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Cocaine behavioral economics: From the naturalistic environment to the controlled laboratory setting

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Abstract

Background—We previously observed that behavioral economic factors predict naturalistic heroin seeking behavior that correlates with opioid seeking in the experimental laboratory. The present study sought to replicate and extend these prior findings with regular cocaine users.

Methods—Participants (N = 83) completed a semi-structured interview to establish income-generating and cocaine-purchasing/use repertoire during the past month. Questions addressed sources/amounts of income and expenditures; price (money and time) per purchase; and frequency/amounts of cocaine purchased and consumed. Naturalistic cocaine purchasing and use patterns were: (1) analyzed as a function of income quartile, (2) perturbed by hypothetical changes in cost factors to assess changes in purchasing/use habits, and (3) correlated with experimental cocaine seeking.

Results—Income was positively related to naturalistic cocaine seeking/use pattern (i.e., income elastic), and behaviors were cost-efficient and sensitive to supply chain. Income was unrelated to proportional expenditure on cocaine (≈55%) but inversely related to food expenditure. In all hypothetical scenarios (changes in income or dealer, loss of income assistance from government or family/friends, and increasing arrest risk when purchasing), the high-income group reported they would continue to use more cocaine daily than other groups. Number of laboratory cocaine choices significantly correlated with cocaine purchase time (positively) and purity of cocaine (negatively) in the naturalistic setting.

Conclusions—These results replicate and extend findings with regular heroin users, demonstrate the importance of income, cost-efficiency and supply-mindedness in cocaine seeking/use, and suggest that this interview-based approach has good external validity.

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Contributors

M.K.G. conceptualized the study, conducted most behavioral economic interviews, directed the analyses and wrote the majority of this manuscript. C.L.S. conducted some interviews, data analyses, prepared the tables and figure, and assisted with manuscript editing. All authors read the manuscript and approved of its submission to the journal.

Conflict of interest

The authors declare no conflict of interest with respect to the conduct or content of this work.

Keywords

Cocaine seeking; Behavioral economics; Income; Price; Supply; Demand

1. Introduction

Regular cocaine use can be conceptualized as a behavioral economic problem, in which cocaine functions as a reinforcer (i.e., maintains seeking behaviors leading to its consumption) and certain environmental features can promote or constrain cocaine use. One key factor is income, which broadly influences purchasing of commodities. However, few studies have systematically examined income-generating activities and expenditures among cocaine users. In one careful analysis of urban African American individuals, Cross et al. (2001) found that, compared to non-frequent users, frequent crack-cocaine users (≥15 of past 30 days) were less likely to engage in full-time work or receive aid to families with dependent children, and more likely to generate income from petty criminal activities and from friends, family, governmental assistance, and panhandling. However, that study did not investigate how income was expended or the cocaine-related behavioral repertoire of those individuals.

Evaluating the income and expenditures of regular cocaine users who are *not* seeking treatment may be useful in understanding factors that maintain cocaine demand. Studies from our laboratory showed that heroin-dependent, non-treatment volunteers had predictable purchasing repertoires (Roddy and Greenwald, 2009; Roddy et al., 2011). When assessed in simulation scenarios, only potent economic challenges such as 33% reduction in income, discontinuation of living subsidies from friends/family, and 4-fold greater likelihood of arrest during drug purchasing, altered these behaviors (Roddy et al., 2011).

The present study adapted this approach to studying regular cocaine users (whose behavior may differ from heroin users) and expands work on income-generating activities of cocaine users (Cross et al., 2001). Previous evidence that higher baseline rate of cocaine use is related to worse treatment outcome (Alterman et al., 1997; Ehrman et al., 2001; Kampman et al., 2001, 2002; Kosten et al., 2005) suggests that behavioral economic metrics could be useful for understanding and predicting treatment response. This study used interview methods to (1) ascertain naturalistic patterns of cocaine purchasing and use (demand metrics) in relation to past-month income; (2) determine in simulation scenarios whether these behaviors are susceptible to change by a variety of cost-related factors; and (3) evaluate whether these naturalistic behaviors predicted experimental cocaine seeking in a laboratory study that included 15 of these participants (Greenwald et al., 2014). We hypothesized that naturalistic cocaine purchasing/use would be (1) income elastic; (2) sensitive to simulated cost factors; and (3) associated with cocaine seeking in the laboratory setting.

2. Methods

2.1. Participant recruitment

The local Institutional Review Board approved all procedures. A certificate of confidentiality was obtained. Regular cocaine using, non-treatment seeking males and females, aged 18–55 years, were recruited by newspaper advertisements and word-of-mouth referral in the Detroit/metropolitan area for participation in experimental cocaine self-administration studies. All volunteers provided written informed consent. The present analyses are based on data from two clinical studies registered on www.clinicaltrials.gov as NCT00946660 and NCT01392092.

