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Choice to view cocaine images predicts concurrent and prospective drug use in cocaine addiction☆

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ABSTRACT

Background: Identifying variables that predict drug use in treatment-seeking drug addicted individuals is a crucial research and therapeutic goal. This study tested the hypothesis that choice to view cocaine images is associated with concurrent and prospective drug use in cocaine addiction.
Methods: To establish choice-concurrent drug use associations, 71 cocaine addicted subjects (43 current users and 28 treatment seekers) provided data on (A) choice to view cocaine images and affectively pleasant, unpleasant, and neutral images [collected under explicit contingencies (when choice was made between two fully visible side-by-side images) and under more probabilistic contingencies (when choice was made between pictures hidden under flipped-over cards)]; and (B) past-month cocaine and other drug use. To establish choice-prospective drug use associations, 20 of these treatment-seeking subjects were followed over the next 6 months.
Results: Baseline cocaine-related picture choice as measured by both tasks positively correlated with subjects' concurrent cocaine and other drug use as driven by the actively-using subjects. In a subsequent multiple regression analysis, choice to view cocaine images as compared with affectively pleasant images (under probabilistic contingencies) was the only predictor that continued to be significantly associated with drug use. Importantly, this same baseline cocaine > pleasant probabilistic choice also predicted the number of days drugs were used (cocaine, alcohol, and marijuana) over the next 6 months.
Conclusions: Simulated cocaine choice – especially when probabilistic and when compared with other positive reinforcers – may provide a valid laboratory marker of current and future drug use in cocaine addiction.

1. Introduction

While many individuals who develop maladaptive patterns of drug use are able to successfully recover (Heyman, 2009), an important minority develops chronic, compulsive patterns of substance use characterized by a high risk for relapse even after long-term treatment and abstinence. Identifying variables that predict relapse in treatment-seeking drug addicted individuals is, therefore, a crucial research and therapeutic goal, as select individuals could be targeted for tailored interventions to reduce risk of relapse. Similarly to animal studies where stress, drug cues, or a priming dose of the drug trigger reinstatement (Sinha et al., 2011), variables used to predict relapse in human cocaine addiction have included response to stress (Sinha et al., 2006; but see Preston and Epstein, 2011), craving (Rohsenow et al., 2007), and recent cocaine use including positive urine screens (Ahmadi et al., 2009; García-Fernández et al., 2011; Poling et al., 2007). Other variables have included neuropsychological functioning encompassing the presence of comorbid psychiatric disorders (Poling et al., 2007), poorer commitment to behavioral change (Aharonovich et al., 2008), lower general cognitive and executive functioning (Aharonovich et al., 2008, 2006, 2003; Verdejo-Garcia et al., 2012) and drug-related attention bias (Carpenter et al., 2012, 2006; Marissen et al., 2006).

Our current goal was to identify whether simulated cocaine choice is an additional predictor of relapse. In particular, we aimed to compare the choice to view drug-associated stimuli with the choice to view other pleasant stimuli. This approach parallels human laboratory studies where the availability of alternative reinforcers such as money curbs cocaine self-administration (Donny et al., 2004; Hart et al., 2000; Stoops et al., 2010), especially

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when such alternative reinforcers are easier to obtain (Stoops et al., 2012) or more likely to be available (Vosburg et al., 2010). The availability of money in such studies may improve general decision-making (Vadhan et al., 2009) or incentivize abstinence (e.g., through contingency management) (Higgins et al., 2004). Most relevant to our study goals, money may constitute a suitable alternative reinforcer to drugs, which has been argued as an essential component of choice paradigms (i.e., to differentiate addicted individuals from those who self-administer drugs because of a lack of other viable options; Ahmed, 2010). To model simulated drug-related choice in abstaining individuals (in whom direct drug administration is unethical), we recently developed two neuropsychological drug choice tasks: one with explicit task contingencies and one with more probabilistic task contingencies. On these tasks, individuals with cocaine use disorder (CUD) indicated choice for viewing cocaine images vis-à-vis standardized pleasant, unpleasant, and neutral images; higher choice to view cocaine images, particularly versus choice to view pleasant images (cocaine > pleasant), correlated with more frequent cocaine use in the past month (Moeller et al., 2010, 2009). In the present study, leaning heavily on the research reviewed above that collectively highlights the importance of suitable alternative reinforcers in drug choice paradigms, we hypothesized that higher cocaine > pleasant choice would prospectively predict more severe drug use over the next 6 months. In addition to this central goal of predicting relapse, we tested associations between baseline choice and concurrent drug use in a larger (updated) sample of CUD, while also exploring the influence of individual differences in treatment-seeking status.

