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Contingency Management Voucher Redemption as an Indicator of Delayed Gratification

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Abstract

This prospective analysis tested whether frequency of voucher redemptions during a contingency management (CM) substance use intervention was significantly associated with participants' ongoing substance use. Homeless, substance-dependent men who have sex with men ($N=131$) were randomized into either a "full" or "lite" voucher-based CM intervention. All participants earned vouchers for attendance and participation; participants in the CM-full condition also received vouchers for substance abstinence and enactment of prosocial and/or health-promoting behaviors. Multivariate longitudinal negative binomial regression analyses ($n = 118$) assessed the association between substance use during the intervention and frequency of voucher redemptions. Participants who used methamphetamine (IRR = 0.66; 95% CI=0.44–0.99) and/or opiates (IRR=0.60; 95% CI=0.40–0.99) during the intervention exhibited less time between voucher redemptions than individuals who achieved abstinence from these substances. Voucher redemption logs can be cost-effective and unobtrusive tools for measuring study participants' tendency to delay gratification.

Keywords

delayed gratification; contingency management; men who have sex with men; methamphetamine; opiates

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1. Introduction

1.1 Substance Dependence and Delayed Gratification

A central feature of substance dependence is the tendency to disproportionately discount the value of delayed rewards in favor of immediate gratification (Bickel & Marsch, 2001; Businelle, McVay, Kendzor, & Copeland, 2010; Crean, de Wit, & Richards, 2000; Higgins, Heil, & Lussier, 2004). Such excessive “delay discounting” leads to an overvaluation of the proximal rewards of substance use and a corresponding undervaluation of the long-term benefits associated with sobriety (MacKillop et al., 2011). This preference for immediate gratification in favor of potentially more valuable distal rewards is a critical mechanism in addiction (Goldstein & Volkow, 2002; Kalivas & Volkow, 2005; Perry & Carroll, 2008), and may be an important factor in relapse after achieved substance abstinence (Doran, Spring, McChargue, Pergadia, & Richmond, 2004; Moeller et al., 2001). Such decreased tendency to delay gratification has been observed among those diagnosed with dependence on alcohol (Bobova, Finn, Rickert, & Lucas, 2009; Dom, D’haene, Hulstijn, & Sabbe, 2006), cocaine (Coffey, Gudleski, Saladin, & Brady, 2003; Heil, Johnson, Higgins, & Bickel, 2006), methamphetamine (Hoffman et al., 2006; Hoffman et al., 2008; Monterosso et al., 2007), and/or opiates (Kirby, Petry, & Bickel, 1999; Madden, Petry, Badger, & Bickel, 1997), among others (Bickel & Marsch, 2001; Bickel et al., 2007; MacKillop et al., 2011; Madden & Bickel, 2009).

Evidence is still inconclusive as to whether overvaluation of immediate reward is a risk factor for (i.e., precedes) or a consequence of (i.e., succeeds) such substance abuse. Some research suggests that increased delay discounting is part of the etiology of substance use disorders (Audrain-McGovern et al., 2009; Verdejo-García, Lawrence, & Clark, 2008); other studies have provided evidence that increased delay discounting can result from substance abuse (Petry, 2001; Perry & Carroll, 2008). Given such dual corroboration, it may be that preference for immediate gratification influences addiction at both stages of the process: overvaluation of immediate reward may increase the likelihood of substance abuse, and substance abuse in turn may make subsequent delay of gratification more difficult and/or unlikely to achieve (Bickel, Jarmolowicz, Mueller, Koffarnus, & Gatchalian, 2012; MacKillop et al., 2011; Perry & Carroll, 2008; Mitchell, 2004).

Though controlled, experimental assessment of individuals’ preference for immediate vs. delayed reward is of clear benefit to addiction research, a common critique of existing delay discounting measures (e.g., Green & Myerson, 2004; MacKillop et al., 2011; Mazur, 1987; Mitchell, Fields, D’Esposito, & Boettiger, 2005; Myerson, Green, & Warusawitharana, 2001) is their reliance upon contrived economic decisions as the source of their data (Kirby, 1997; Bickel & Marsch, 2001; Frederick, Loewenstein, & O’Donoghue, 2002; Madden, Begotka, Raiff, & Kastern, 2003). Though years of robust findings certainly corroborate the value and usefulness of such measures, it is also true that observation of real-life economic decisions might be a preferable source of data, insofar as they reflect actual choices made by participants and not artificial choices conceived of by experimental researchers. In pursuit of such an ecologically valid measure, we suggest that voucher redemption logs that are standard in contingency management (CM) substance use interventions may serve as useful

and unobtrusive measures of the tendency to delay gratification among individuals with a substance use disorder.

