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Decision-Making Tendencies and Voucher Spending Independently Support Abstinence Within Contingency Management for Methamphetamine Use Disorder

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Abstract

Decision-making tendencies and spending within cash voucher-based interventions have individually been shown to be related to future abstinence among participants with methamphetamine use disorder (MUD), but less is known of their independent contributions. This study of participants in a contingency management (CM) trial investigated whether decision-making and spending were each associated with future abstinence. Thirty-two outpatients with MUD, predominately male (68%) and mixed ancestry (94%) with a median age of 34 years, participated in an 8-week cash voucher-based CM pilot trial. Prior to commencing the trial, participants completed a computerized Iowa Gambling Task (IGT) to measure decision-making

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The authors declare no competing interests.

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preferences for more *frequent* rewards and longer term gains of greater *magnitude*. Spending and abstinence of participants were tracked over the duration of the trial. In a secondary analysis, time-lagged counting process Cox Proportional Hazard models were conducted. Baseline decision-making, characterized by a preference for *frequent* rewards, was associated with a greater likelihood of future spending, Hazard Ratio; HR = 1.13 [1.06: 1.21]. Avoidance of short-term rewards to realize longer term, higher *magnitude* rewards, and spending at the prior visit were each associated with abstinence on the trial, HR = 1.12 [1.03: 1.22] and HR = 1.32 [1.08: 1.61], respectively. Controlling for decision-making, spending, and cumulative abstinence, prior abstinence remained the largest predictor of future abstinence, HR = 3.85 [2.88: 5.16]. Decision-making tendencies and spending are correlated yet independently associated with abstinence reinforcement in CM. Findings highlight the opportunity for behavioral treatment programs to tailor program structures to individual-specific characteristics.

Keywords

decision-making; spending; contingency management; methamphetamine use disorder; behavioral economics

One common decision-making process attributed to individuals with substance use disorders (SUD) is a preference for *immediate* and *large* rewards irrespective of future consequences (Bechara & Damasio, 2002; Bechara et al., 2002), with this pattern also specifically noted in methamphetamine use disorder (MUD; Gowin et al., 2014; Kohno et al., 2014). Preliminary research has tied baseline decision-making tendencies of individuals with MUD to treatment attrition (Chen et al., 2015) and relapse (Lake et al., 2020), suggesting the critical role that such reward preferences may play in sustained abstinence.

Cash and other reward-based reinforcer programs have demonstrated high efficacy in establishing abstinence in stimulant use disorder (Higgins et al., 2007; Roll, 2007; Shoptaw et al., 2005). Although saving behavior has been associated with success in treatment programs (Subramaniam et al., 2017), fewer studies have examined the financial decision-making specifically associated with the rewards received in contingency management (CM) trials. Ling Murtaugh et al. (2013) examined the role that the *spending* of rewards might play in reinforcing abstinence in CM trials. They found that both cumulative and *recent* spending of cash vouchers on prosocial goods and services promoted future abstinence among a sample of U.S. treatment-seeking men with MUD, self-identifying as gay or bisexual. This *recency effect* was replicated by Krishnamurti et al. (2020) among a sample of South African male and female participants in a CM trial for methamphetamine use, although cumulative prior expenditure did not predict future abstinence in this sample.

Within the same South African study sample, Lake et al. (2020) demonstrated that a baseline preference for more frequent rewards and less frequent losses was associated with future abstinence over the entire duration of an 8-week CM trial. Together, these results point to a potential relationship between baseline decision-making tendencies and the timing of the reinforcing impact of a reward in promoting sustained abstinence among participants in CM trials. However, it is unclear whether reward spending patterns are a manifestation of

a baseline decision-making tendency to value more frequent rewards or whether spending patterns represent a potential independent influence on abstinence outcomes.

In a novel way, we seek to examine the relationship between baseline decision-making tendencies and spending, and whether decision-making tendencies and spending of CM rewards are independently associated with abstinence in a CM trial. In this secondary analysis, we aim to understand whether decision-making tendencies are correlated with future (a) CM reward spending, controlling for abstinence, and with (b) abstinence, controlling for spending. We hypothesize that the tendency to avoid *immediate* and *large* short-term rewards in favor of larger long-term rewards and the tendency to favor *frequent* rewards will be associated with greater future spending and abstinence.

