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### Repository Citation

Strickland, Justin Charles; Beckmann, Joshua S.; Rush, Craig R.; and Stoops, William W., "A Pilot Study of Loss Aversion for Drug and Non-Drug Commodities in Cocaine Users" (2017). *Psychology Faculty Publications*. 172.

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Digital Object Identifier (DOI)

<https://doi.org/10.1016/j.drugalcdep.2017.08.020>

### Notes/Citation Information

Published in *Drug and Alcohol Dependence*, v. 180, p. 223-226.

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The document available for download is the author's post-peer-review final draft of the article.



# HHS Public Access

Author manuscript

*Drug Alcohol Depend.* Author manuscript; available in PMC 2018 November 01.

Published in final edited form as:

*Drug Alcohol Depend.* 2017 November 01; 180: 223–226. doi:10.1016/j.drugalcdep.2017.08.020.

## A pilot study of loss aversion for drug and non-drug commodities in cocaine users

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### Abstract

**Background**—Numerous studies in behavioral economics have demonstrated that individuals are more sensitive to the prospect of a loss than a gain (i.e., loss aversion). Although loss aversion has been well described in “healthy” populations, little research exists in individuals with substance use disorders. This gap is notable considering the prominent role that choice and decision-making play in drug use. The purpose of this pilot study was to evaluate loss aversion in active cocaine users.

**Methods**—Current cocaine users ( $N = 38$ ; 42% female) participated in this within-subjects laboratory pilot study. Subjects completed a battery of tasks designed to assess loss aversion for drug and non-drug commodities under varying risk conditions. Standardized loss aversion coefficients ( $\lambda$ ) were compared to theoretically and empirically relevant normative values (i.e.,  $\lambda = 2$ ).

**Results**—Compared to normative loss aversion coefficient values, a precise and consistent decrease in loss aversion was observed in cocaine users (sample  $\lambda \approx 1$ ). These values were observed across drug and non-drug commodities as well as under certain and risky conditions.

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#### Author Disclosure

##### Contributors

These data were collected as a part of the first author’s Master’s thesis. J.C. Strickland, W.W. Stoops, C.R. Rush, and J.S. Beckmann developed the study concept and data collection measures. Data were collected by J.C. Strickland. J.C. Strickland performed the data analysis and interpretation under the guidance of W.W. Stoops. J.C. Strickland drafted the initial manuscript and all authors provided critical reviews. All authors approved the final version of the manuscript for submission.

##### Conflict of interest

The authors have no financial conflicts of interest in regard to this research

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**Conclusions**—These data represent the first systematic study of loss aversion in cocaine-using populations and provide evidence for equal sensitivity to losses and gains or loss equivalence. Futures studies should evaluate the specificity of these effects to a history of cocaine use as well as the impact of manipulations of loss aversion on drug use to determine how this phenomenon may contribute to intervention development efforts.

### Keywords

Behavioral Economics; Drug; Gamble; Prospect Theory

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## 1. Introduction

The application of behavioral economics to drug use has advanced addiction science (Bickel et al., 2014; Hursh and Roma, 2013; MacKillop, 2016). For example, research on delay discounting has informed the etiology of substance use disorders and intervention efforts (Bickel et al., 2012, 2017; Washio et al., 2011). Exploration of other behavioral economic principles not traditionally studied in substance use may provide insight into the origins and persistence of maladaptive patterns of drug taking.

Loss aversion has received extensive attention in behavioral economics (Novemsky and Kahneman, 2005). Numerous studies have demonstrated that, all things being equal, losses tend to have a greater impact on behavior than gains as represented by the standardized coefficient, lambda ( $\lambda$ ) (Kahneman and Tversky, 1979; Tversky and Kahneman, 1991, 1992). Although this relationship may differ across paradigms and environmental contexts, this literature highlights the importance of framing outcomes as losses or gains on subsequent decision-making.

