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Differences in self-reported and behavioral measures of impulsivity in recreational and dependent cocaine users☆

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ABSTRACT

Background: Dependent cocaine users consistently display increased trait impulsivity on self-report questionnaires and less consistently exhibit elevated motor impulsivity in some behavioral tasks. However, trait and behavioral impulsivity measures have rarely been investigated in recreational users. Therefore, we examined self-reported trait and motor impulsivities in recreational and dependent cocaine users to clarify the role of impulse control in cocaine addiction and non-dependent cocaine use.
Methods: We investigated relatively pure recreational (n = 68) and dependent (n = 30) cocaine users, as well as psychostimulant-naïve controls (n = 68), with self-report questionnaires (Barratt Impulsiveness Scale 11; Temperament and Character Inventory) and behavioral tasks (Rapid Visual Information Processing Task; Stop-Signal Task).
Results: Compared with controls, recreational and dependent cocaine users displayed higher trait impulsivity and novelty seeking scores on self-report questionnaires. Trait impulsivity scores were strongly associated with an increased number of symptoms of depression and attention deficit hyperactivity disorder and correlated significantly with long-term cocaine intake parameters. By contrast, none of the behavioral motor impulsivity measures showed significant group effects or correlated with cocaine use parameters. The correlations among the self-report measures were high, but self-reports were scarcely correlated with behavioral task measures.
Conclusions: These findings suggest that relatively pure cocaine users already display increased trait impulsivity at a recreational level of use. However, the results do not indicate any cocaine-related elevation of behavioral impulsivity in terms of motor or response inhibition. In summary, our data imply that elevated trait impulsivity is not a specific feature of dependent cocaine use.

1. Introduction

According to the United Nations Office on Drugs and Crime (2012), the annual number of cocaine users (CU) is estimated to be up to 20 million people worldwide. Despite the high addictive potential of cocaine (Nutt et al., 2007), a substantial proportion of CU display a recreational and non-dependent pattern of use (European Monitoring Centre for Drugs and Drug Addiction, 2012).

For years, impulsivity has been recognized as a fundamental feature of substance users (de Wit, 2009). During the past two decades, a growing body of literature has consistently linked impulsivity to the use of cocaine and postulated impaired cognitive control in CU (Beveridge et al., 2008; Bolla et al., 2004; Garavan and Hester, 2007). This relationship has recently been investigated with not only behavioral techniques but also neurobiological and imaging techniques (Perry and Carroll, 2008). Because such imaging studies in chronic CU have repeatedly reported reductions in gray matter density in the dorsolateral prefrontal cortex, anterior cingulate cortex, and orbitofrontal cortex (Bolla et al., 2004; Ersche et al., 2011; Franklin et al., 2002; Matochik et al., 2003), evidence has accumulated that cocaine affects the very same brain regions that are crucially involved in cognitive control (Beveridge et al., 2008; Cabeza and Nyberg, 2000; Garavan and Hester, 2007) and, consequently, impulsivity (Dalley et al., 2011; Garavan and Hester, 2007).

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Impulsivity, a construct with multiple facets (Evenden, 1999), is generally defined as behavior that occurs rapidly and lacks planning and foresight (Moeller et al., 2001a). Various instruments exist that measure a range of attitudes generally termed as "impulsive" (Dawe et al., 2004). Regarding substance use, previous studies primarily focused on constructs such as trait impulsivity, disinhibition, novelty seeking, and reward discounting (Dawe et al., 2004; de Wit, 2009). Whereas trait impulsivity was mainly assessed with self-report questionnaires relying on individual self-perception, impulsive action or choice was assessed with behavioral tasks (Winstanley et al., 2010). However, trait and behavioral impulsivity measures commonly displayed only slight correlations in healthy individuals (Lijffijt et al., 2004; Reynolds et al., 2006).

Chronic or dependent cocaine use has consistently been associated with higher scores for trait impulsivity and novelty seeking on self-report questionnaires. Research has also revealed that dependent cocaine users (DCU) display impaired performance in behavioral impulsivity measures such as Stop-Signal and Go/No-go tasks (Ersche et al., 2010; Perry and Carroll, 2008; Verdejo-Garcia et al., 2008). Preliminary data from a small study using the Stop-Signal Task (SST) have also suggested impaired inhibitory control in recreational cocaine users (RCU; Colzato et al., 2007). Additionally, a large study has confirmed higher self-reported impulsivity in recreational stimulant users (Reske et al., 2010).

Although the link between impulsivity and cocaine use seems to be proven, there exists a lack of clarification on the relation between different facets of impulsivity and the extent of cocaine use. It is also unknown whether elevated impulsivity affects only DCU or whether RCU are also affected. Clarifying this issue is important notably in regard to risk markers, prevention, and treatment success (Patkar et al., 2004). Studies investigating impulsivity in a large sample of pure RCU, with little or no polydrug use, do not exist. Furthermore, impulsivity analysis studies categorized for groups of differing cocaine use patterns, ranging from RCU to DCU, have not been published thus far. Therefore, we investigated fairly large samples of relatively pure RCU, DCU, and matched stimulant-naïve healthy controls with a comprehensive battery of commonly used impulsivity measures (de Wit, 2009; Perry and Carroll, 2008). The aims were to examine different aspects of impulsivity and to clarify the role of impulsivity in cocaine addiction and controlled use. Based on previous results of elevated impulsivity scores in DCU, we expected to find increased trait and behavioral impulsivity in DCU and similar, albeit less pronounced, results in RCU. Because attention deficit hyperactivity disorder (ADHD; Wilson, 2007), craving (Tziortzis et al., 2011), and depression (Swendsen and Merikangas, 2000) have been linked to both impulsivity and substance use, we also assessed their relationships with cocaine use. Finally, by performing quantitative urine and hair toxicology analyses, we were able to characterize objectively the participants' drug use over the past six months.