Method

Study Design, Participants

This secondary analysis is based on data from a larger pilot, which aimed to measure the efficacy of an 8-week CM trial in treating MUD through behavioral and neuroimaging outcomes. Ethics approval for the larger pilot study, “Contingency Management, Neuroplasticity and Methamphetamines Abuse in South Africa” was obtained by the University of Cape Town’s (UCT) Human Research Ethics Committee (HREC) as well as the University of California, Los Angeles’ (UCLA) Institutional Review Board (IRB). Data were collected in Cape Town, South Africa, from August 2016 to January 2017. We report on how our sample size was determined, in addition to describing any data exclusions, manipulations, and all measures used in the study. The pilot trial aimed to select approximately 30 participants with MUD, in line with the pilot nature of the study containing a neuroimaging component, which is in line with samples sizes reported in neuroimaging studies of substance use disorder participants within a treatment setting (Forster et al., 2017; Martinez et al., 2011; Paulus et al., 2005). A total of 269 individuals were recruited via drug rehabilitation centers and then screened, of which 33 participants were eligible and consented to partake in the 8-week CM trial, in addition to completing a computerized risk-taking task and various self-report measures. One participant was excluded due to missing baseline computerized decision-making task data, resulting in a final analytic sample size of 32.

Participants were eligible to participate in the study if they were between the ages of 18 and 45 years, if they met the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) criteria for current and primary MUD as assessed using the Structured Clinical Interview for DSM-5 (SCID-5), were able to attend several visits over a 2-week baseline period to complete screening tools, be available for CM pilot visits over a further 8 weeks, and tested positive for methamphetamine (MA) during the baseline phase. Exclusion criteria included meeting DSM-5 criteria for a substance other than MA, excluding secondary tobacco, marijuana, or methaqualone use disorder. Other psychiatric comorbidities were excluded for, including schizophrenia spectrum disorder, bipolar and related disorders, obsessive-compulsive related disorder, as well as depressive and anxiety disorder not induced by MUD. Currently receiving treatment for a substance other than MA, requiring inpatient treatment and/or current use of psychoactive medication, and scoring

a subthreshold score (<55) on the Wechsler Abbreviated Scale of Intelligence (WASI) was excluded for. Additional exclusion criteria included chronic physical or neurological illness, previous head injury, Human Immunodeficiency Virus (HIV)-seropositive status based on pin-prick test, left-handedness, and exclusion criteria relating to the neuroimaging component of the study included current pregnancy, claustrophobia, pacemaker, or presence of any metal in the body.

Measures

Contingency Trial: Tracking Abstinence and Spending—Participants attended thrice weekly clinic visits over an 8-week period to undergo drug urine testing, where urine collection was supervised and verified through urine cup temperature-sensitive strips. Urine was assessed for the presence of MA using radioimmunoassay strips (CLIAwaived Inc., San Diego, California, United States), which detects MA in urine over the prior 48–73 hr. Participants were rewarded with cash vouchers for MA-negative urine tests, where the value of each subsequent cash voucher was incrementally increased by ZAR12.50 (~USD $0.75) with sustained abstinence, starting at ZAR25 (~USD $1.5). A total of 24 cash vouchers could be obtained, worth a maximum of ZAR4850 (~USD $300). At every visit, abstinence was defined as either confirmed, with a MA-negative urine test, or as a relapse, with either a MA-positive urine test or missing test. A missing test was defined as an unattended scheduled visit with no attempt by the participant to reschedule it. Where a MA-negative urine test was followed by a MA-positive test, the voucher for the next MA-negative urine sample was reset to ZAR25 (~USD $1.5). A “rapid reset” rule was applied to sustain motivation, which allowed a participant to return to their highest received voucher value after providing three consecutive MA-negative urine tests. In addition to testing for MA, participants were randomly tested on a weekly basis for barbiturates, cocaine, opiates, and cannabis. However, vouchers were exclusively contingent on MA nonusage.

Spending during the CM trial was defined as the expenditure of a voucher on nondrug rewards following a MA-negative test, which was documented through retrieval of voucher expenditure receipts.

Computerized Risk-Taking Task and Self-Report Measures—At baseline, participants completed a sociodemographic questionnaire, the SCID-5, WASI, and Addiction Severity Index (ASI), as well as providing usage history of MA and other substances.

