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The role of childhood maltreatment in the altered trait and global expression of personality in cocaine addiction

Lisa K Brents, Shanti Prakash Tripathi, Jonathan Young, G Andrew James, and Clinton D Kilts

Brain Imaging Research Center, Psychiatric Research Institute, University of Arkansas for Medical Sciences, Little Rock, AR

Abstract

Background and aims—Drug addictions are debilitating disorders that are highly associated with personality abnormalities. Early life stress (ELS) is a common risk factor for addiction and personality disturbances, but the relationships between ELS, addiction, and personality are poorly understood.

Methods—Ninety-five research participants were assessed for and grouped by ELS history and cocaine dependence. NEO-FFI personality measures were compared between the groups to define ELS- and addiction-related differences in personality traits. ELS and cocaine dependence were then examined as predictors of personality trait scores. Finally, k-means clustering was used to uncover clusters of personality trait configurations within the sample. Odds of cluster membership across subject groups was then determined.

Results—Trait expression differed significantly across subject groups. Cocaine-dependent subjects with a history of ELS (cocaine+/ELS+) displayed the greatest deviations in normative personality. Cocaine dependence significantly predicted four traits, while ELS predicted neuroticism and agreeableness; there was no interaction effect between ELS and cocaine dependence. The cluster analysis identified four distinct personality profiles: Open, Gregarious, Dysphoric, and Closed. Distribution of these profiles across subject groups differed significantly. Inclusion in cocaine+/ELS+, cocaine-/ELS+, and cocaine-/ELS- groups significantly increased the odds of expressing the Dysphoric, Open and Gregarious profiles, respectively.

Conclusions—Cocaine dependence and early life stress were significantly and differentially associated with altered expression of individual personality traits and their aggregation as

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Address correspondence to: Clint Kilts PhD, Psychiatric Research Institute, University of Arkansas for Medical Sciences, 4301 W. Markham St, Mail Slot 554, Little Rock, AR 72205, cdkilts@uams.edu, Phone: (501) 526-8163, Fax: (501) 526-8199.

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personality profiles, suggesting that individuals who are at-risk for developing addictions due to ELS exposure may benefit from personality centered approaches as an early intervention and prevention.

Keywords

childhood maltreatment; addiction; five-factor model; personality; person-centered; resilience

INTRODUCTION

Drug addiction remains a major socioeconomic problem associated with marked morbidity and mortality. Genetic and environmental factors are thought to represent the major determinants of drug addiction (Agrawal and Lynskey, 2008, Enoch, 2012), though their impacts are often indirect and intertwined with intermediate factors such as personality variables (Davis and Loxton, 2013, Gorwood et al., 2012). Personality is defined as an individual's set of enduring, largely predictable traits, behaviors, and thought processes and is represented by both individual traits, such as neuroticism and impulsiveness, as well as clusters or profiles that represent global trait organization. Although most personality studies of drug use disorders (DUDs) focus on categorical DSM-defined Axis-II personality disorders (PDs), individuals who have or are at high risk for having a DUD also deviate significantly from general population scores for dimensional, non-pathological personality traits (Allen and Lauterbach, 2007, Drerup Stokes et al., 2013, Franken et al., 2006, Kotov et al., 2010, Sher et al., 2000).

Every stage of the addiction process, from drug use initiation to relapse, is closely associated with altered normative personality trait expression (Elkins et al., 2006, Grekin et al., 2006, Prisciandaro et al., 2011). Certain personality traits predict DUDs (Lukasiewicz et al., 2008, Turiano et al., 2012) and are associated with an early onset of drug use (Anderson et al., 2007, Malmberg et al., 2012, Nees et al., 2012), the transition from impulsive to compulsive drug abuse (Ersche et al., 2013), and an increased risk of drug use relapse (Fisher et al., 1998).

Childhood adversity, which represents a major risk for drug addiction (Dube, et al., 2003), is highly associated with personality alterations. Although personality variation is approximately 50% heritable (Turkheimer et al., 2013), personality development is significantly influenced by early-life experience, especially adversity and maltreatment (Congdon et al., 2012). Particular subtypes of childhood maltreatment (e.g., physical abuse, sexual abuse, emotional neglect) are each associated with increased risk for specific PDs (Nederlof et al., 2010, Zhang et al., 2012), and experiencing multiple subtypes of maltreatment increases risk of having one or more PDs (Zhang, Chow, 2012). PDs are frequently comorbid with other psychiatric disorders such as DUDs with a reported 46% prevalence of one or more PDs in a DUD inpatient population (Langas et al., 2012). As the number of adverse childhood experiences increases, graded increases occur in the prevalence of PDs and the risk of DUDs (Dube, Felitti, 2003, Johnson et al., 2006). Evidence suggests that personality development that has been negatively impacted by early life adversity may act to strengthen the association between susceptibility for DUDs and