1.2 Voucher-based Contingency Management

Voucher-based CM interventions (Higgins et al., 1994; Higgins et al., 1993) rely on the principle of operant condition (Skinner, 1953) to promote substance abstinence in participants, with rewards coming in the form of vouchers redeemable for valued goods. The value and desirability of these goods are pitted against the reinforcing nature of drug use, thereby substituting immediate rewards for abstinence (i.e., vouchers) in place of the immediate rewards associated with substance use (e.g., euphoria). Voucher-based CM has been efficacious in the treatment of a wide range of substance abuse and dependence disorders (Lussier, Heil, Mongeon, Badger, & Higgins, 2006; Peirce et al., 2006; Prendergast, Podus, Finney, Greenwell, & Roll, 2006; Reback et al., 2010).

In most cases, participants enrolled in a CM intervention can redeem the vouchers they earn at any rate they choose, meaning they can choose to spend them immediately on smaller items (e.g., bag of chips, a soda), or they can save up over the course of the intervention for more impactful rewards (e.g., a cell phone, a bicycle). Many CM interventions keep logs of these voucher redemptions (Higgins, Silverman, and Heil, 2007), including what was bought, when, and by whom. Furthermore, nearly all CM-based substance use interventions also routinely collect biomarker data to confirm participant abstinence during the course of the intervention (Stitzer & Petry, 2006). In combination, these two data sources supply a longitudinal view of participant substance use and economic decision-making, and can therefore serve to corroborate or reject the hypothesis that substance use leads to increased preference for immediate gratification. This research agenda is further supported by two recent studies on the voucher spending and substance use patterns of CM participants.

First, Bickel and colleagues (Bickel et al., 2010) showed that observed rates of voucher redemption during a CM substance abuse intervention were positively correlated with experimentally assessed rates of delay discounting. This finding corroborates the logical assertion that real-life economic behavior should exhibit concurrent validity with established experimental methods, and serves as a “proof of concept” that CM voucher logs can be used to assess participants’ tendency to discount the value of delayed rewards.

Second, Ling-Murtaugh and colleagues revealed a significant positive association between rates of CM voucher redemption and biomarker-confirmed substance abstinence (Ling-Murtaugh, Krishnamurti, Davis, Reback, Shoptaw 2013), corroborating the existence of an empirical link between substance use and real-life decision making. Results showed that treatment-seeking, substance-dependent gay and bisexual men were more likely to submit clean urine samples if they redeemed their CM vouchers with greater frequency, a result the authors ascribed to the “substitutability” of the rewards offered through voucher redemption. This proposed causal sequence (i.e., economic decision-making influences substance use) is a reversal of the logic most commonly expressed in the literature (i.e., that substance use influences economic decision-making), and contradicts the expected finding that drug-using participants would spend their vouchers more impulsively (i.e., at a higher rate) than

substance-abstinent participants. Given the unexpected nature and direction of the findings, further research is indicated.

Both of these innovative recent studies (Bickel et al. 2010; Ling-Murtaugh et al. 2013) reveal the importance of CM voucher redemption logs as valuable sources of data, and in combination have inspired the research question and analytical design of the current study. This prospective analysis of a randomized controlled trial tested whether the frequency of participants' voucher redemptions during a CM intervention was associated with ongoing substance use. It was hypothesized that ongoing substance use during the CM intervention would be associated with reduced time between participants' voucher redemptions.

2. Materials and methods

2.1 Participants

Study procedures, intervention design, and primary outcomes have been previously described (Reback et al., 2010). Eligible participants were recruited from a community-based, low-intensity, health education/risk reduction HIV prevention program serving homeless, substance-using MSM in the Hollywood/West Hollywood area of Los Angeles County. Eligibility criteria for the study included being male, over 18 years of age, dependent on at least one substance (SCID-verified), non-treatment-seeking, self-reported sex with a male in the previous 12 months, and current homelessness.