Participants were administered the Psychology Experiment Building Language (PEBL) 0.14 computerized version of the Iowa Gambling Task (IGT) at baseline, which has been demonstrated to capture deficits in real-world decision-making under conditions of uncertain reward and loss outcomes (Bechara et al., 1994). The IGT has been extensively utilized to demonstrate risky decision-making among various clinical populations, including participants who use substances and those with lesions of the ventromedial prefrontal cortex (Bechara & Damasio, 2002; Bechara et al., 2002; Verdejo-garcia et al., 2006). The IGT was designed to assess the extent to which individuals can learn to switch from short-term to greater long-term gains, what will be referred in this article as the “IGT Magnitude

Effect," as the metric has, in part, much to do with the size of rewards and losses. Lower "IGT Magnitude Effect" scores are more reflective of a riskier, maladaptive strategy that prioritizes immediate, large short-term rewards over long-term gains, whereas in contrast, higher "IGT Magnitude Effect" scores typically illustrate a greater tendency to avoid short-term rewards for larger long-term gains. Decision-making on the IGT can also be driven by the *frequency* with which rewards and losses are presented (Chiu et al., 2008; Horstmann et al., 2012; Lake et al., 2020; Lin et al., 2012), where the preference for more frequent rewards will be referred to as the "IGT Frequency effect."

The IGT consists of four virtual decks, decks A, B, C, and D, each associated with a unique reward and loss probability, where participants were instructed to select decks over a series of 100 trials in a time unconstrained, quiet, and distraction-free room, after participants successfully passed a Snellen chart test for visual competence. The "IGT Magnitude Effect" is measured by a greater selection of riskier decks, A and B, where the score was calculated as the sum of deck selections (deck C + deck D)–(deck A + deck B), where lower scores exhibit the "IGT Magnitude Effect." In contrast, the "IGT Frequency effect" was demonstrated by a greater selection of decks associated with more frequency rewards, namely B and D, and was calculated as the sum of deck selections (deck B + deck D)–(deck A + deck C), where a higher score reflects the "IGT Frequency effect." Given that the objective of the IGT is to obtain a net positive payout, to promote optimal performance, participants received a flat rate of ZAR25 (˜$US 1.5) if they obtained an overall positive net payout following 100 trials.

Data Analysis

Participants were first described according to various sociodemographic and socioeconomic factors, including gender, ethnicity, age, education, employment, household income, and broad intellectual function. Participants were also described according to substance use characteristics, such as MA use quantity, history, and severity of use, in addition to use of other substances. Data were summarized using frequencies and percentages, for categorical variables, and median and interquartile range (IQR), for continuous variables.

A series of time-lagged counting process Cox Proportional Hazards models, computing standard errors using the grouped jacknife method, were conducted to assess whether baseline decision-making tendencies (preference for more *frequent* rewards and prioritization of longer term gains of greater *magnitude* over short-term rewards) were associated with (a) spending at future visits and (b) whether these baseline decision-making tendencies and spending at visits were associated with future abstinence. Models controlled for recent and cumulative earnings, recent and cumulative expenditure, as well as baseline household income. Specific to Aim (2), adjusted models were first run, controlling only for recent and cumulative expenditure and baseline household income, and were then rerun to incorporate recent and cumulative earnings (see Krishnamurti et al., 2020). All data analyses were conducted in R (R Core Team, 2020), using the *survival* package, version 3.2–13 (Therneau, 2021). Manuscript data and code are available from corresponding author upon request. Hypotheses and methods were registered on the Open Science Framework (Lake et al., 2021).

Results

Group Characteristics

Participants were predominately males (21, 68%) of mixed ancestry (30, 94%), with a median of 34 years old. Most participants were unemployed (25, 86%), had completed a median of 11 years of education, and obtained a median WASI score of 89. Participants used a median of 1 g of MA per day over a 12-year period, and 18 (62%) of participants used methaqualone and/or cannabis as a secondary substance/s alongside MA (see Table 1). During the trial, MA was the only substance detected in the urine of participants except for Tetrahydrocannabinol (THC), which was detected in three participants.

Reward Tendency and Spending

Overall, 30 out of the 32 participants provided all 24 urine samples (i.e., thrice weekly urine samples over an 8-week period), whereas one participant provided 18 urine samples and another provided 10 out of the 24 required urine samples before dropping out. Thirty-two percent of the total possible number of vouchers that could be received (assuming 100% abstinence of all participants over the 8-week trials) were missing due to MA-positive urine samples. Only “IGT Frequency Effect” was significantly associated with greater probability of spending at the current visit after controlling for last and cumulative earnings and expenditure (see Table 2; $p = <.001$). Obtaining a preceding MA-negative sample and greater cumulative past expenditure significantly predicted greater odds of spending at the current visit. In contrast, there was no association between “The Magnitude Effect” and spending.

Reward Tendency and Spending in Relation to Abstinence

A higher baseline “IGT Magnitude Effect” score (i.e., tendency to avoid short-term rewards for larger long-term rewards) and recent voucher spending were linked to significantly greater odds of remaining abstinent at the current visit (see Table 2). In contrast, baseline “IGT Frequency Effect” was not associated with abstinence at the current visit. In both “IGT Magnitude and Frequency Effect” models, the most recent purchase significantly increased the likelihood of being abstinent at the current visit, whereas cumulative expenditure did not. Moreover, a higher baseline household income decreased the likelihood of being abstinent at the current visit. After incorporating the impact of prior abstinence in predicting current abstinence, recent expenditure no longer predicted current abstinence.