early life stress (ELS) (Kim et al., 2009) (Oshri et al., 2013). The drug addiction process, therefore, has well-established relationships to both personality development and childhood maltreatment, but—to our knowledge—the distinct personality outcomes associated with ELS, drug addiction and their interaction have not been previously reported. Such new knowledge could support the development of personality-targeted interventions that promote resilience and prevent addictions in at-risk individuals who have a significant history of ELS. Similarly, Conrod and colleagues successfully reduced drug and alcohol use behaviors in adolescents by assessing problematic trait expression (e.g., sensation seeking, impulsivity, anxiety sensitivity, hopelessness) to identify at-risk individuals, who then received cognitive behavioral therapy (Conrod et al., 2010, Conrod et al., 2013). The present study expands these findings by identifying divergences in personality expression between resilient and susceptible subjects who each carry a major risk factor for addiction (i.e., ELS).

The present study investigated relationships between drug (i.e., cocaine) addiction, exposure to childhood maltreatment and personality variation (Figure 1). We performed a secondary analysis of a case-control, cross-sectional dataset that probed the brain-behavior relationships underlying impulsivity in ninety-five individuals, including participants who were cocaine dependent at the time of recruitment (Elton et al., 2014a, Elton et al., 2014b); therefore, the personality trait scores measured in the present study were taken from individuals who had already developed cocaine dependence. This study does not exhaustively probe the directionality of every possible relationship between ELS, cocaine dependence and normative personality; rather, its purposes are to determine if and how ELS history or absence affects personality expression in cocaine-dependent individuals and whether resilient individuals (those with ELS history but no addiction) display unique personality features. In the present work, we tested the overall study hypothesis that ELS history and cocaine dependence are associated with distinct alterations in personality. As enumerated in Figure 1, the following specific hypotheses were also tested: 1) that ELS and cocaine dependence each predict altered personality trait expression, 2) that ELS and cocaine dependence interact in predicting altered personality expression, 3) that clusters of distinct trait configurations, referred to as profiles, would emerge from within the sample, and 4) that ELS and cocaine dependence would be selectively associated with specific personality profiles. To test these hypotheses, we compared personality traits (trait-centered approach, Figure 1A) and trait configurations as profiles (person-centered approach, Figure 1B) (Crockett et al., 2006) across four groups of adults that differed with respect to the presence and absence of cocaine dependence or moderate to severe ELS. We constructed multiple linear regression models that predict trait expression for ELS and cocaine dependence status. Because clusters of multiple personality dimensions better predict psychopathology and risk profiles than do individual traits (Janson and Mathiesen, 2008, Rettew et al., 2008, Wessman et al., 2012), we used a data-driven cluster analysis of trait expression to uncover the most prevalent combinations of traits (i.e., profiles) among individuals within the sample (see Supporting Information). We also determined how subject group membership affects the odds of expressing each personality profile. The identification and analysis of specific personality traits was based on the well-established five-factor model (FFM) of personality (McCrae and Costa, 1985). To our knowledge, this is the first case-control cross-sectional study design used to test the hypothesis that both

cocaine addiction and exposure to childhood maltreatment are associated with significant alterations in personality and that their co-occurrence is associated with increased risk of expressing specific profiles of altered personality traits.

METHODS

Subjects

Ninety-five participants ages 18 to 50 (37 female, mean age 38 ± 8.8 years) were enrolled in the study. Recruitment advertisements targeting individuals with childhood maltreatment, current cocaine dependence and healthy comparison subjects were posted in the community (Little Rock, AR), including city buses, and in area newspapers. A phone screening preliminarily assessed study eligibility and described the study procedures; eligible participants provided written informed consent to participate in the study. Prior to recruitment, all advertisements and study procedures were approved by the Institutional Review Board at the University of Arkansas for Medical Sciences (Little Rock, AR).

