



Using behavioral economics to predict opioid use during prescription opioid dependence treatment



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ABSTRACT

Background: Research grounded in behavioral economics has previously linked addictive behavior to disrupted decision-making and reward-processing, but these principles have not been examined in prescription opioid addiction, which is currently a major public health problem. This study examined whether pre-treatment drug reinforcement value predicted opioid use during outpatient treatment of prescription opioid addiction.

Methods: Secondary analyses examined participants with prescription opioid dependence who received 12 weeks of buprenorphine–naloxone and counseling in a multi-site clinical trial ($N = 353$). Baseline measures assessed opioid source and indices of drug reinforcement value, including the total amount and proportion of income spent on drugs. Weekly urine drug screens measured opioid use.

Results: Obtaining opioids from doctors was associated with lower pre-treatment drug spending, while obtaining opioids from dealers/patients was associated with greater spending. Controlling for demographics, opioid use history, and opioid source frequency, patients who spent a greater total amount ($OR = 1.30, p < .001$) and a greater proportion of their income on drugs ($OR = 1.31, p < .001$) were more likely to use opioids during treatment.

Conclusions: Individual differences in drug reinforcement value, as indicated by pre-treatment allocation of economic resources to drugs, reflects propensity for continued opioid use during treatment among individuals with prescription opioid addiction. Future studies should examine disrupted decision-making and reward-processing in prescription opioid users more directly and test whether reinforcer pathology can be remediated in this population.

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1. Introduction

Prescription opioid addiction has become a significant public health problem and economic burden in the United States and in other developed nations (Birnbaum et al., 2011; Ling et al., 2011). Prescription opioids are currently the second-most commonly abused drug in the United States (SAMHSA, 2013b). Furthermore, among all drugs of abuse prescription opioid-related overdoses are currently the most common and had the greatest proportional increase in the last 15 years (Calcaterra et al., 2013; Jones et al., 2013). Rates of prescription opioid abuse and admissions

for prescription opioid addiction treatment have also increased rapidly during this time period (SAMHSA, 2013a; Atluri et al., 2014; Compton and Volkow, 2006). These disturbing trends have prompted increased federal attention on prescription opioid addiction, including research aimed at developing effective treatments and understanding treatment response (Compton and Volkow, 2006; Manchikanti, 2006).

Among various theoretical models of addictive behavior, behavioral economics has rapidly developed as a conceptual framework for explaining maladaptive substance use. As a blend of behavior analysis and principles of economics, behavioral economics examines decision-making processes that govern the allocation of limited resources (e.g., time, money, effort) to competing goals under various constraints (Hursh, 1993). Individuals with addiction typically have dysfunction in these processes. Despite increased psychosocial and financial costs, these individuals continually expend greater amounts of resources to obtain and use drugs (Bickel et al., 2014a, 2010). Perhaps the most well-known marker

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of such dysfunction in addiction is excessive delay discounting, as individuals with drug dependence typically exhibit irrational preferences for immediate vs. delayed rewards (Bickel et al., 2014b; MacKillop et al., 2011). Individuals with drug abuse or dependence also exhibit elevated drug demand, characterized by greater valuation of substances that persists despite the presence of situational factors that typically reduce consumption (Hursh et al., 2005) such as increased unit price or the presence of other reinforcers (Murphy and MacKillop, 2006; Murphy et al., 2009). Recent linkage to neural and genetic biomarkers has also demonstrated the potential importance of excessive delay discounting and elevated drug demand as phenotypic markers of addictive behavior (MacKillop, 2013; MacKillop et al., 2014).

In addition to these decision-making phenotypes established primarily in laboratory research settings, behavioral economic theory has guided the development of ecologically valid indices of drug reinforcement value in the natural environment. These metrics infer drug reinforcement value by quantifying the amount of actual resources, such as time or money, that one directs toward obtaining and using a substance. For example, a discretionary spending index that compares income allocated to alcohol vs. savings has predicted future alcohol relapse in abstinent drinkers (Tucker et al., 2002, 2006, 2009). Naturalistic cocaine purchase time has also predicted self-administration of cocaine in the laboratory (Greenwald and Steinmiller, 2014). Similar to delay discounting and demand, drug-seeking in the natural environment has been validated as a distinct phenotype with genetic underpinnings (Greenwald et al., 2013). These naturalistic metrics are promising potential markers of drug reinforcement value and poor treatment response in individuals with prescription opioid addiction, but have not been previously examined in this population.