Few studies have examined loss aversion in clinical populations and even fewer have evaluated individuals with a substance use disorder. The primary method used to evaluate loss aversion in substance use is computational modeling of Iowa Gambling Task (IGT) performance. These studies have found that IGT performance is consistent with decreased loss aversion (e.g., Ahn et al., 2014; Fridberg et al., 2010; Vassileva et al., 2013). However, reliance on indirect methods not traditionally applied in behavioral economics makes comparisons across disciplines difficult. The lack of studies examining ecologically relevant drug commodities is also a limitation. This pilot study examined loss aversion in active cocaine users using a multi-method test battery that varied in risk and the commodity available (drug and non-drug).

## 2. Materials and Methods

### 2.1 Subjects

Thirty-eight subjects participated in this within-subjects study (Table 1). Recruitment included formal advertisement, community flyers, and word of mouth. All subjects underwent comprehensive screening (see Stoops et al., 2010). Diagnostic criteria for cocaine use disorder were assessed using the computerized Structured Clinical Interview for DSM-IV. All subjects were non-treatment seeking and reported cocaine use verified by urinalysis.

## 2.2 Procedure

Subjects had to provide an expired air sample negative for alcohol and a urine specimen negative for all substances except cocaine and THC prior to participation. Subjects could proceed if THC positive, but had to pass a standard field sobriety test to ensure they were not acutely intoxicated. Sessions took approximately one hour. Subjects were provided \$30 at study onset for use in behavioral tasks. One choice from the non-drug valuation task was randomly selected and subjects received money, the commodity, or nothing depending on their decisions. Subjects were also told to respond carefully on the mixed gambles and risk aversion tasks because one trial from each would be randomly selected and compensation provided (or lost) based on that trial. In actuality, all subjects received \$10 for these tasks. Subjects were informed of task outcomes at the end of the session to avoid differential responses based on the results. All drug commodities were hypothetical and no cocaine was received. This study was approved by the Institutional Review Board of the University of Kentucky and conducted in accordance with the Declaration of Helsinki.

## 2.3 Behavioral Measures

**2.3.1 Valuation Task**—A valuation task was used to determine loss aversion under certain conditions (Gachter et al., 2007; Kahneman et al., 1990). In the “Willingness-to-Accept” (WTA) condition, subjects were given a commodity (e.g., a mug) and asked to indicate the price(s) at which they would be willing to sell the commodity. The “Willingness-to-Purchase” (WTP) condition was identical except that subjects were shown the commodity and asked at what price(s) they would purchase it. Price ranges were \$0.50 to \$10 in \$0.50 increments. In a novel cocaine valuation task, subjects were asked to make hypothetical decisions about purchasing or selling 1 g of cocaine for prices ranging from \$10 to \$200 in \$10 increments. All other procedures were identical. Presentation order for WTA and WTP conditions was counterbalanced with approximately 30 minutes between tasks. The primary outcome was the WTA/WTP ratio ( $\lambda$ ; Novemsky and Kahneman, 2005).

**2.3.2 Mixed Gambles Task**—A mixed gambles task was used to determine loss aversion under uncertain conditions (Tom et al., 2007). Subjects were asked if they would accept gambles offering a 50/50 chance of winning or losing variable monetary amounts. Gains ranged from \$10 to \$40 in \$2 increments, whereas losses ranged from \$5 to \$20 in \$1 increments. These ranges were selected based on the original task variant (Tom et al., 2007). A novel cocaine version was used with identical procedures, but presenting hypothetical gains and losses of 0.2 to 2.0 g of cocaine in 0.2 g increments. The primary outcome was  $\lambda$ , calculated as  $\lambda = -\beta_{\text{loss}}/\beta_{\text{gain}}$  derived from the logistic regression of gain and loss magnitude on trial choice. Nine subjects were excluded because of model non-convergence (Money Task = 2; Cocaine Task = 4; Both Tasks = 3). In general, this reflected a propensity to accept every or nearly every gamble.