2.2. Measures

Participants completed a novel semi-structured interview, Cocaine Purchasing and Use Patterns (CPUP), adapted from our study with heroin users (Roddy et al., 2011), to assess past-month income generating and cocaine seeking/use repertoires. In part one of the interview, data were obtained on amounts of income from legal sources including employment (both taxable and non-taxed earnings from bartering work such as handyman services, babysitting, yard work, hair styling/cutting, housework/cleaning), unemployment insurance, pension or Social Security, public assistance (e.g., food stamps), family and friends (without lying about its intended use), net earnings from approved gambling venues, borrowing on credit, and various illegal sources (e.g., selling drugs, stealing, “con game” or lying, prostitution, scrapping metal).

Interview questions evaluated the past-month number of and distance from cocaine/crack dealers; unit price, money spent and round-trip time per average cocaine purchase; frequency, amounts and estimated purity of cocaine purchased; and expenditures on other goods besides cocaine such as food, shelter/utilities, cigarettes, alcohol, other drugs, and non-drug items (e.g., transportation, clothing, and personal care). Measures of cocaine use were confirmed with collateral indices from a standardized, comprehensive, and locally developed Drug History and Use Questionnaire (DHUQ) and qualitative urine toxicology (positive result ≥ 300 ng/ml).

An internal validity check was established during each interview: If past-month total income and total expenditures did not closely agree (±3%), the participant’s data were excluded from analysis. Only a few participants’ data failed to meet this criterion.

In the majority of this sample (time allowing, due to required demographic, medical and psychiatric screening procedures for the laboratory studies), part two of the interview assessed, in a sequence of related questions, how the participant would adapt to this hypothetical situation: “If your current primary cocaine/crack dealer was arrested or unavailable for the next month and you had to go to another dealer from whom you’ve previously bought cocaine/crack”–

1. Would the time you’d have to travel differ from what it is now? (>10 min shorter, ≤10 min shorter, same time, ≤10 min longer, or >10 min longer)

2. Would your primary mode of transportation have to change from what it is now? (no, yes)
3. How much would a bag/rock cocaine/crack cost from the new dealer compared to what it is now? ($3–$5 less per unit, <$2 less per unit, same cost, <$2 more per unit, $3–$5 more per unit, or ≥$5 per unit)
4. Would the purity of the new dealer's cocaine/crack change from what you buy now? (≥20% decrease, 10–20% decrease, no big change [±10%], or 10–20% increase (≥20% increase)
5. Would the reliability of the new dealer (his ability to get you what you need) change from what you are used to now? (much less reliable, somewhat less reliable, no significant change, somewhat more reliable, or much more reliable).

In a follow-up sequence of questions, each participant was then asked: "How much cocaine/crack (dollar amount) would you buy on each day (on average)"–

1. If you had to switch to the new cocaine/crack dealer?
2. If your next month's income decreased 50% from its current level?
3. If your next month's income increased 50% from its current level?
4. If your family or friends no longer paid for your housing/other living expenses?
5. If you no longer received any governmental assistance (e.g., no food stamps, social security or unemployment compensation)?
6. If you had to buy from a cocaine/crack dealer who sold in a neighborhood where you would be: 25% (one-quarter) as likely to be arrested? 50% (one-half) as likely to be arrested? 2 times as likely to be arrested? 4 times as likely to be arrested? 8 times as likely to be arrested?

A subset of 15 participants completed one inpatient laboratory study for which they were screened (Greenwald et al., 2014). In one session (presented randomly in the context of other conditions that are not central here), these participants could work for 10-mg units of intranasal cocaine or $1.00 money units on an 11-trial choice, progressive ratio schedule. The participant could allocate these choices in any manner, e.g., earn the maximum cocaine dose of 110-mg (i.e., 11 trials X 10-mg per trial, but no money would be earned) or $11 (i.e., 11 trials X $1 per trial, but no cocaine would be earned), or a mixture of cocaine and money (but not the maximum amount of either).

2.3. Data analyses

Participants were included in the data analyses if they reported recent cocaine use and completed at least part one of the CPUP interview. All analyses were conducted using SPSS v. 21. The sample was divided into quartiles based on the distribution of total past-month income (independent variable). Dependent measures that were not normally distributed were transformed ($\log_{10}$) then used in analyses.