Recruitment was performed in two cohorts. For cohort 1 ($n = 84$), presence of current Axis 1 disorders other than cocaine dependence represented an exclusion criterion; nicotine dependence or alcohol dependence were exceptions to this, provided that cocaine was the preferred drug of abuse. Non-cocaine-dependent subjects were excluded if they had current or lifetime drug or alcohol dependence. Other lifetime Axis 1 disorders were permitted for all subjects as long as symptoms had been absent for at least 1 year. For cohort 2 ($n = 11$), exclusion criteria were slightly less stringent and allowed for current Axis I mood and anxiety disorders (see Table 1). To ensure that the differences in exclusion criteria did not confound results, scores for each personality trait were compared between the two cohorts with a Student's *t*-test. There was no significant difference in personality trait scores between the cohorts ($P = 0.17, 0.79, 0.23, 0.69, 0.23$ for neuroticism, extraversion, openness, agreeableness and conscientiousness, respectively); therefore, the two cohorts were collapsed into one group.

For both cohorts, exclusion criteria were presence of major medical disorders (such as organ disease) and medically unstable allowable medical disorders (e.g., hypertension, diabetes). Because subjects were concurrently recruited for a functional MRI study, additional exclusionary criteria were related to MRI contraindications, including pregnancy (determined through urinalysis), claustrophobia, loss of consciousness for greater than 10 minutes, medications known to alter hemodynamic coupling (e.g., beta blockers, diuretics), and ferromagnetic implants (e.g., pacemakers and aneurysm clips).

Assessments

Cocaine dependence (+/–) and other current or lifetime DSM-IV Axis 1 disorders were assessed in all subjects with a Structured Clinical Interview for DSM-IV Axis 1 Disorders (SCID-1) (First et al., 2007) that was administered by an experienced master's-level research coordinator.

Measures of ELS and addiction severity were compared across the subject groups using the Childhood Trauma Questionnaire (CTQ) and the Addiction Severity Index (ASI),

respectively. The CTQ is a 28-item questionnaire with items scored by a 5-point Likert scale. It provides a quantitative measure of physical and emotional abuse and neglect and of sexual abuse with acceptable-to-excellent within-factor reliability in multiple respondent populations ($0.61 < \alpha < 0.95$) and factors significantly predicting therapist ratings in a criterion-related validation analysis (Bernstein et al., 2003). For some analyses, ELS severity was dichotomized (+/−) by a median split of CTQ total scores. Elsewhere, CTQ scores were used as a continuous variable to characterize ELS severity. The ASI, which has high concurrent reliability (0.74–0.99) and significant concurrent validity (McLellan et al., 1992) quantifies status for seven aspects of functioning: medical, employment, alcohol, drug, legal, family, and psychiatric (McLellan, Kushner, 1992). Personality was assessed with the NEO-FFI, a self-reported, 60-item questionnaire that has high retest reliability (0.86–0.90), good internal consistency ($\alpha = 0.68$ –0.86) and high correlation (>0.76) with the full NEO-PI-R (McCrae, 2004). The NEO-FFI is a widely used assessment that is based on the FFM of personality (Costa and McCrae, 1992, Saucier, 1998), which was empirically derived from factor analysis of trait-descriptive adjectives (Cattell, 1943, Norman, 1963, Tupes and Christal, 1992). The five personality factors measured by the NEO-FFI are neuroticism, extraversion, openness to experience (hereafter referred to as “openness”), agreeableness, and conscientiousness. Neuroticism is subserved by the facets *self-reproach* and *negative affect*; extraversion is subserved by *positive affect*, *sociability*, and *activity*; openness is subserved by *aesthetic interests*, *intellectual interests*, and *unconventionality*; agreeableness is subserved by *nonantagonistic orientation* and *prosocial orientation*; and conscientiousness is subserved by *orderliness*, *goal-striving*, and *dependability* (Saucier, 1998). Items in the NEO-FFI are self-descriptive statements written in a first-person narrative (e.g., “I like to have a lot of people around me.” “I generally try to be thoughtful and considerate.”), to which subjects can respond either “I strongly disagree,” “I disagree,” “I’m neutral,” “I agree,” or “I strongly agree.” These possible responses correspond with a 5-point Likert scale, which ranges from 0–4 (0 being “I strongly disagree,” and 4 being “I strongly agree”). Each item corresponds with one personality factor, and items are evenly divided among the personality factors (i.e., there are 12 items per factor). Twenty-seven of the 60 items on the NEO-FFI were reverse scored. Personality factor scores were attained by summing the item scores within each personality factor. A subject’s score for a given personality factor was excluded if he or she failed to give one response for each item within that personality factor (i.e., gave no response or more than more response per item); this resulted in subject samples of $n=93$ for neuroticism, $n=91$ for extraversion, $n=92$ for openness, $n=93$ for agreeableness, and $n=92$ for conscientiousness.