2.2 Procedures

Participants provided informed consent and were randomized into either the CM-full (n = 64) or CM-lite (n = 67) condition for a 24-week intervention, with follow-up evaluations at 7-, 9-, and 12-months post randomization. Participants in both conditions received CM vouchers for program attendance and participation (max = \$364.00). Participants in the CM-full condition also received vouchers for engaging in verified drug/alcohol abstinence and targeted prosocial and health-promoting behaviors; there was no limit to the number of vouchers a participant in the CM-full condition could earn for verified prosocial/health-promoting behaviors (for full CM payout schedules and procedures, see: Reback et al., 2010). Each point earned was equivalent to \$1 in purchasing power. Voucher points earned during the 24-week intervention were redeemable at an onsite store that participants could access at any time during normal business hours (10:00 am to 6:30 pm, Monday through Friday). No restrictions were placed on how many earned voucher points a participant could redeem at one time. To maximize the reinforcing potential of the intervention, the store was stocked with participants' preferred products (as determined by biannual focus groups) and priced with items for all earning levels (valued from 1-200 points). Participants' points expired one week following their final 12-month follow-up evaluation. All procedures followed were reviewed and approved by the Friends Research Institute's Institutional Review Board.

2.3 Measures

2.3.1 Cross-sectional Measures

2.3.1.1 Substance dependence: The Structured Clinical Interview for DSM-IV (SCID-II; First, Spitzer, Gibbon, & Williams, 1996) was administered at baseline to determine substance dependence (an eligibility criterion).

2.3.1.2 Sociodemographics: The Addiction Severity Index (McLellan et al., 1985) includes measures of basic sociodemographic characteristics (i.e., race/ethnicity, age, HIV status, etc.) and was administered at baseline.

2.3.1.3 Baseline Delay Discounting: Delay-discounting at baseline was assessed using the indifference point hyperbolic model described by Mazur (1997). The resultant measure (k) is an empirically derived constant proportional to the degree of discounting of hypothetical monetary rewards exhibited by the participant at baseline, with larger values of k representing greater rates of discounting (i.e., greater tendency towards immediate gratification). Each participant's baseline rate of delay discounting was included in the model for the purpose of statistical control, thereby accounting for some of the individual differences in tendency towards immediate gratification at intervention start. All procedures and instructions in the calculation of k were adopted from previous work (Mazur, 1987), and are discussed in more detail elsewhere (Dierst-Davies et al., 2010).

2.3.2 Longitudinal measures

2.3.2.1 Substance Use: Urine drug screens using a 6-panel FDA-approved urine test cup (Accutest - JANT Pharmacal, Inc.) and an alcohol breathalyzer were both administered twice a week (two nonconsecutive days) at all study visits. Urine was screened for amphetamines, methamphetamine, cocaine, PCP, THC and opioid metabolites; breathalyzer tested for blood alcohol level ≥ 0.05 . Biomarker-confirmed use of each substance was operationalized dichotomously (i.e., 0 = abstinence; 1 = use) for each study visit, making use of or abstinence from each substance a longitudinally assessed, repeated measures variable.

2.3.2.2 Contingency Management Vouchers: The primary outcome of interest for this secondary analysis was time between participants' CM voucher redemptions. A voucher redemption occurred any time a participant turned in earned voucher points for goods at the onsite store. Time between such redemptions was measured in calendar days, implying that all redemptions occurring on the same calendar day were not differentiated. Days between redemptions were only counted when a participant had voucher points to spend; days when a participant did not have points were not counted. The resultant outcome was a longitudinally assessed, repeated measures variable counting the number of days between each episode of voucher redemption. To avoid the confounding effects introduced by differential earning ability across treatment conditions (i.e., CM-full participants could earn more than CM-lite participants) and across individuals (i.e., some participants earned more and thus had more vouchers to spend), each participant's treatment condition and total voucher points earned over the course of the entire intervention were applied as statistical controls.

2.4 Statistical analyses

This study utilized a two-group randomized and controlled experimental design with repeated measures. To test the association between substance use and time between voucher redemptions, a jackknifed random-effects negative binomial regression for longitudinal data analysis was carried out. Examination of the goodness of fit indices during diagnostic stages of data analysis revealed the negative binomial distribution to be a significantly better fit to the distributional properties of the data than the Poisson, zero-inflated Poisson, or zero-inflated negative binomial distributions (all $p < 0.001$). Sensitivity tests carried out in the early stages of data analysis also revealed significant influence from outliers; to counteract this influence, standard errors were estimated using the jackknife procedure (Efron, 1981), in which the full analysis is rerun n times, with n being equal to the total number of participants in the analytical sample (in this instance, $n = 118$). During each iteration of the analysis, one participant is removed from the analytical sample, thereby allowing for results to be re-estimated absent the influence of that individual. Final standard error estimates are then aggregated across all such iterations, making them robust against the influence of outliers. One iteration of the jackknife procedure failed to converge, leaving a final analytical sample of 117 unique runs. Participant sociodemographics (age, race/ethnicity, educational attainment, and HIV status), condition assignment, total voucher points earned, and baseline delay discounting were included in the negative binomial analysis for the purpose of statistical control. Results of these multivariate analyses are presented as incidence rate ratios (IRR), and express the estimated factor change in the incidence rate of the outcome variable (in this case, days between voucher redemptions) for each unit increase of the independent variable. All analyses were carried out using Stata v13 SE (StataCorp).