Discussion

In this secondary analysis, spending of CM rewards was associated with a higher chance of obtaining abstinence at the future visit, as was a baseline tendency to avoid short-term rewards for larger long-term gains on the IGT. This spending result is consistent with findings from Krishnamurti et al. (2020) and Ling Murtaugh et al. (2013), even after controlling for decision-making tendency. However, this finding contrasts with work showing that less frequent drug use was associated with lower expenditure of money earned through participating in a job training program (Subramaniam et al., 2017). An important distinction in our study: Providing a MA-negative sample yielded payment, whereas in the

Subramaniam et al.'s (2017) study, participants earned money in an account at an hourly rate for work performed.

In the present study, measured baseline decision-making tendencies were associated with future voucher spending during the CM trial. Specifically, a baseline tendency to favor *frequent* rewards ("IGT Frequency Effect") was associated with a greater likelihood of voucher spending at the current visit after controlling for other confounding factors that could also impact spending at the current visit, including prior abstinence during the trial (represented by recent and cumulative earnings), prior wealth accrued during the trial (represented by both recent and cumulative expenditure), and baseline household income. This finding points to how individual differences in responding to reward frequency, measured using the IGT, link with spending in real life during a cash voucher-based CM program.

Although a tendency to favor *frequent* rewards was related to future spending, this tendency was not also related to abstinence in our study. Only recent spending was related to future abstinence. This result could suggest that the decision-making process characterized by a prioritization of frequent reward outcomes may be related to abstinence, but only *indirectly*, via recent spending. It may also be that the baseline decision-making process underlying the favorability of *frequent* rewards and spending happens to *independently* influence behaviors that support drug abstinence—influences that may be masked by our small sample size. Future, fully powered research should aim to test these hypotheses further. In contrast, a baseline tendency to avoid *immediate* and *large* short-term rewards in favor of longer term gains was not associated with future spending but was associated with a greater likelihood of future abstinence. This finding may be because the preference for *frequent* rewards is associated with immediate spending, which reduces the opportunity for longer term spending.

Despite the possible indirect role recent spending may have in explaining the relationship between an individualized tendency to favor *frequent* rewards and future abstinence, this is outweighed by the stronger relationship between prior abstinence and current abstinence. This finding is supported by several treatment studies that have demonstrated a link between baseline abstinence and future abstinence during treatment with respect to both methamphetamine and cocaine (Chen et al., 2015; Dean et al., 2009; Ehrman et al., 2001). However, given the confounding nature of the relationship between abstinence and spending embedded in the CM trial design, that is, one's ability to spend cash vouchers is contingent on abstinence; the true extent of the relationship between decision-making in favor of frequent rewards and future abstinence via recent spending may in fact be under- or overestimated in this sample. Future study designs should look to decouple spending from abstinence to independently test such factors.

There are several study limitations that should be identified. The small sample limits the generalizability of findings. Moreover, given that spending was conditional on abstinence, this led to a reduced sample size consisting only of the cases where a voucher was distributed (i.e., abstinence was achieved), potentially biasing the sample toward participants who were able to achieve some degree of abstinence, and excluding those participants

who were unable to achieve any abstinence. Although this study has demonstrated how individual decision-making tendencies and spending may support abstinence, other factors including executive function capacity have also been shown to support sustained abstinence, demonstrated within the same CM pilot study (van Nunen et al., 2021).

In summary, among participants with MUD, a baseline tendency to avoid short-term rewards in favor of larger long-term gains as well as recent spending were independently associated with abstinence reinforcement in a CM setting. Such findings highlight the importance of person-specific decision-making tendencies and spending in predicting the likelihood of achieving abstinence on CM, as well as providing an opportunity for cash voucher reinforcement programs to be individually tailored to maximize treatment success. Future work should further investigate the potential mechanistic role/s of decision-making tendencies and spending in promoting abstinence in cash voucher reinforcement treatment programs for individuals with substance use disorders.

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Public Health Significance

Study findings highlight that decision-making tendencies and spending are independently associated with future abstinence in contingency management among individuals with methamphetamine use disorder.