Correlations were computed among CPUP measures, and with cocaine seeking in the laboratory (Greenwald et al., 2014). Pearson correlations were computed between continuous measures, Spearman correlations were used with income quartile (ordinal) data, and Kendall's *tau* correlations were used with cocaine urinalysis (positive/negative) results.

Regression analyses from two independent samples of regular heroin users (Roddy and Greenwald, 2009; Roddy et al., 2011) led to creation and use of the CPUP in this project. In those earlier studies, we observed that (1) total past-month income was significantly related to drug purchasing and/or use; (2) drug purchasing measures (weekly purchases, purchase time, purchase amount) were significantly related to one another; and (3) drug use was significantly related to purchasing measures (positively) and unit price (negatively). Based on these findings, we hypothesized these variables might be related among cocaine users. Thus, we decided that using strict family-wise error adjustment for multiple correlation tests shown in Table 4 would be overly conservative and increase Type 2 error rate (Curtin and Schulz, 1998). Thus, we employed the Benjamini and Hochberg (1995) step-up procedure. To reduce the dimensionality of selected CPUP measures, we conducted a Varimax-rotated principal component analysis, toward parsimonious interpretation of these measures.

For examining associations between naturalistic and laboratory cocaine seeking, we computed Pearson correlations between the number of cocaine 10-mg unit choices (vs. $1 unit alternative) and five measures related to naturalistic drug acquisition: cocaine unit price and purity, purchase time, purchase amount, and number of weekly purchases.

One-way Analyses of Variance (ANOVAs) and Tukey *post hoc* tests were conducted to identify income-quartile group differences in the CPUP interview and simulation data. A mixed model ANOVA was used to analyze hypothetical change in cocaine purchasing in relation to risk of arrest. For all statistical analyses, significance level was set at $p < .05$.

3. Results

3.1. Participant characteristics

CPUP interview data were available for 83 participants. The overall sample was primarily male (66 male, 17 female) and African-American (64 AA, 15 white, and 4 multi-racial or Hispanic). Mean (±1 SD) age was 45.4 ± 6.9 years and most participants had at least a high school education ($M = 13.1 \pm 1.6$ years). Demographic characteristics (gender, race, age, education level) and body mass index ($M = 26.5 \pm 4.9$) did not significantly differ across income quartile groups.

Reported duration of lifetime cocaine use was 21.1 ± 7.7 years. Smoking 'crack' (90.4%) or insufflating/'snorting' cocaine (9.6%) were the primary routes of use. Based on urinalyses at the initial screening visit, 75% of subjects tested positive for cocaine, 29% were positive for marijuana, and 1% tested positive for benzodiazepines.

3.2. Past-month cocaine purchasing and use patterns as a function of income

3.2.1. Income generation—Total past-month income ranged from $275 to $5800. Each income quartile had 20 or 21 individuals. Table 1 indicates the proportions of income

obtained from various sources. Employment was the proportionally largest source of income (at least one-third) overall, especially for the highest quartile. Illegal income also was proportionally largest for the highest quartile. Conversely, proportion of public assistance income decreased across quartiles. Proportion of income from family/friends was smaller in the fourth than third quartile group.

3.2.2. Expenditures—In the overall sample, greater proportional expenditure of income on cocaine was significantly related to lower proportional expenses on food ($r = -.40$), shelter/utilities ($r = -.51$), and non-drug personal items ($r = -.53$), all ps < .001. Table 2 presents proportional expenditures on various goods for each income quartile. The groups did not significantly differ in the proportion of past-month income spent on cocaine (averaging 54.5%). Proportional expenditures on food (second highest overall expenditure) significantly decreased as income quartile increased. Spending on non-drug personal items and shelter/utilities ranked third and fourth (ranging from 5 to 16% of income). Although expenditures in other substances and savings were smaller (<5% of income), proportional marijuana expenditures were highest in the third quartile, and heroin expenditures were highest in the fourth quartile. Participants generally did not report savings.

3.2.3. Cocaine purchasing and use—Table 3 summarizes income quartile differences in naturalistic cocaine purchasing and use. Higher income quartile showed significant positive relationships with the frequency and amount of cocaine used during the past month (DHUQ), and with weekly frequency of cocaine purchases and daily use, but was unrelated to cocaine purchase time or amount per occasion (CPUP).

Table 4 lists correlations between CPUP interview-based measures of income, cocaine supply and purchasing factors, and cocaine use. Income quartile was positively related to weekly number of cocaine purchases, expenses, and amount of use. Cocaine purchase time and amount (positively related to one another) were each negatively related to weekly purchasing frequency, indicating an efficiency tradeoff (i.e., longer purchase times and larger amounts but fewer purchases). More frequent cocaine purchasing was associated with having more suppliers and a lower unit price, and with greater likelihood of a cocaine-positive urine drug screen. Higher unit prices were associated with fewer weekly purchases and less daily cocaine use.