2.4.1 Missing data—Breathalyzer and urinalysis data was tested for missing data patterns using generalized estimation equations (Zeger & Liang, 1986). As breathalyzer and urinalysis data was gathered at each scheduled study visit, these two variables should be most sensitive to missing data patterns. Analyses revealed no significant differences in missing data between the CM-full and CM-lite conditions, implying that the data is at least “missing at random,” and is thus appropriate for inferential analysis. Further missing data relevant specifically to this prospective analysis includes seven participants that never earned and/or spent any vouchers during the course of the study (and were thus omitted from the analysis), four subjects that are missing baseline delay discounting data, and two subjects whose baseline delay discounting data were orders of magnitude divergent (i.e., more severe) from the remainder of the sample, and were determined to be too divergent for inclusion in the final analysis. Of these 13 participants excluded from the analysis, six had been randomized into the CM-full condition and seven had been randomized into the CM-lite condition. Missing data were not imputed.

3. Results

Participant median age was 37 (interquartile range = 29-43). Slightly more than half of all participants identified as Caucasian/white (53%), while a sizeable minority of participants reported less than a high school education (20%) and/or being HIV-positive (28%). All participants were diagnosed as currently dependent on at least one substance (an eligibility

criterion); most participants were diagnosed as having been dependent on amphetamine/methamphetamines (72%), alcohol (62%), and/or cocaine (55%) at some point in their lifetime. The natural log of the mean rate of delay discounting (i.e., $\log[\bar{x}_k]$) exhibited by participants at baseline was 0.72 (standard deviation [SD] = 4.58). Participants earned an average of \$437.25 (SD = \$475.91) vouchers during the course of the intervention, and redeemed an average of \$418.00 vouchers (SD = \$481.00). Participants' average delay between earning and redeeming their vouchers was 13.24 days (SD = 34.37).

Jackknifed longitudinal random-intercept negative binomial regression analysis revealed that biomarker-confirmed methamphetamine (IRR = 0.66; 95% confidence interval [CI] = 0.44 – 0.99) and/or opiate (IRR = 0.60; 95% CI = 0.40 – 0.99) use during the course of the intervention were associated with significant decreases in the number of days between voucher redemptions. The coefficient estimate on marijuana use was also trending towards significance (IRR = 0.82; $p = 0.07$). None of the included statistical controls produced coefficient estimates significant at $\alpha = 0.05$ in the full model.

4. Discussion

Participants earned an average of \$437.25 in vouchers over the course of the intervention; demonstrating robust engagement in the study's voucher earning mechanism. Correspondingly, participants spent an average of \$418.00 in vouchers, revealing the suitability and acceptability of the goods available through the redemption process. Though participants could redeem their vouchers on any weekday during normal business hours, average time between voucher redemptions was nearly two weeks; this implies participants were aware of their ability to save vouchers for later redemption and did not feel compelled to redeem them immediately upon acquisition.

Jackknifed multivariate longitudinal analysis revealed that ongoing methamphetamine and/or opiate use during the course of the 24-week intervention was associated with significantly reduced time between participant voucher redemptions. Though the coefficient estimate failed to reach significance, the predicted association of ongoing marijuana use with redemption delays was also negative and trending towards significance. Use of methamphetamine and/or opiates have both been associated with increased preference for more immediate rewards in prior studies (MacKillop et al., 2011).

Importantly, associations between ongoing use of methamphetamine and/or opiates increased the tendency for immediate gratification even after controlling for participants' baseline level of delay discounting (as measured by the indifference point measure, k). Thus, though the frequency of real-life voucher redemptions during a CM intervention may share a moderate statistical association with rates of experimental delay discounting (Bickel et al., 2010), the two are not synonymous. Our results demonstrate that voucher redemption rates constitute a unique and significant measure of individuals' economic decision-making and tendency to delay gratification.