**2.3.3 Risk Aversion Task**—A risk aversion task measured general aversion towards outcome variability. Subjects were presented with 11 double or nothing gambles ranging from \$2 to \$50. Previous studies have used this measure to account for general aversion to risk over specific aversion to loss (De Martino et al., 2010).

## 2.4 Data Analysis

One-sample  $t$ -tests were used to determine if  $\lambda$  differed from a population normative value of 2. This number was selected because it is the value proposed by theoretical accounts of loss aversion in non-clinical (i.e., normative) populations (Kahneman and Tversky, 1979; Novemsky and Kahneman, 2005; Tversky and Kahneman, 1992). This value also lies within the ranges described by meta-analyses on WTP/WTA disparities (Neumann and Böckenholt, 2014; Sayman and Öncüler, 2005; Tunçel and Hammitt, 2014). Sensitivity analyses were conducted using a lower threshold suggested by one meta-analysis (1.49; Neumann and Böckenholt, 2014). Confidence intervals and individual data were evaluated for precision and margin of difference.

Risk, Commodity, and Risk x Commodity effects were evaluated using linear mixed-effects models in the *lme4* package of R (Bates et al., 2015). Risk aversion and task order were included as covariates.

## 3. Results

### 3.1 Valuation Task

Figure 1 shows  $\lambda$  values for valuation tasks (i.e., black circles) and normative value comparators (i.e., dotted lines). Similar magnitude prices for selling (WTA) and buying (WTP) were observed, specified by  $\lambda$  values of approximately 1. One-sample  $t$ -tests indicated that  $\lambda$  values for the mug,  $p < .001$ ,  $d = 1.13$ , and cocaine,  $p < .001$ ,  $d = 1.48$ , were significantly lower than a normative value of 2. Similar outcomes were observed with a conservative threshold of 1.49,  $p$  values  $< .01$ . Confidence intervals indicated precision and individual subject data supported the consistency of this estimate, with a majority of subjects clustering around the value of 1.

Analyses using only the first task completed supported these conclusions. These tests did not reveal significant between-subject differences in prices for selling and buying conditions, Mug  $p = .49$ ; Cocaine  $p = .55$ . Similar magnitude  $\lambda$  values were also observed when computed using median WTA and WTP values from this first-task only subset,  $\lambda$ : Mug = 1.20; Cocaine = 1.17.

### 3.2 Mixed Gambles Task

Mean gamble acceptance rates were 65.5% (SD = 27.0%) for money and 47.8% (SD = 24.0%) for cocaine. Figure 1 shows  $\lambda$  values on the gambles tasks (i.e., white squares). Subjects were equally sensitive to losses and gains, reflected by  $\lambda$  values of approximately 1. One-sample  $t$ -tests supported this conclusion indicating a significant difference from 2 for money,  $p < .001$ ,  $d = 1.53$ , and cocaine,  $p < .001$ ,  $d = 1.55$ . Similar outcomes were observed when comparing to 1.49,  $p$  values  $< .01$ . Confidence intervals indicated estimate precision and individual subject data supported consistency.

### 3.3 Risk and Commodity Effects

No significant Risk, Commodity, or Risk by Commodity effects were observed,  $p$  values  $> .29$ . Risk aversion and task order were also not significant covariates,  $p$  values  $> .28$ .

### 3.4 Individual Differences

Loss aversion across all tasks was not related to income, ZKPQ-Impulsivity Subscale, DAST scores, risk aversion, or Cocaine Dependence,  $p$  values  $> .08$ .

## 4. Discussion

Cocaine users showed a reliable reduction in loss aversion when compared to theoretically and empirically relevant normative values. This loss equivalence, as indicated by  $\lambda$  of 1, was consistent across risk and commodity type. These data represent the first study on multiple dimensions of loss aversion in a substance-using population and suggest that reductions in loss aversion are associated with a history of cocaine use.