Table 5 presents Varimax-rotated factor loadings from principal component analysis of the nine CPUP variables that cover past-month behavior (i.e., same as Table 4, but without urinalysis results). Factor 1 had positive loadings of income quartile, purchasing and consumption. Greater income facilitates greater cocaine use, so this factor was labeled ‘income elasticity’. Factor 2 had positive loadings of cocaine unit price and purchase amount, and negative loading of weekly purchases. Higher unit prices should result in greater episodic purchasing amounts, and number of weekly cocaine purchases might correspondingly decrease, so this factor was labeled ‘demand-efficiency’. Factor 3 had positive loadings of subjective cocaine purity and purchase time, and negative loadings of daily use amount and number of dealers. Higher cocaine purity (which could reduce cocaine use) might motivate subjects to tolerate longer travel time to a select dealer, so this factor was labeled ‘narrow supply chain’.

3.3. Cocaine purchasing and use in response to simulated perturbations of cost factors

Table 3 (lower rows) indicate the effect of a hypothetical increase or decrease in monthly income on cocaine use, and effects of a change in dealer or loss of two specific types of income (family/friends or government aid) on cocaine use. In each case, there was a significant effect of income perturbation, and a significant effect of income quartile. Fig. 1 shows anticipated changes in cocaine purchasing as hypothetical risk of arrest increases. All income quartiles differed and were sensitive to risk (arrest probability), but there was no interaction. Some respondents indicated their cocaine use would not decrease but, rather, they would purchase larger quantities less often to reduce risk of arrest.

3.4. Relationships between naturalistic and experimental cocaine seeking behavior

We determined whether five CPUP purchasing-related variables would relate to experimental cocaine choices. Among the 15 participants who also completed the laboratory study (Greenwald et al., 2014), number of cocaine 10-mg unit choices positively correlated with cocaine purchase time ($r = 0.52$, $p < .05$), and negatively correlated with cocaine purity ($r = -0.53$, $p < .05$) in the naturalistic setting, but experimental choices were not significantly related to naturalistic cocaine unit price, purchase amount, or number of weekly purchases.

4. Discussion

In this metropolitan community sample of cocaine users, there were several notable findings related to behavioral economic patterns of cocaine acquisition and use. First, income-generating activities and amounts varied considerably across participants. The three upper income quartile groups reported their two largest proportional sources of income were from legitimate work and illegal activities (Table 1). In contrast, the lowest quartile (which, if their past-month income is extrapolated cautiously to a yearly total, falls below the 2013 U.S. federal poverty line of $11,490 for a single-member household; http://aspe.hhs.gov/poverty/13poverty.cfm; accessed 3/24/14) reported legitimate work and public assistance as their two major income sources. Not surprisingly, proportion of public assistance dropped markedly (4.6-fold) from lowest to highest quartiles. In contrast, proportional income from unemployment insurance, borrowing on credit, legalized gambling, and savings were minimal (≤5%) and did not differ across quartiles. Unexpectedly, the third quartile received proportionally more money from family/friends than the upper quartile. Although reasons for this finding are unclear, participants in the upper quartile may avoid depending on friends/family due to their substantial other earnings, whereas the third quartile may have relied more on interpersonal subsidies (which rivaled their illegal income) to enhance their economic means. Notably, the CPUP interview attempted to account for such strategies as rent or utility sharing, which some participants reported. The present findings on income-generating activities concur with Cross et al. (2001), who found that more frequent cocaine use was associated with greater total and illegal income. There has been a general lack of attention in the literature to income variation among drug users, the role of interpersonal factors in subsidizing income (e.g., discounted shelter, utilities and food), and how income might influence the persistence of addictive behaviors and treatment outcomes. This study expands knowledge about typically hidden income generating activities of regular cocaine

users, and highlights stark variations in income levels (“haves” and “have-nots”) within this group.

Second, because expenditures differed across participants, we distinguished *proportional* from *absolute* expenditures to emphasize allocation within a constrained budget. Although higher-income individuals spent more absolute money on most goods (cocaine, food, cigarettes, marijuana, personal items), consistent with income elasticity, proportional expenditures did not statistically differ across income quartiles for cocaine, cigarettes, alcohol, personal items, or shelter/utilities (Table 2). The lowest quartile spent more than twice the proportion of income on food than the highest quartile. Mean proportional spending on the primary drug among these cocaine-using participants (54.5%) is lower than among regular heroin users, where mean heroin spending exceeded 70% (Roddy and Greenwald, 2009; Roddy et al., 2011). This could be due to greater influence of physical dependence in the case of heroin, relative to cocaine.