2. Methods

2.1. Participants

The study included 68 RCU, 30 DCU, and 68 healthy and cocaine-naïve controls (recruitment and selection details appear in Supplementary Methods 1[1]). Specific inclusion criteria for the two user groups were cocaine as the primary used illegal drug, cocaine use of >0.5 g per month, and abstinence duration of <6 months. Cocaine dependence was diagnosed in accordance with the Diagnostic and Statistical Manual of Mental Disorders IV (DSM-IV; American Psychiatric Association, 1994), with only DCU fulfilling the dependence criteria. Exclusion criteria for all participants were an acute or previous neurological disorder or head injury, any clinically significant medical diseases, and use of prescription drugs affecting the brain. Additional exclusion criteria for the control subjects were any Axis I DSM-IV psychiatric disorder, including ADHD, and any form of addiction or regular illegal drug use (lifetime >15 occasions), with the exception of recreational cannabis use. Specific exclusion criteria for the CU groups were use of opioids, a polytoxic drug use pattern, and any Axis I DSM-IV adult psychiatric disorders, with the exception of cocaine, cannabis, and alcohol abuse; history of affective disorders (acute major depression was excluded); and ADHD. All participants were asked to abstain from illegal substances for a minimum of 72 h and from alcohol for at least 24 h before the testing session. Compliance with these instructions was controlled by urine and 6-month hair toxicologies (Supplementary Methods 2[2]). The study was approved by the Cantonal Ethics Committee of Zurich. All participants provided written informed consent and were compensated for their participation.

2.2. Procedure

The cross-sectional data presented in this article were collected as part of the longitudinal Zurich Cocaine Cognition Study (ZuCo^{2}St; Hulka et al., 2013; Preller et al., 2013; Vonmoos et al., 2013). The Structured Clinical Interview for DSM-IV Axis I disorders (SCID-I) was carried out by trained psychologists. The Mehrfachwahl Wortschatz Intelligenztest (MWT-B) was applied to estimate premorbid verbal intelligence (Lehrl, 1999). Drug use was assessed by means of a structured and standardized interview for psychotropic drug consumption (Quednow et al., 2004). The brief version of the Cocaine Craving Questionnaire (CCQ) was used to capture current cocaine craving (Sussner et al., 2006). The current severity of depression was measured by the Beck Depression Inventory (BDI; Beck et al., 1961), and the ADHD self-rating scale (ADHD-SR; Roesler et al., 2004) captured the DSM-IV criteria of ADHD. To consider the various aspects of impulsivity, we applied four measures often used in substance use studies (de Wit, 2009; Perry and Carroll, 2008): two self-report questionnaires for trait impulsivity (Barratt Impulsiveness Scale, BIS-11; Patton et al., 1995) and novelty seeking (Temperament and Character Inventory, Novelty Seeking Scale, TCI NS; Cloninger et al., 1999) as well as the two behavioral tasks, Rapid Visual Processing (RVP; www.cantab.com) and SST (Logan, 1994) for motor or response inhibition (details in Supplementary Methods 3[3]). The RVP was based on a standardized procedure described in the test manual (www.cantab.com), and the SST was based on the stop-signal paradigm software STOP-IT (Verbruggen et al., 2008). The SST requires subjects to respond quickly to pseudo-randomly presented visual go-signals on a computer screen (arrows to left/right, 50% each) and to inhibit a response when an auditory stop-signal occurs (25% of trials). Thirty-two not further analyzed practice trials were followed by three blocks of 64 trials. A staircase tracking procedure systematically varied the time between the go stimuli and stop signals until the stop-signal delay was found (the point when the participant was able to inhibit the responses 50% of the time).

The behavioral tasks were always presented in the same order during a standard neuropsychological test battery, as published elsewhere (Vonmoos et al., 2013). Participants were allowed to take breaks at any time, and smoking was permitted during the breaks.

2.3. Statistical analysis

Statistical analyses were performed with IBM SPSS Statistics 19.0. Frequency data were analyzed by means of Pearson's chi-square test, and quantitative data by analysis of variance (ANOVA). Sidak post hoc comparisons were performed based on significant main effects.

Because evidence suggests that some facets of impulsivity change throughout the life span (Steinberg et al., 2008), age was introduced as a covariate in analysis of covariance (ANCOVA; uncorrected ANOVA in Supplementary Table 1[4]). Pearson's product-moment correlation analyses were conducted across a consolidated CU group to relate cocaine use parameters to each other and to impulsivity measures. Cumulative cocaine use and weekly use in grams were ln-transformed for statistical analyses because of the highly skewed distribution and the resulting deviation from the normal distribution (Shapiro–Wilk $W < .001$).

Some data were missing owing to incomplete questionnaires (TCI: 1 control, 2 DCU) or technical failures (RVP: 1 control; SST: 1 control, 1 RCU, 1 DCU; urine toxicology: 1 RCU; hair toxicology: 3 controls, 1 RCU).

For the SST parameter stop-signal reaction time (SSRT), reliable estimates, as calculated in this study, depended on a horse-race model with a staircase tracking procedure, resulting in a probability (respond/signal) of ideally .5 (Verbruggen et al., 2008). Because the SSRT analysis is not useful for subjects significantly differing from this value (Verbruggen et al., 2008), we excluded an additional 6 participants (2 controls, 2 RCU, 2 DCU) with a deviation of more than two standard deviations of the total sample.

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