A control group was not examined in this pilot study. Nevertheless, large and significant differences were observed when comparing our sample to a normative value of 2 as well as a lower threshold value. This uniform response to gains and losses stands in contrast to a rich behavioral economic literature demonstrating that losses generally have a greater impact on behavior than gains (Tversky and Kahneman, 1991, 1992). The use of theoretically relevant and empirically supported normative values is important given the general failure to consider such population normative comparisons when evaluating cognitive-behavioral processes in substance-using populations (Hart et al., 2012). It is possible, however, that loss aversion is epiphenomenally related to other primary causal agent(s) associated with substance use disorders. For example, socioeconomic status (SES) is frequently connected to substance use (Galea and Vlahov, 2002; Gilman et al., 2003) and lower SES may be correlated with lower loss aversion (Gachter et al., 2007). Individual difference variables were not related to loss aversion. However, these outcomes may reflect sample homogeneity rather than population level relationships. Future studies specifically designed to investigate individual differences are needed to clarify these results.

A substantial proportion of data were excluded from the mixed gambles task due to problems with model convergence. Non-convergence occurred in most cases due to acceptance of every or nearly every gamble, which could be indicative of task confusion. These data could also indicate an extreme decrease in loss aversion in which any loss is ineffective for changing behavior. These gambling tasks differed in price range and qualitative nature (i.e., dollars versus grams). It is possible that a wider range of loss values would have produced higher rates of systematic responding. However, a recent study found that the gain/loss ranges used could influence  $\lambda$  (Walasek and Stewart, 2015). We selected those parameters that mostly closely resembled the original task for this pilot purpose. This range also produced loss aversion in the aforementioned study ( $\lambda = 1.79$ ; Walasek and Stewart, 2015) as well as other demonstrations of loss aversion in healthy participants ( $\lambda = 1.93$ ; Tom et al., 2007). Thus, it is unlikely that the loss equivalence observed was due to this procedural variation. Another possibility is that some subjects showed extreme rates of gambling due to differential perceptions of the endowment received given that greater rates of risk-taking can occur following profits (i.e., “house money effect”; Thaler and Johnson, 1990). The findings collectively suggest that future research should investigate methodological parameters designed to increase rates of systematic data, such as additional

training sessions, attention checks verifying engagement and understanding, and alternative gain/loss ranges.

Prospect theory and loss aversion were developed to explain deviations from choices guided by expected utility (Kahneman and Tversky, 1979). We observed behavior operating under conditions more consistent with expected utility hypotheses, namely an equal sensitivity to gains and losses under a variety of experimental conditions. Such decisions based on expected utility may be advantageous under certain contexts (e.g., investing). However, loss equivalence may also be harmful in other situations, such as when attention is needed to the consequences of drug use. In this way, rigid loss aversion may represent a behavioral mechanism underlying disadvantageous choice characteristic of substance use and incorporating strategies to shift loss aversion in a context-dependent manner may help modify undesirable drug-taking behavior. This possibility is not unwarranted given that loss aversion is sensitive to cognitive-regulation strategies (Sokol-Hessner et al., 2009). Research examining the functional relationship between loss aversion and substance use will be crucial for informing loss aversion's role in intervention development efforts.

## Acknowledgments

### Role of Funding Source

This work was supported by grant number R21 DA035376 (WWS) from the National Institute on Drug Abuse and grant number 1247392 (JCS) from the National Science Foundation. These funding sources had no role in study design, data collection and analysis, or preparation and submission of the manuscript.