In the overall sample, proportional spending on cocaine was negatively related to spending on food, shelter/utilities, and personal items. These negative associations between proportional expenses on cocaine vs. non-drug goods – but not between cocaine vs. other substances – suggest behavioral specificity in budget constraint, namely, that within this group marginal utilities of some non-drug goods might vary inversely with cocaine utility. This observed relationship is consistent with the practice of contingency management treatment, i.e., enabling patients to obtain non-drug reinforcers more readily by engaging in low-cost behaviors (brief drug abstinence) can initiate longer-term decreases in cocaine consumption (e.g., Rothfleisch et al., 1999; Schumacher et al., 2000). Another implication of these findings is that it may be valuable to conduct behavioral economic assessments at treatment intake among cocaine-dependent individuals (e.g., to identify expenditures on cocaine and other goods), and is consistent with the emerging use of practical money management strategies to promote recovery from substance use disorders (Carpenter-Song, 2012; Chivers and Higgins, 2012; Rosen, 2012; Rosen et al., 2003, 2009). A noteworthy finding from this interview process is that many participants are unaware of, and often surprised by, the proportion of income they spend on their primary drug. Such a discovery may offer a “therapeutic moment” for patients during brief motivational or cognitive-behavioral interventions.

A third outcome of this study, similar to our work with heroin users, is that we replicated patterns and cost-benefit tradeoffs in routine drug purchasing behaviors in these regular cocaine users (Tables 4 and 5). Specifically, there were significant positive associations between number of weekly cocaine purchases with: number of suppliers, cocaine expenses, amount of cocaine used daily, and a cocaine-positive urine drug test. Also, there were negative associations between number of weekly cocaine purchases with: cocaine purchase time, purchase amount, and unit price, such that subjects who purchased cocaine less frequently also had longer travel times to their dealer, they purchased more cocaine per buying episode, and obtained cocaine they reported was relatively higher in purity. These findings imply that similar basic dimensions of behavior may underlie drug-acquisitive and consumption patterns of heroin and cocaine users. However, it remains unknown whether these relationships might generalize to other types of drug users.

Income was positively related to cocaine purchasing/use, consistent with prior findings of income elasticity (Petry, 2000, 2001), which emerged from principal component analysis. However, to establish a more direct relationship, we posed experimental questions to assess whether simulated changes in total income would affect participants' daily cocaine purchasing. This approach of obtaining consumer reaction to simulated change is called 'contingent valuation' (Bateman et al., 2002), and proves useful when real-world prices and purchasing metrics are difficult to observe (Diener et al., 1988). In all scenarios studied (50% decreased or increased income, change in dealer, loss of income assistance from government or family/friends, and increasing arrest risk when purchasing), there was an income effect, such that the high-income group reported they would still use more cocaine daily than lower-income groups (Table 3). Relatively higher past-month income among cocaine users may indicate risk for continued cocaine purchasing when encountering novel challenges, e.g., in the simulation, subjects in the highest-income quartile maintained cocaine demand at relatively high levels despite increased odds of being arrested when buying cocaine (Fig. 1).

Principal component analysis revealed two dimensions besides 'income elasticity', which we labeled 'demand-efficiency' (higher cocaine unit price and purchase amount, and fewer weekly purchases) and 'narrow supply chain' (higher cocaine purity, longer purchase time, less daily use amount and fewer cocaine dealers). This pattern of associations between cocaine cost factors (unit price and purchase time), purity of cocaine available from dealers, and frequency and amount of cocaine acquired, suggests behavioral self-regulation of cocaine purchasing. Eighteen percent of subjects in this sample reported only one past-month dealer, whom they likely selected based on experience with price and perceived purity. Thus, having a single dealer may be self-optimizing more than an externally imposed constraint. In contrast, subjects who bought cocaine from multiple dealers reportedly did not use all dealers with equal frequency. Thus, their purchasing options and choices may have been more variable, and perhaps involved more bartering. This might favor using a 'foraging' approach that minimizes risk-exposure or energy expenditure (Bickel et al., 2004; Pietras et al., 2008). In effect, the user is attempting to resolve a labor-supply problem within multiple complex constraints (e.g., income, dealer reliability, time of day, purchase time, transportation, and current state of cocaine or food deprivation). Under such constraints, the user may adopt a "bliss-point" utilitarian approach (Allison, 1993; Allison et al., 1979; Allison and Boulter, 1982; Staddon, 1979) or "satisficing" strategy (Simon, 1956) that minimizes labor, e.g., shorter purchase time, to obtain sufficiently pure cocaine, which may also conserve time for alternative reinforcing activities.