Statistical analysis

Assessment of the association of personality traits and trait configurations with cocaine dependence and childhood maltreatment involved a four-step data analysis plan. To initially assess how trait expression differed with the presence or absence of ELS and cocaine dependence, we first performed a group-wise comparison of individual personality traits based on subject classification across two sets of independent variables—cocaine dependence (+/−) and ELS (+/−) (Table 2). Second, to assess independent and interaction effects on personality trait expression, a step-wise multiple linear regression analysis was used to test cocaine dependence (+/−), ELS (CTQ scores) and demographic covariates (age,

sex, education, income, and employment) as predictors of personality (Table 3). Third, to assess the effects of cocaine dependence and ELS on comprehensive, global personality organization, subjects with similar constellations of FFM personality trait expression were segregated in a cluster analysis to identify predominant FFM personality profiles within the sample (person-centered cluster analysis detailed in Supporting Information; cluster selection criteria are shown in Table S1). The resultant major aggregate personality profiles are displayed in Figure 2. Finally, this global organization of the FFM personality traits was examined as a function of cocaine dependence and ELS by comparing the personality profile compositions of each subject group. A chi-squared analysis of personality profile prevalence across subject groups was performed first, followed by binomial logistic regression to predict the odds of expressing each personality profile (vs. expressing any other profile) given subject group membership.

Between-group differences in individual personality factor scores were assessed with one-way analysis of variance (ANOVA) with a significance level of $P < 0.05$, followed by *post-hoc* analyses of all possible pair-wise comparisons, using Bonferroni correction for 6 multiple comparisons ($P < 0.0083$). Correlations among personality factors were assessed with Pearson correlation analysis.

One-way ANOVA, binomial logistic regression and associated *post-hoc* analyses were performed with R version 3.0.3 (Team, 2014), Excel 2007 (Microsoft) was used for the χ^2 analysis of subject group by personality cluster distribution and SAS version 9.2 (SAS Institute, Inc.) was used for all other analyses.

RESULTS

Subject groups

Cocaine-dependent subjects were significantly older than non-cocaine-dependent subjects ($P < 0.0083$, one-way ANOVA with Bonferroni's correction for six pairwise comparisons). There were significant group differences in the proportion of subjects with education beyond high school ($\chi^2 = 22.56$, $df = 3$, $P < 0.0001$); subjects in cocaine-dependent groups were less educated than those in non-cocaine-dependent groups. Groups did not differ in sex, race, income, and employment. As expected, cocaine-dependent subjects scored higher on all categories of the Addiction Severity Index (ASI). Overall childhood maltreatment scores for the two ELS+ groups exceeded the 95th percentile scores for the corresponding age group in a community sample (Scher et al., 2001). All incidences of current Axis 1 pathology were from recruitment cohort 2 (see "Subjects" in Methods section). The most prevalent current diagnosis was of PTSD, which occurred in groups cocaine+/ELS+ (11.8%), cocaine-/ELS+ (7.7%), and cocaine+/ELS- (3.3%). Lifetime diagnosis of PTSD was also prevalent and differed significantly across subject groups ($\chi^2 = 10.70$, $df = 3$, $P = 0.01347$); diagnostic criteria were met by 26.5% of cocaine+/ELS+ subjects, 15.4% of cocaine-/ELS+ subjects, and 3.3% of cocaine+/ELS- subjects. The most prevalent lifetime diagnosis across all subject groups was major depressive disorder, ranging from 11.8% of group 4 to 61.5% of group 2 ($\chi^2 = 12.0096$, $df = 3$, $P = 0.00735$). All other diagnoses, current and lifetime, had a prevalence of less than 5% in each group.

Association of cocaine dependence and ELS with individual personality traits

Individual personality trait scores for study control subjects (cocaine-/ELS-, $n=17$) were comparable to those of the general population (Saucier, 1998). Consistent with Hypothesis #1, Table 2 shows that subject group had a significant effect (one-way ANOVA, $P < 0.05$) on scores for four personality factors: neuroticism, openness, agreeableness, and conscientiousness; there were no group-wise differences for extraversion. Pair-wise comparisons using Bonferroni's correction demonstrated that cocaine+/ELS+ subjects ($n=32-34$) were significantly more neurotic, less open, less agreeable, and less conscientious than control subjects (cocaine-/ELS-). Additionally, cocaine+/ELS+ subjects expressed lower openness than their non-cocaine dependent counterparts (cocaine-/ELS+, $n=13$). Cocaine-dependent subjects with little or no history of ELS (cocaine+/ELS-, $n=29-31$) were also significantly less open than non-cocaine-dependent subjects (cocaine-/ELS+ and cocaine-/ELS-). In contrast, neuroticism differed significantly between cocaine-dependent subjects who experienced ELS (cocaine+/ELS+) and those who did not (cocaine+/ELS-), with cocaine+/ELS+ subjects expressing greater neuroticism.