In a previous multi-site treatment study for prescription opioid addiction, participants received enhanced or standard medical management and 12 weeks of open-label buprenorphine–naloxone (BUP–NLX). Endpoint abstinence was achieved by 49% of the sample, with no difference between psychosocial treatment conditions (Weiss et al., 2011). Older age, lifetime major depression, no history of non-oral use of opioids, and no previous opioid treatment predicted greater odds of endpoint abstinence (Dreifuss et al., 2013). Although markers of opioid use history and baseline dependence severity have predicted treatment outcome (Dreifuss et al., 2013; Hillhouse et al., 2013; Soyka et al., 2008), patients with similar levels of severity in opioid dependence or opioid use may be allocating vastly different levels of resources to obtain and use drugs. These individual differences in drug reinforcement value may be uniquely and incrementally predictive of treatment response. Furthermore, as opposed to relatively immutable demographic and historical factors, behavioral economic processes of decision-making can be altered through interventions (Koffarnus et al., 2013; Murphy et al., 2013, 2012). An examination of drug reinforcement value in prescription opioid users may therefore provide insight into malleable processes that could be used to bolster treatment effects, perhaps with interventions that increase the salience of substance-free rewards (Murphy et al., 2012).

This study is an initial investigation of behavioral economic predictors of opioid use during prescription opioid addiction treatment. We examined the total amount and proportion of income allocated to drugs prior to treatment in the aforementioned multisite clinical trial (Weiss et al., 2011). We hypothesized that individuals who spent greater total amounts and a greater proportion of their income on drugs prior to treatment would be more likely to continue using opioids during treatment. Considering that prescription opioid users obtain opioids from a variety of sources and the purchase price from illicit sources tends to be higher (Cicero et al., 2008; Mars et al., 2014), we expected that individuals who frequently obtained opioids from illicit sources would spend greater

Table 1

Summary statistics of study variables for participants receiving treatment for prescription opioid dependence ($N = 353$).

Variable	% (n) or M (SD)
Gender: % (n) male	58% (204)
Race: % (n) white	90% (319)
Years of education: M (SD)	12.9 (2.1)
Marital status: % (n) currently married	26% (93)
Major depression: % (n) with lifetime MDD	34.3 (121)
Days of prescription opioid use in past 30 days: M (SD)	27.9 (3.6)
Heroin history: % (n) ever used	26% (91)
Prescription opioid route history: % (n) ever used non-orally	85% (300)
Prescription opioid treatment history: % (n) ever received	35% (123)
Number of prescription opioid dependence criteria: M (SD)	6.4 (0.88)
Total money (\$) spent on drugs in last month: M (SD)	1013.4 (1243.7)
Proportion of income spent on drugs in last month: M (SD)	141.6 (283.6)
Prescription opioid source in last 6 months	
Doctor for legitimate pain/medical problem: % (n) with any	59% (207)
Dealer or patient that sells their medication: % (n) with any	93% (328)

amounts of money on drugs. We also considered that this effect could confound the expected relationship between drug spending and within-treatment opioid use, because frequently obtaining opioids from illicit sources might correspond to both greater spending and greater severity of dependence. Therefore we controlled for prescription opioid source variables and measures of opioid dependence severity in our analyses of opioid use outcomes, to examine whether the hypothesized association between baseline drug reinforcement value and opioid use during treatment was independent of these potential confounds.

2. Methods

2.1. Study design

This study involved secondary analyses of Phase 2 of the Prescription Opioid Addiction Treatment Study (POATS), a multi-site, adaptive, randomized clinical trial of psychosocial treatment with adjunctive open-label BUP–NLX for prescription opioid addiction (Weiss et al., 2011, 2010). All POATS participants were initially randomized to standard or enhanced medical management and entered a 4-week BUP–NLX detoxification (Phase 1). Those who failed to sustain abstinence during the detoxification and an 8-week follow-up (93% of the full sample) were eligible to enter Phase 2. In Phase 2, hereafter referred to as the “treatment phase”, participants were re-randomized to psychosocial treatment condition, received 12 weeks of BUP–NLX maintenance, and attended the clinic weekly for physician appointments, urine drug screens, and completion of other study measures. The primary POATS report revealed no significant main effects of enhanced psychosocial treatment on achievement of endpoint abstinence in Phase 1 or Phase 2 (Weiss et al., 2011).

2.2. Study sample

All POATS participants were at least 18 years old, met DSM-IV criteria for current prescription opioid dependence, were physiologically dependent on opioids, were cleared by their prescribing physician if receiving prescription opioids for pain, agreed to birth control if female, and had no unstable medical or psychiatric conditions. Key exclusion criteria included use of heroin on ≥ 4 days in the past month, any lifetime injection of heroin, or physiological dependence on alcohol, sedatives, or stimulants. The full inclusion/exclusion criteria can be found in previous reports (Weiss et al., 2010, 2011). The current study included all Phase 2 participants with full data on baseline covariates and predictors ($n = 353$), with seven participants from the original Phase 2 sample excluded due to missing baseline information. General clinical and demographic characteristics of the sample are displayed in Table 1. Analyses revealed no significant differences between this subsample and the full POATS Phase 2 sample.

2.3. Study measures

2.3.1. Opioid use. Opioid use during treatment was measured via urine drug screens (UDS) obtained at each weekly study visit, which tested for prescription analgesics, illicit opioids, and methadone. Weekly UDS results were coded as positive or negative for any opioids, which provided a weekly dichotomous and biologically confirmed measure of opioid use. Participants provided a total of 4006 UDS during treatment, with a mean of 10.4 (SD = 2.8) each, 29% of which were positive for opioids.

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