The final finding of this study is that number of experimental cocaine choices on a progressive ratio schedule of reinforcement, among 15 participants that completed the laboratory study (Greenwald et al., 2014), was positively related to naturalistic cocaine purchase time and negatively related to perceived purity of cocaine. These findings suggest that participants' willingness to respond more (greater effort and time on the progressive ratio schedule) to obtain nearly pure experimental cocaine can be predicted by their habitually longer purchase times and subjectively less pure cocaine in their usual environment. These analogous measures of cocaine reinforcing efficacy across settings

support the external validity of our screening tool that measures naturalistic cocaine seeking behaviors.

Limitations with this dataset and interpretations should be acknowledged. First, subjects were a convenience sample applying to participate in inpatient cocaine self-administration studies, and may not represent all cocaine users. Second, self-reported income and cocaine purchasing/use may not reflect actual levels. However, studies on cigarettes, alcohol, and other drug use (Hatziandreu et al., 1989; Smith et al., 1990; Darke, 1998) suggest that self-report is highly correlated with variables such as state *per capita* sales and biomarkers, thus these may be reliable estimates of actual use. This semi-structured interview approach used careful probing to ensure that participants were internally consistent when responding, and a few subjects' data were excluded for unreliability. Third, several factors that were modeled in the study are not perfectly or even accurately discriminable in real world settings. For instance, cocaine users typically do not know the purity of the drug they are purchasing, prices and quantities may vary from the dealer's stated amounts, likelihood of being arrested cannot be anticipated, and so on. As noted earlier, the use of contingent valuation is intended to measure events that are frequently not directly observable, thus we view these evaluations as provisional estimates. Finally, the sample size of those completing the laboratory study was small relative to the sample that completed the screening interviews, which reduces the ability to make some generalizations.

In summary, these cocaine users exhibited income- and price-sensitive, and efficient purchasing repertoires; high income enabled users to defend higher consumption against simulated cost-related changes. Naturalistic and experimental cocaine purchasing measures were related, providing external validity of interview measures. The extent to which a patient's cocaine demand is more income-elastic, cost-efficient, and narrowly sourced could, in future studies, be examined as a predictor of treatment outcome. This assessment approach may thus have practical value, while improving our theoretical understanding of environmental conditions that maintain cocaine use.

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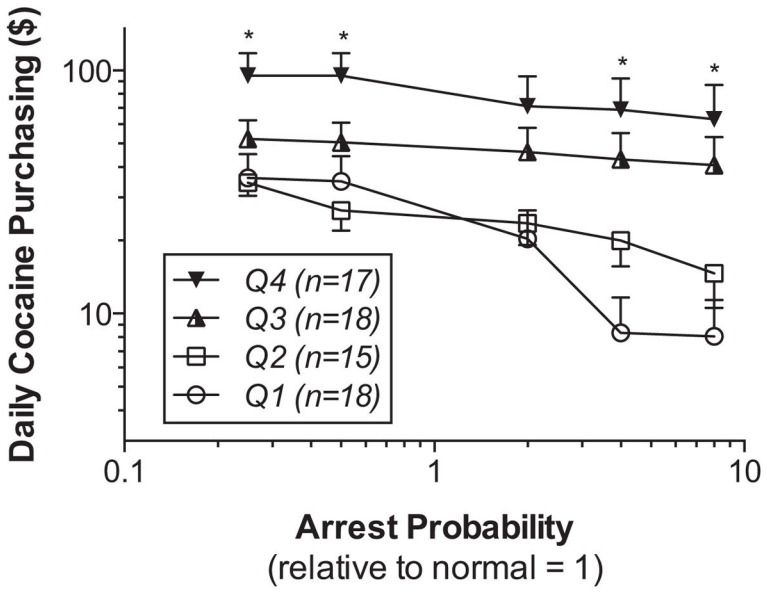

Fig. 1.

Hypothetical changes in daily cocaine purchasing (U.S. dollars) as a function of the likelihood of arrest (0.25–8 times normal risk) when buying cocaine. As shown in this demand curve, the highest-income quartile (Q4) reported they would purchase significantly more cocaine than the low-income quartile (Q1) at most arrest probabilities (asterisks). Overall, there was a main effect of income quartile on expected cocaine purchasing (i.e., a shift in demand intensity), however, cocaine purchasing did not differentially decrease across groups as arrest probability increased (i.e., no group differences in price-elasticity).