Prediction of personality trait expression by cocaine dependence and ELS

We used multiple linear regression modeling to determine whether cocaine dependence (+/-) and ELS (CTQ scores) predicted individual scores for neuroticism, openness, agreeableness, and conscientiousness. The models controlled for age (years), employment status (yes/no), sex (male/female), education (12 years or >12 years), and income (median monthly income or >median monthly income). The mean beta-weights from the regression analysis represent the strength of association of the variables with each personality factor. In support of Hypothesis #1, cocaine dependence positively predicted neuroticism and negatively predicted openness, agreeableness, and conscientiousness; ELS positively predicted neuroticism and negatively predicted agreeableness (Table 3). These models explained between 11% and 26% of variance in FFM personality for the sample.

Based on the findings that cocaine dependence and ELS each significantly predicted trait neuroticism and trait agreeableness and that having both cocaine dependence and a history of ELS was associated with the most pronounced personality trait deviations (cocaine+/ELS+, Table 2), we assessed whether cocaine dependence and ELS interact to alter the personality traits of neuroticism and agreeableness. To test this hypothesis, we included the interaction term of cocaine dependence-by-ELS in the multiple linear regression models for neuroticism and agreeableness. This interaction effect hypothesis (Hypothesis #2) was not supported as the interaction term was not a significant predictor of neuroticism ($P = 0.40$) or agreeableness ($P = 0.39$).

Clustering subjects by patterns of personality traits

Individuals express varying configurations of individual personality traits, forming discrete personality profiles that often exhibit non-random associations with population variables (Rentfrow et al., 2013, Wessman, Schonauer, 2012) and better predict developmental outcomes and variables such as psychiatric and somatic health than do individuals traits (Janson and Mathiesen, 2008, Rettew, Althoff, 2008, Shiner and Caspi, 2003, Wessman, Schonauer, 2012). With the exception of neuroticism and openness, each personality trait

was significantly and moderately correlated with all others ($0.24 \leq |r| \leq 0.59$) (Table 4), indicating interdependence of the traits in the present sample and further supporting an analysis of trait configurations. Therefore, we assessed the patterns of FFM trait organization exhibited by the study participants, using a “person-centered” approach (Crockett, Moilanen, 2006) in which a personality profile was constructed from each individual’s five NEO-FFI personality scores.

Similar to Congdon and colleagues’ approach, (Congdon, Service, 2012), a data-driven cluster analysis of the subjects’ aggregate personality trait scores detected four distinct clusters, or profiles, within the subject sample, providing support for Hypothesis #3. As shown in Figure 2, each profile is described as a grouping of the five trait Z-scores relative to the sample mean of the respective trait scores. Consistent with the nomenclature of Rogosch and Cicchetti (Rogosch and Cicchetti, 2004), these profiles were labeled Open ($n=17$), Gregarious ($n=22$), Dysphoric ($n=23$), and Closed ($n=33$). The distinguishing characteristics of the Open and Closed personality profiles were robustly high and low openness scores, respectively. The Closed profile individuals also exhibited elevated neuroticism ($z = 0.25$) and low conscientiousness ($z = -0.36$), while the Open profile individuals showed elevated conscientiousness ($z = 0.30$). The Gregarious profile was characterized by very low neuroticism ($z = -1.14$) and high extraversion ($z = 0.86$), openness ($z = 0.46$), agreeableness ($z = 1.21$), and conscientiousness ($z = 1.13$). Of all the personality profiles, Dysphoric profile individuals exhibited the highest levels of neuroticism ($z = 0.88$) and the lowest levels of extraversion ($z = -1.12$), agreeableness ($z = -0.88$), and conscientiousness ($z = -0.84$). The Gregarious and Dysphoric personality profiles have been previously described (Rogosch and Cicchetti, 2004).