Table 1

Participant Characteristics

Variable	Participants (*n* = 32)
Gender	
Male [*n*, %]	21 (68%)
Ethnicity	
Mixed ancestry [*n*, %]	30 (94%)
Black African [*n*, %]	2 (6%)
Age (years) [*mdn*, IQR]	34 (30, 40.5)
Highest education [*mdn*, IQR]	11 (9.5, 12)
Employed: No (%) [*n*, %]	25 (86%)
Household income (monthly, RAND) [*mdn*, IQR]	15,000 (2,500, 62,500)
WASI IQ [*mdn*, IQR]	89 (76, 104)
MA quantity use per day (g) [*mdn*, IQR]	1 (0.5, 1.2)
Duration of MA use (years) [*mdn*, IQR]	12 (10, 14.8)
ASI drug use severity [*mdn*, IQR]	0.2 (0.20, 0.32)
Secondary substance	
Methaqualone and/or cannabis [*n*, %]	18 (62%)[a]
ASI alcohol use severity [*mdn*, IQR]	0.1 (0.09, 0.11)

Note. IQR = interquartile range; RAND = South African Rand; WASI = Wechsler Abbreviated Scale of Intelligence; MA = methamphetamine; ASI = addiction severity index.

[a]Missing data for three patients.

Table 2

Baseline Decision-Making Tendencies, Spending, and Abstinence

Variable	IGT magnitude effect			IGT frequency effect		
	ß (SE)	**HR [95% CI]**	***P* value**	**ß (*SE*)**	**HR (95% CI)**	***p* value**
Hypothesis 1) Current spending as outcome						
Baseline IGT score[a]	0.05 (0.04)	1.05 [0.96: 1.14]	.266	0.12 (0.03)	1.13 [1.06: 1.21]	**<.001*****
Last (recent) expenditure	0.08 (0.07)	1.08 [0.95: 1.23]	.251	0.04 (0.08)	1.04 [0.89: 1.21]	.606
Cumulative expenditure	0.01 (0.002)	1.01 [1.00: 1.01]	**<.001*****	0.01 (0.002)	1.01 [1.00: 1.01]	**<.001*****
Last MA-negative sample	2.14 (0.65)	8.53 [2.38: 30.58]	**.001****	2.22 (0.66)	9.26 [2.54: 33.72]	**<.001*****
Cumulative MA-negative samples	0.08 (0.09)	1.08 [0.90: 1.29]	.390	0.02 (0.08)	1.02 [0.88: 1.19]	.802
Baseline household income	0.00 (0.01)	0.99 [0.98–1.01]	.581	0.00 (0.01)	1.00 [0.99: 1.02]	.827
Hypothesis 2) Current abstinence as outcome (Partial model)						
Baseline IGT score[a]	0.11 (0.04)	1.12 [1.03: 1.22]	**.009****	0.04 (0.03)	1.04 [0.98: 1.11]	.189
Last (recent) expenditure	0.28 (0.10)	1.32 [1.08: 1.61]	**.006****	0.29 (0.11)	1.34 [1.09: 1.66]	**.007****
Cumulative expenditure	0.00 (0.005)	1.00 [0.99: 1.01]	.687	0.00 (0.005)	1.00 [0.98: 1.01]	.507
Baseline household income	−0.02 (0.01)	0.98 [0.97: 0.99]	**.002****	−0.01 (0.01)	0.98 [0.97: 0.99]	**.025***
Hypothesis 2) Current abstinence as outcome (Full model)						
Baseline IGT score	−0.01 (0.01)	0.99 [0.96: 1.02]	.389	−0.02 (0.02)	0.98 [0.94: 1.01]	.220
Last (recent) expenditure	0.01 (0.04)	0.99 [0.92: 1.07]	.852	0.00 (0.03)	1.00 [0.93: 1.07]	.980
Cumulative expenditure	0.01 (0.003)	0.99 [0.99: 1.00]	.111	0.01 (0.003)	0.99 [0.99: 1.00]	.110
Last MA-negative sample	1.35 (0.15)	3.85 [2.88: 5.16]	**<.001*****	1.33 (0.15)	3.80 [2.82: 5.12]	**<.001*****
Cumulative MA-negative samples	0.28 (0.07)	1.33 [1.15: 1.53]	**<.001*****	0.29 (0.07)	1.34 [1.16: 1.54]	**<.001*****
Baseline household income	0.00 (0.002)	1.00 [0.99–1.01]	.321	0.00 (0.002)	1.00 [0.99–1.00]	.710

Note. IGT = Iowa Gambling Task; HR = Hazard Ratio; MA = methamphetamine. Bold p-values indicate significance at the level of at least <.05.

[a]"Baseline IGT score" refers to either the IGT magnitude or the frequency effect.

* $p < .05$.

** $p < .01$.

*** $p < .001$.