Table 1

Mean (±1 SD) total past-month income quartile group differences in sources of past-month income (proportion of total income within quartile).

Income Quartile	Q1 (*n* = 21) $275–$784	Q2 (*n* = 21) $785–$1050	Q3 (*n* = 20) $1051–$1738	Q4 (*n* = 21) $1739–$5800	*df*	*F*	*p*
Employment	33.9 (32.4)	37.2 (31.7)	34.1 (31.9)	48.9 (36.1)	3, 82	0.96	.416
Public assistance	31.6 (25.6)[b]	16.8 (14.9)[a]	10.7 (7.5)[a]	6.8 (6.5)[a]	3, 82	10.12	.000
Illegal income	17.2 (24.7)	16.9 (24.2)	16.1 (18.8)	28.9 (34.3)	3, 82	1.13	.341
Pension/SSI	6.8 (22.3)	11.5 (29.3)	10.3 (18.9)	7.5 (23.0)	3, 82	0.19	.905
Family/Friends	6.3 (11.8)[ab]	9.0 (13.2)[ab]	15.7 (22.6)[b]	2.6 (6.7)[a]	3, 82	2.91	.040
Unemployment insurance	2.5 (11.3)	3.3 (13.8)	5.1 (17.9)	1.5 (6.8)	3, 82	0.29	.833
Borrow on credit	1.2 (2.7)	2.2 (7.1)	0.7 (1.6)	2.7 (5.4)	3, 82	0.82	.487
Legalized gambling	0.4 (1.5)	2.4 (7.1)	3.1 (10.9)	1.1 (4.0)	3, 82	0.68	.565
Savings	0.0 (0.0)	0.7 (3.1)	4.2 (18.7)	0.0 (0.0)	3, 82	0.94	.427

Values are means (±1 SD). Means that share superscript letters do not significantly differ.

Table 2

Mean (±1 SD) past-month expenditures (percentages of total income) for each income quartile group.

Income Quartile	Q1 (*n* = 21) $275–$784	Q2 (*n* = 21) $785–$1050	Q3 (*n* = 20) $1051–$1738	Q4 (*n* = 21) $1739–$5800	*df*	*F*	*p*
Substance items							
Cocaine	53.9 (27.3)	50.9 (24.4)	56.9 (25.1)	56.5 (24.4)	3, 82	0.25	.860
Cigarettes	4.3 (4.0)	3.2 (3.6)	4.3 (4.7)	2.7 (3.2)	3, 82	0.92	.437
Alcohol	3.3 (4.6)	2.4 (4.2)	4.0 (4.4)	1.6 (3.6)	3, 82	1.21	.311
Marijuana	0.3 (0.9)[a]	0.8 (1.3)[a]	3.9 (7.5)[b]	1.4 (3.6)[ab]	3, 82	2.92	.039
Heroin	0.0 (0.0)[a]	0.0 (0.0)[a]	0.1 (0.3)[a]	4.3 (11.6)[b]	3, 82	2.82	.044
Non-substance items							
Food	22.5 (19.2)[a]	17.2 (9.9)[ab]	11.4 (6.7)[b]	10.4 (8.9)[b]	3, 82	4.43	.006
Personal items	10.8 (12.3)	8.4 (10.1)	12.7 (21.3)	16.3 (18.9)	3, 82	0.87	.460
Shelter	5.0 (14.9)	16.0 (21.3)	7.1 (12.5)	4.5 (10.5)	3, 82	2.55	.061
Savings	0.0 (0.0)	1.7 (7.8)	0.0 (0.0)	0.0 (0.0)	3, 82	0.98	.405

Values are means (±1 SD). Means that share superscript letters do not significantly differ.

Table 3

Mean (±1 SD) income quartile group differences in cocaine purchasing, expenditures and use, and anticipated change in expenditures.