Association of cocaine dependence and childhood maltreatment with personality clusters

Based on this cluster solution, we next examined the personality trait configurations of each subject group to determine whether cocaine dependence and/or ELS are associated with particular configurations of personality traits. Indeed, in support of Hypothesis #4, the subject groups exhibited significantly different compositions of trait configurations ($\chi^2 = 32.2$, $df = 9$, $P = 0.0002$). The predominant personality profile of cocaine-dependent subjects (cocaine+/ELS+ and cocaine+/ELS-) was the Closed type (44% and 37%, respectively) (Figure 3). Cocaine-dependent subjects were also highly represented by the Dysphoric profile; this profile was exhibited by a higher proportion of cocaine+/ELS+ subjects than cocaine+/ELS- subjects (41% and 23%, respectively). Further comparison of the cocaine-dependent groups revealed that cocaine+/ELS- subjects exhibited a higher proportion of both the Gregarious profile (23% vs. 9%) and Open profile (17% vs. 6%) than did cocaine+/ELS+ subjects. The personality profile distributions within the non-cocaine-dependent subject groups differed remarkably from each other, suggesting that ELS influences personality profile. The Gregarious profile predominated for the cocaine-/ELS- group (53%), followed by the Closed profile (24%), the Open profile (18%), and the Dysphoric profile (6%). In contrast, the personality profile of the cocaine-/ELS+ group was predominately Open (54%), followed by Gregarious (23%), Closed (15%), and Dysphoric (8%).

To better understand the relationship of ELS and cocaine dependence with global, person-centered personality, the odds with which subject group membership predicted personality profile was determined using a binomial logistic regression. Results of this analysis, which also provides supporting evidence for Hypothesis #4, are displayed in Table 5. Cocaine dependent subjects with a history of significant ELS (cocaine+/ELS+) were 3.97 times more likely to express the Dysphoric profile vs. any other profile. Subjects who had a history of ELS but were not cocaine dependent (cocaine-/ELS+) were 8.28 times more likely to express the Open profile compared to any other profile. Control subjects in this sample (cocaine-/ELS-) were 5.54 times more likely to express a Gregarious profile than any other profile. Interestingly, being cocaine dependent without having a history of ELS (cocaine+/ELS-) was not associated with increased odds of expressing any particular personality profile.

DISCUSSION

The present study demonstrated that individuals with both cocaine dependence and childhood maltreatment histories have significant and distinct alterations in the expression of both individual personality traits and configurations of traits compared with individuals who have zero or only one of the independent variables. As a group, cocaine-dependent individuals with a history of ELS were significantly more neurotic and less open, agreeable, and conscientious than controls. These findings generally agree with previous reports that high neuroticism, low agreeableness and low conscientiousness are significantly associated with DUDs (Kotov, Gamez, 2010, Sher, Bartholow, 2000). We also report that cocaine-dependent individuals with ELS histories are significantly more neurotic than their non-ELS cocaine-dependent counterparts, whose neuroticism scores did not differ from those of cocaine-/ELS+ subjects or controls. This suggests that previous reports of elevated neuroticism expressed by individuals with DUDs may have been driven by hidden effects of ELS that were not statistically controlled in previous studies. Our finding that ELS predicts neuroticism when cocaine dependence and demographic variables are controlled in a multiple linear regression analysis further supports the idea that ELS promotes neuroticism. Finally, being cocaine dependent with a history of ELS increased the odds of expressing the Dysphoric personality profile, while being cocaine dependent without ELS did not attribute increased odds to any particular personality profile. This suggests that early life adversity may shunt a subset of vulnerable individuals toward expressing the putatively maladaptive Dysphoric profile, which may increase their risk of later drug addiction. This possibility is supported by results of a study on personality organization in children by Rogosch and Cichetti (2004) in which children ages 6–9 who expressed a Dysphoric personality profile were five times more likely to have experienced documented maltreatment than children who expressed other personality profiles. Alternatively, adults with ELS histories who go on to develop cocaine addictions may be more susceptible than cocaine-dependent individuals without ELS to drug-induced changes in personality that result in Dysphoric profile expression.

Unlike most previous studies on FFM and addiction, we found that low trait openness was highly associated with cocaine dependence. Individuals who were exposed to ELS, a well-established risk factor for DUDs, but were not cocaine-dependent (cocaine-/ELS+) were

significantly more open than their cocaine-dependent counterparts (cocaine+/ELS+). Furthermore, the odds of expressing the Open profile were strongly and significantly increased for cocaine-/ELS+ individuals, while cocaine-dependent counterparts of the cocaine-/ELS+ group—that is, cocaine+/ELS+ subjects—had *reduced* odds of expressing the Open profile that did not survive multiple comparisons corrections (see Table 5). It is reasonable to propose that for individuals who were exposed to significant ELS, expressing an Open profile is protective, while expressing the Dysphoric profile is maladaptive, but further study is required to determine if causal relationships exist between ELS, global personality organization, and the prevalence and severity of DUDs.

