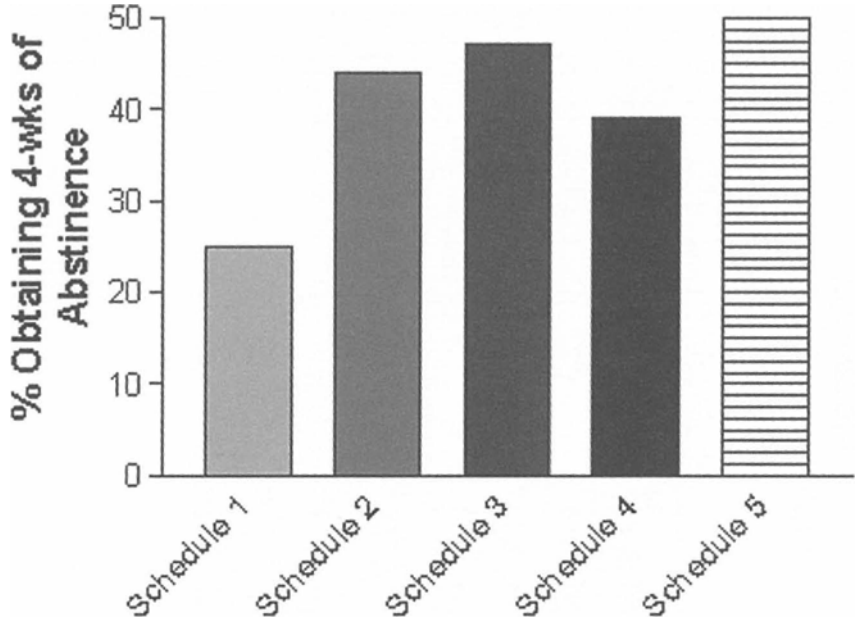

Figure 4. The percentage of participants in each condition obtaining at least 4 weeks of consecutive abstinence during the intervention phase.

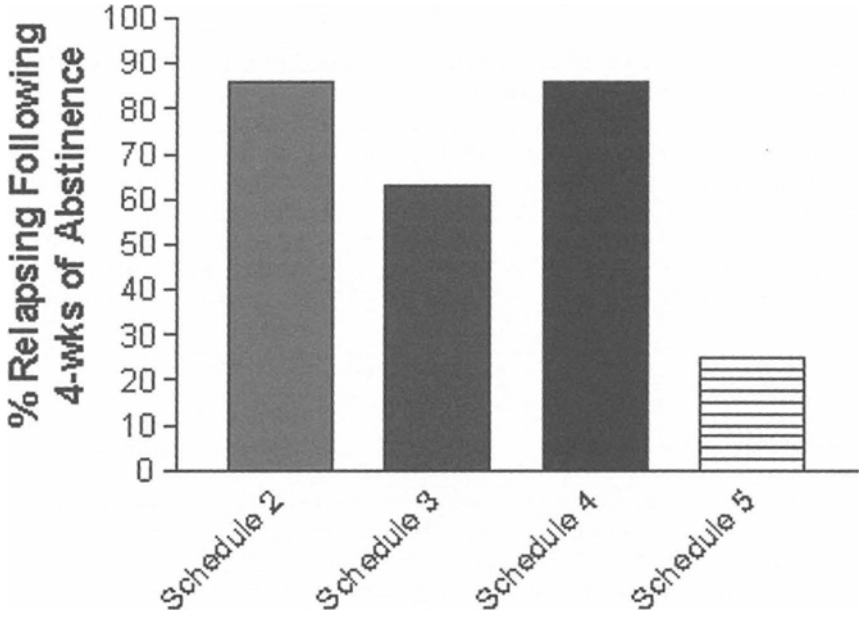

Figure 5. The percentage of participants relapsing following a 4-week period of abstinence. Since few individuals in the Schedule 1 condition obtained 4 weeks of abstinence (see Figure 4) they were excluded from this analysis.

interest was in comparing Schedules 1-4 with Schedule 5. We believe this is the best strategy for accomplishing the purposes of this study.

Discussion

Several aspects of these results merit discussion. First, it appears that the schedule developed by Higgins and colleagues (Schedule 5) is generally superior to those to which we compared it in terms of initiating abstinence and preventing relapse when delivered in the context of thrice weekly drug abuse counseling groups. Schedule 5 initiated abstinence in a shorter time than Schedules 1 or 2 and performed equally to Schedules 3 and 4 in this regard. In terms of maintenance of abstinence, there were no significant differences between the different schedules although Schedule 5 engendered slightly longer continuous periods of abstinence than any of the other schedules. Schedule 5 did, however, outperform the others in terms of its utility in protecting against relapse, suggesting that it is superior in producing continuous abstinence.

One limitation of these findings is that the strategy employed in this project does not facilitate an examination of the different components of the schedules. For instance Roll and colleagues (e.g., Roll & Higgins, 2000; Roll et al., 1996) previously examined the relative contributions of reinforcer escalation and reset contingencies in initiating and maintaining abstinence. This was accomplished by comparing schedules that were systematically varied in order to isolate the relative contributions of specific components of the schedules. In many ways, this strategy is to be preferred from a scientific point of view to that employed in the present investigation.

Although this study was not designed to isolate schedule components, or to assess their relative contributions to the initiation and maintenance of abstinence, it does permit some comments on the topic. With regards to the initiation of abstinence, it suggests that high magnitude reinforcers are effective at promoting abstinence (Schedule 4) as are escalating reinforcement magnitudes (Schedules 3 & 5). The results suggest that, relative to escalating reinforcer magnitudes or high initial rates of reinforcement, flat rates of reinforcement (Schedule 1) are not particularly effective in initiating abstinence. The results from Schedule 2 in which large bonuses were made available for blocks of abstinence partially replicate those of Silverman and colleagues (Silverman et al., 1996) who reported that large bonuses early in treatment were counterproductive. The reasons underlying this are not clear and the present data do not provide any obvious explanation.

With regards to the maintenance of abstinence the present results suggest that schedules which combine escalating reinforcer magnitude with reset contingencies (Schedule 5) are more likely to protect against relapse following a period of abstinence than any of the other scheduling arrangements investigated. This supports earlier work demonstrating the importance of combining escalating reinforcer magnitude and a reset contingency (Roll & Higgins, 2000; Roll et al., 1996).

With regards to attendance, Schedules 3 and 5 produced greater attendance than did Schedule 1; however, all of the contingency management procedures produced fairly good rates of attendance suggesting that the procedures were acceptable to participants as evidenced by their voluntary attendance.

Although the present study was designed to compare different scheduling arrangements, and not to directly assess the impact of contingency management on the treatment of methamphetamine abuse, the results do merit comment in this context. Recently Roll and collegues (Roll et al., submitted) demonstrated in a randomized clinical trial that contngency management was effective in treating methamphetamine use disorders. The results from the present study further support the use of contingency management as a component of treatment strategies for methamphetamine use disorders.

The results of this present study demonstrate the exquisite sensitivity of human behavior to reinforcement schedules. All five schedules delivered vouchers contingent on providing methamphetamine negative urine specimens and all five provided approximately the same magnitude of reinforcement. The only difference was the manner in which the reinforcers were scheduled, yet statistically significant differences were observed between the schedules in terms of their ability to both initiate and maintain abstinence. Based on available data it appears that using the escalating schedule of reinforcement with a reset contingency for use developed by Higgins (Higgins, Budney, et al., 1994) provides the best chance for a successful substance abuse treatment episode. Future research attempting to isolate schedule components to assess their contribution to abstinence and combining schedule components in new ways is sorely needed.

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