Income Quartile	Q1 (*n* = 21) $275–$784	Q2 (*n* = 21) $785–$1050	Q3 (*n* = 20) $1051–$1738	Q4 (*n* = 21) $1739–$5800	*df*	*F*	*p*
Drug history and use questionnaire (DHUQ)							
Past-month cocaine use days (#)	10.5 (8.4)[a]	14.3 (7.0)[a]	14.8 (7.9)[ab]	21.3 (8.4) [b]	3, 81	6.73	.000
Past-week cocaine use days (#)	2.8 (2.1)[a]	3.1 (1.8)[ab]	3.5 (1.8)[ab]	4.6 (2.3)[b]	3, 81	3.08	.032
Avg. cocaine/use-day (# $10 units)	2.1 (1.7)[a]	3.7 (2.7)[ab]	4.6 (4.2)[ab]	5.2 (4.7)[b]	3, 81	3.12	.031
Cocaine purchasing and use patterns (CPUP)							
Current pattern							
Cocaine purchase amount ($)	56.19 (84.81)	31.19 (15.08)	43.50 (32.81)	53.00 (31.72)	3, 82	1.11	.352
Cocaine purchase time (min)	28.1 (20.6)	28.2 (18.1)	28.0 (29.9)	29.4 (34.2)	3, 82	0.13	.998
Cocaine use daily (# $10 units)	4.1 (3.9)[a]	8.6 (7.1)[ab]	12.0 (13.7)[b]	9.1 (6.0)[ab]	3, 80	3.01	.035
Cocaine purchases weekly (#)	3.8 (3.8)[a]	5.5 (5.8)[a]	5.5 (3.7)[a]	11.4 (12.7)[b]	3, 82	4.13	.009
Hypothetical amount [$] that would be spent on cocaine daily (due to changes in income):							
Increase income by 50%	45.14 (37.58)[a]	67.67 (38.49)[a]	75.00 (46.53)[a]	141.18 (107.10)[b]	3, 67	7.08	.000
Decrease income by 50%	17.78 (15.07)[a]	22.33 (13.21)[ab]	39.17 (43.43)[ab]	60.29 (49.26)[b]	3, 67	5.23	.003
New cocaine dealer	33.89 (30.61)[a]	38.86 (17.39)[a]	59.44 (42.87)[ab]	93.53 (68.64)[b]	3, 67	6.28	.001
No help from family/friends	23.24 (24.43)[a]	19.82 (16.83)[a]	33.17 (50.17)[ab]	82.33 (101.79)[b]	3, 60	3.74	.016
No government aid	15.59 (12.61)[a]	29.67 (19.68)[ab]	44.41 (60.28)[ab]	76.47 (89.94)[b]	3, 65	3.64	.017

Values are means (±1 SD). Means that share superscript letters do not significantly differ.

Table 4

Correlations between income[1], cocaine-supply related[2], cocaine-purchasing[3], and cocaine-use[4] variables.

	Total income quartile[1]	**Number of suppliers[2]**	**Unit price[2]**	**Cocaine purity[2]**	**Cocaine expenses[3]**	**Weekly purchases[3]**	**Purchase time[3]**	**Purchase amount[3]**	**Daily cocaine use amount[4]**
Total income quartiel[1]									
Number of suppliers[2] ($\log_{10}$)									
Unit price[2] ($\log_{10}$)		−.23							
Cocaine subjective purity[2]									
Cocaine expenses[3] ($\log_{10}$)	***.71***								
Weekly purchases[3] ($\log_{10}$)	***.38***[a]	***.28***[b]	−.28[b]		***.47***[a]				
Purchase time[3] ($\log_{10}$)				.24[b]		−***.32***[a]			
Purchase amount[3] ($\log_{10}$)			.48[a]		***.32***[a]	−***.37***[a]	***.28***[a]		
Daily cocaine use amount[4] ($\log_{10}$)	***.32***[a]	***.30***[a]	−***.34***[a]	−***.33***[a]	***.43***[a]	***.28***[b]			
Cocaine positive urine sample[4]	.21				.23	.33[a]	−.29[a]	−.21	

Correlations in bold italics replicate similar significant relationships in prior studies with regular heroin users (Roddy and Greenwald, 2009; Roddy et al., 2011; Greenwald et al., 2013). Pearson correlation values of $|r| \leq .20$ are suppressed for clarity. Correlations of $|r| \leq .23$ that were significant at $p < .05$ without adjustment for multiple comparisons ([a]$p < 0.01$; [b]$p < 0.05$) were no longer significant using the Benjamini and Hochberg (1995) step-up procedure to control the false discovery rate (19 of 45 correlations declared significant; effective $p \leq .021$).

Table 5

Varimax-rotated factor loadings from principal component analysis of CPUP measures.

Variable	Factor 1 Income elasticity	Factor 2 Demand-efficiency	Factor 3 Narrow supply chain
Total income quartile	.85		
Cocaine expenses (log_{10})	.93		
Daily cocaine use amount (log_{10})	.61		−.44
Weekly purchases (log_{10})	.56	−.53	
Purchase amount (log_{10})	.37	.84	
Unit price (log_{10})		.76	
Cocaine subjective purity			.87
Purchase time (log_{10})			.60
Number of suppliers (log_{10})	.32		−.38

Total variance explained = 64%. Loadings < |.30| are suppressed for clarity.