Our findings contribute to the growing body of evidence that use of certain substances can exacerbate the preference for immediate gratification, perhaps due to changes in brain

structure and function resultant from such substance use (Verdejo-García, López-Torrecillas, Giménez, & Pérez-García, 2004). Though our data cannot address biological and neurological mechanisms, our results provide empirical support for further behavioral and biomedical study of the effects of ongoing substance use on the processes of economic decision-making. When our results are combined with the established finding that impulsivity and disproportionate delay discounting can be risk factors for substance abuse (e.g., Verdejo-García et al., 2008), it seems increasingly likely that preference for immediate gratification plays a dual role in the process of addiction: not only does it increase the likelihood of initiation into substance use, but substance use in turn exacerbates preference for immediate (vs. delayed) reward.

4.1 Conclusions and Limitations

This study was limited by its relatively small sample size and its reliance upon a highly specialized population (i.e., homeless, substance-dependent, non-treatment seeking men who have sex with men). It is unknown whether results presented here are generalizable to other (e.g., less impacted, treatment seeking) populations. For example, recall that among treatment-seeking, substance-dependent gay and bisexual men, those participants who redeemed their CM vouchers more frequently were more likely to submit clean urine samples (Ling-Murtaugh et al., 2013). Such a result contrasts with the findings presented here and may be due to the aforementioned study participants' status as treatment-seekers. Treatment-seeking individuals (especially those who respond well) may exhibit a greater tendency or desire for ongoing, persistent engagement with such interventions relative to non-treatment seekers. This could manifest as more frequent engagement in the voucher redemption process, especially for those experiencing the most success in the treatment process. Future studies should attempt to clarify the association between ongoing substance use and rates of voucher redemption, especially across treatment-seeking and non-treatment-seeking samples.

To date, this study is the first to demonstrate a direct association between ongoing drug use and increased delay discounting of real-world rewards. Additionally, these findings reveal a potentially unrecognized benefit of drug abstinence achieved during substance use interventions: reductions in preference for immediate over delayed gratification. Given the growing evidence that preference for immediate rewards plays an important role in both initiation of, and relapse into, substance abuse, any evidence suggesting that such preferences can be mitigated or overcome is encouraging and warrants close attention. Future studies should attempt to replicate the associations reported here as well as isolate the underlying mechanism(s) of action. If the pattern of results presented here can be reliably replicated, researchers or service providers conducting CM interventions may look to monitor the voucher redemption habits of participants, and may even offer counseling or additional support for those participants who exhibit difficulty saving vouchers for more impactful rewards. CM voucher redemption logs represent a cost-effective and unobtrusive method of assessing the tendency of those with a substance abuse disorder to delay gratification of real-world rewards.

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Table 1

Participant sociodemographics, substance dependence, baseline delay discounting, and contingency management voucher earning/redemption (N = 131)

Characteristic	Median [Interquartile Range], N { % }, or Mean (SD)
Age	37 [29-43]
Race	
Caucasian/white	70 {53.4%}
African American/black	30 {22.9%}
Multiracial/other race	31 {23.7%}
Educational Attainment	
Less than high school	26 {19.8%}
High school or greater	105 {80.2%}
HIV Status	
HIV-positive	37 {28.3%}
Substance Dependence (Lifetime)	
Amphetamine/Methamphetamine	94 {71.8%}
Alcohol	81 {61.8%}
Cocaine	72 {55.0%}
Marijuana	53 {40.5%}
Opiates	26 {19.9%}
Baseline Delay Discounting Rate ^a	
<i>k</i>	2.1 (4.6)
Contingency Management Vouchers (1 voucher = \$1)	
Vouchers Earned	437.3 (475.9)
Vouchers Redeemed ^b	418.3 (481.0)
Days between Voucher Redemptions ^b	13.2 (34.0)

^a
n = 125

^b
n = 124

Table 2

Jackknifed longitudinal random-intercept negative binomial analysis—days between voucher redemptions regressed onto substance use during the intervention, (n = 118)^a

Substance Use (biomarker-confirmed)	IRR ^b	95% CI ^c	Sig.
Amphetamine(s)	1.43	0.91-2.23	p= 0.12
Methamphetamine	0.66	0.44-0.99	p= 0.05
Alcohol	1.04	0.73-1.48	p= 0.81
Cocaine	0.84	0.64-1.12	p= 0.23
Marijuana	0.82	0.66-1.02	p= 0.07
Opiate(s)	0.60	0.40-0.99	p= 0.05

^aStatistical controls: age, race, educational attainment, HIV status, delay discounting (i.e., k) at baseline, treatment condition, total vouchers earned

^bIRR: Incidence Rate Ratio

^cCI = Confidence Interval