If future studies confirm that expressing the Open profile and/or elevated openness trait scores confers protection against DUDs and that expressing the Dysphoric profile increases risk of psychiatric problems, such as DUDs, then future preventative interventions for young at-risk individuals with ELS might include using personality-targeted training programs to nurture the development of traits openness, conscientiousness (elevated in Open individuals and reduced in Dysphoric individuals) and agreeableness (reduced in Dysphoric individuals) while reducing neuroticism (elevated in Dysphoric individuals). Such programs would promote adaptive coping strategies that would aim to diminish problematic drug use by young at-risk individuals. This prevention approach is consistent with, and perhaps complementary to, an effective intervention that uses the Substance Use Risk Profile Scale (SURPS) to identify at-risk adolescents by assessing personality risk dimensions (e.g., anxiety, sensitivity, hopelessness, impulsivity, and sensation seeking), followed by a personality-targeted coping skills intervention to prevent early drug and alcohol use behavior (Conrod, Castellanos-Ryan, 2010, Conrod, O'Leary-Barrett, 2013). This strategy also significantly reduced symptoms of common comorbidities of DUDs—depression, anxiety and conduct disorder—in a trait-specific manner (O'Leary-Barrett et al., 2013), which may contribute to the observed reduction in drug use behaviors associated with the intervention. The established long-term effectiveness of this intervention, which focuses on mitigating anxiety sensitivity, hopelessness, impulsivity and sensation seeking (Castellanos-Ryan et al., 2013), validates personality traits as therapeutic targets in decreasing risk of DUDs.

Understanding the biological basis of personality would inform the mechanisms of the prevalent co-occurrence of DUDs and childhood maltreatment histories, but the goal of defining a personality neuroscience has proven challenging even in normative populations. Although personality is highly heritable, the search for personality-associated genes has been relatively unfruitful in explaining trait variance (Turkheimer, Pettersson, 2013). Turkheimer, Patterson and Horn (Turkheimer, Pettersson, 2013) have suggested that personality may be better understood by analyzing it at an endophenotypic level (e.g., neural processing). Functional magnetic resonance imaging has been used in recent years to better understand the brain representation of personality. Such studies typically relate expression of individual personality traits to distributed, segregated regions of neuroactivation that are induced by tasks that engage processes such as emotion regulation, impulse inhibition, attention, anticipation, and reward (Kennis et al., 2013). Few studies have extended this characterization to include models that associate personality traits with patterns of intrinsic,

non-task-dependent neural functional connectivity (Adelstein et al., 2011) or have undertaken the analysis of personality trait profiles rather than individual traits. From this new knowledge, alterations in the neural representation of personality related to psychiatric disorders, such as DUDs, could potentially be identified and targeted by personality-tailored therapies. Furthermore, identifying the specific neural correlates of personality for healthy individuals with risk factors, such as ELS, might provide novel insight into the neural mechanisms of risk and resilience, further informing the development of preventive interventions in at-risk individuals and effective treatments in patient populations.

In conclusion, certain personality traits and profiles may promote a heightened risk of cocaine dependence, while others may be protective to at-risk individuals. The study design, however, has clear limitations that temper study interpretation and impact. The analysis of personality traits and their organization was exclusively based on the FFM; therefore, the association of cocaine addiction and ELS with personality could possibly differ with specific personality constructs and assessment instruments used. While the FFM represents one of the more widely used and accepted constructs for personality research, different taxonomies of personality are stressed by other models, such as Gray's biopsychosocial theory of personality (Gray, 1987, Wilson et al., 1989), Eysenck's theory of personality (Eysenck, 1951), and Cloninger's psychobiological model of temperament and character (Cloninger et al., 1993). This study also does not disentangle the influence of personality in promoting cocaine dependence from the possible alteration of personality by prolonged cocaine use. Prospective longitudinal studies that assess childhood maltreatment, drug use initiation and progression, and personality across childhood, early adolescence, and adulthood would offer direct insight into the relationship of these three variables and better define possible targets and means of intervention for at-risk youth. Nonetheless, the present study is novel in that it is the first, to our knowledge, that examines the relationship of three highly interrelated variables of drug addiction, childhood maltreatment and personality. Furthermore, personality is uniquely examined here in both trait- and person-centered analyses, providing multiple perspectives on the relationships of drug addiction and childhood maltreatment with personality organization.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights