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### Highlights

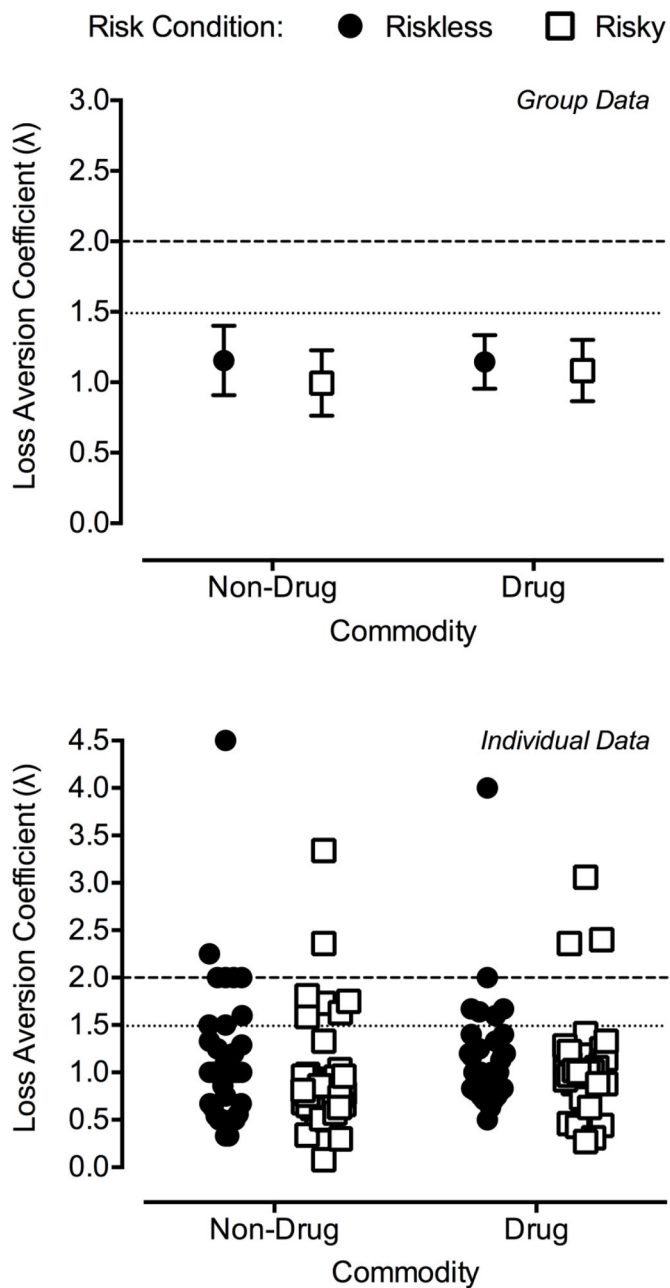
- Loss aversion was tested in active cocaine users
- Cocaine users showed equal sensitivity to losses and gains
- Performance was similar under uncertain (risky) and certain conditions
- Performance was similar for drug (cocaine) and non-drug commodities

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**Figure 1.** Loss aversion coefficients for valuation (black circles) and mixed gambles (white squares) tasks. Dotted lines are normative loss aversion value of 2 (thick dotted line) and lower bound estimate of 1.49 (thin dotted line). Top Panel: Estimates represent mean values and error bars represent 95% confidence intervals. Bottom Panel: Plotted are individual subject data for each task.

**Table 1**

## Subject Demographics and Drug Use Variables

	Mean/Count	SD
Age	45.7	5.8
Female	16 (42%)	
Race		
Caucasian	7 (18%)	
African American	31 (82%)	
Years of Education	12.1	1.5
Income	\$7155	\$7479
<b>ZKPO</b>	<b>1.4</b>	<b>1.7</b>
CPD	11.8	7.4
FTND	3.8	2.3
Alcoholic Drinks Per Week	14.6	17.0
MAST	8.4	8.8
DAST	10.2	5.6
Cocaine Use		
Days Used Per Month	15.7	9.2
Money Spent Per Month	\$659.5	\$701.0
Lifetime Uses	3562.6	2715.6
Years Used	20.3	8.3
Cocaine Abuse	11 (28.9%)	
Cocaine Dependence	25 (65.8%)	

Note. **ZKPO = Impulsivity Subscale of the Zuckerman-Kuhlman Personality Questionnaire**; CPD = cigarettes per day; FTND = Fagerström Test for Nicotine Dependence; MAST = Michigan Alcohol Screening Test; DAST = Drug Abuse Screening Test.