2. Methods

2.1. Subjects

Seventy-one CUD (43 active cocaine users and 28 individuals who were seeking treatment for cocaine dependence at study time) were recruited from newspaper advertisements, word-of-mouth, and treatment facilities located in the New York Tri-State Area (see Table 1 for demographic and drug use information). Of these, 39 CUD have been included in prior reports; 32 were studied here for the first time. Moreover, the current study is entirely novel as prior studies did not include prediction of relapse. For predicting relapse, we followed for an additional 6 months after baseline 20 of these treatment-seekers, a CUD subgroup representing the severe end of the addiction spectrum (i.e., as these individuals were currently seeking treatment for their maladaptive and intransigent drug use) and therefore representing an appropriate and important sample in whom to predict relapse. All subjects provided written informed consent to participate in accordance with Stony Brook University's Institutional Review Board. Subjects underwent a comprehensive diagnostic interview (see Supplementary Material for interview components). This interview identified the following cocaine-related diagnoses in the current sample: current cocaine dependence ($N = 55$), cocaine dependence in early partial remission ($N = 8$), cocaine dependence in early full remission ($N = 5$), cocaine dependence in sustained partial remission ($N = 1$), and cocaine dependence in fully sustained remission ($N = 2$) (see Supplementary Material for subjects' comorbidities).

2.2. Procedures

2.2.1. Drug choice tasks (all subjects). Completed at baseline, these two previously validated drug choice tasks have been extensively described elsewhere (Moeller et al., 2009, 2010, 2012a). They use standardized pleasant (e.g., babies), unpleasant (e.g., disfigurement), and neutral (e.g., household objects) images selected from the International Affective Picture System (IAPS; Lang et al., 2008); and matched cocaine images (on size and ratio of human to non-human content) depicting cocaine and individuals preparing, using, or simulating use of cocaine. These choice tasks assess subjects' objective preference for viewing these images, therefore distinct from tasks of attention bias (Carpenter et al., 2012, 2006; Hester et al., 2006; Marissen et al., 2006). In particular, attention is captured by emotional stimuli of both pleasant and unpleasant valence (Hajcak et al., 2010), whereas choice entails computing the value of the given options, involving other considerations such as commodity, cost, risk, and motivation (Padoa-Schioppa, 2011).

2.2.1.1. Explicit choice task. Subjects chose via continued button pressing between two fully-visible side-by-side images from different picture categories. Choice for a desired image enlarged this chosen image to fully cover the screen, which subjects could view for the trial duration of 5000 ms by continued button pressing; 500 ms of non-response, however, returned the side-by-side image display. After each trial, a new trial with new images ensued. Button pressing (i.e., "working") for images was an important design feature of this task, meant to echo classical animal studies where subjects work for drug infusions as related to the severity of addiction. More proximally, it was modeled after a prior functional magnetic resonance imaging study where human subjects button pressed to keep beautiful faces (compared with less attractive faces) on the screen (Aharon et al., 2001). Data processing for this explicit task occurred as follows: during each trial, we calculated which of the two pictures had the higher number of button presses, and then indicated that picture category as the choice for that trial. For example, if during a trial there were 10 button presses for a cocaine image and 8 button presses for a pleasant image, then the score for the trial was scored as '1' for cocaine. We then summed the total number of these 'choices' separately for each picture category (pleasant, unpleasant, neutral, cocaine) across the 70 trials that comprised the task (note that for trials where equal number of presses occurred for both available picture types, the trial was scored as 0.5 for both picture categories).

2.2.1.2. Probabilistic learning choice task. On each trial, subjects chose via a single button press to view pictures hidden under flipped-over cards, arranged in four decks. Immediately after choosing from a particular "deck," an image was revealed that covered the entire screen for 2000 ms of passive viewing. The images were arranged probabilistically: each deck contained 26 (out of a total of 30) pictures from a particular category (e.g., pleasant), allowing pictures from other categories to be interspersed within each deck (two pictures from a secondary category, e.g., cocaine; and one picture from each of the two remaining categories, e.g., unpleasant and neutral). Such incomplete certainty of the choice outcome enabled insight assessment (Moeller et al., 2010, 2012a; see Supplementary Material for description and analyses of this variable vis-à-vis drug use severity). After subjects selected from a particular deck eight total times (corresponding to one task run), deck location of the four picture categories shifted (note that the task was designed so that at least one other picture category would be interspersed within the first eight card draws of each deck, such that each run always included presentation of at least two picture types). Data processing for this probabilistic task occurred as follows: during each trial, the chosen picture category was recorded (e.g., selection of a cocaine deck). Then, across the four total task runs, we summed the total number of deck selections, separately for each of the four picture categories (pleasant, unpleasant, neutral, cocaine). Unlike the "working" component of the explicit task, the probabilistic task was meant instead to tap into more standard