- Cocaine dependent individuals with a history of moderate to severe ELS (Coc+/ELS+) expressed the greatest deviations in Five Factor Model trait expression relative to controls. Members of this subject group scored significantly higher in neuroticism and lower in openness to experience, agreeableness and conscientiousness.
- Cocaine dependence positively predicted neuroticism and negatively predicted openness to experience, agreeableness and conscientiousness, and ELS positively predicted neuroticism and negatively predicted agreeableness.
- A hypothesized interaction between cocaine dependence and ELS did not significantly predict any personality trait.
- Personality profiles were constructed from the relative expression of the five traits of the Five Factor Model of Personality. Optimized cluster analysis revealed four discrete clusters of personality profiles expressed by the total subject sample.
- These four personality profiles were found to distribute across the four subject groups (Coc+/ELS+, Coc-/ELS+, Coc+/ELS-, Coc-/ELS-) in a non-random fashion, suggesting an association between global personality expression and the independent variables cocaine dependence and ELS.
- Logistic regression showed that differing profiles of personality traits predicted being Coc+/ELS+, Coc-/ELS+ or Coc-/ELS-.

Figure 1.

Hypothetical conceptual model of the relationships between childhood maltreatment (early life stress), addiction (drug use disorders) and personality. Bolded arrows represent the relationships examined in the present cross-sectional case-control factorial study. Bracketed numbers specify each hypothesis posed in the introduction.

Figure 2.

Cluster analysis-derived personality profiles. The k-means clustering method revealed four optimum clusters ($CCC=6.5$, $R^2=0.40$) defined as Open, Gregarious, Open or Closed as configurations of the five personality factors. Abbreviations: N, neuroticism; E, extraversion; O, openness; A, agreeableness; C, closed.

Figure 3.

Distribution of personality profiles within each subject group. Personality profile was significantly associated with subject group assignment ($\chi^2=32.2$, $P = 0.0002$, $n=94$).

Table 1

Demographic and clinical variables for the study participant groups

	Coc+/ELS+ n=34	Coc-/ELS+ n=13	Coc+/ELS- n=31	Coc-/ELS- n=17	Total n=95
Age, years (SD) ****	40.9 (6.7)	32.0 (10.1)	40.2 (7.7)	31.3 (8.3)	37.7 (8.8)
Sex, % female	35.3	61.5	30.0	41.2	38.3
Race					
% White, non-Hispanic origin	29.4	23.1	10.0	35.3	23.4
% Black, non-Hispanic origin	70.6	69.2	90.0	64.7	75.5
% Other □	0.0	7.7	0.0	0.0	1.1
Education, % subjects >high school ****	32.3	84.6	20.0	70.6	42.5
Income, % subjects earning above median	44.1	53.8	43.3	70.6	50.0
Unemployed, %	73.5	46.2	56.7	47.1	59.8
Current Axis I Disorders					
% MDD	0.0	0.0	3.3	0.0	1.1
% PTSD	11.8	7.7	3.3	0.0	6.4
% GAD	2.9	0.0	0.0	0.0	1.1
Lifetime Axis I Disorders					
% MDD **	47.1	61.5	23.3	11.8	35.1
% PTSD **	26.5	15.4	3.3	0.0	12.8
% Mania	2.9	0.0	0.0	0.0	1.1
% Bipolar I	2.9	0.0	0.0	0.0	1.1
% Panic Disorder/Agoraphobia	2.9	0.0	0.0	0.0	1.1
% GAD	2.9	0.0	0.0	0.0	1.1
CTQ scores (SD)					
Total ****	70.0 (19.5)	66.3 (14.0)	34.3 (5.5)	30.6 (6.3)	50.3 (22.5)
Physical Abuse ****	13.4 (5.6)	11.8 (5.3)	8.1 (2.7)	5.6 (1.4)	9.7 (5.2)

	Coc+/ELS+ n=34	Coc-/ELS+ n=13	Coc+/ELS- n=31	Coc-/ELS- n=17	Total n=95
Emotional Abuse ****	15.7 (4.6)	17.6 (4.9)	6.9 (2.0)	6.5 (2.0)	11.7 (6.0)
Sexual Abuse ****	12.9 (7.8)	13.7 (7.6)	5.2 (1.0)	5.5 (1.9)	9.3 (6.7)
Physical Neglect ****	12.1 (4.8)	8.6 (2.8)	6.0 (1.6)	6.0 (1.7)	8.2 (4.3)
Emotional Neglect ****	15.9 (5.0)	14.6 (5.2)	8.1 (3.5)	7.0 (3.1)	11.4 (5.8)
<hr/>					
Cocaine use frequency, days in past 30 days (SD)	11.9 (10.8)	0.0 (0.0)	13.2 (9.3)	0.0 (0.0)	12.6 (10.0)
<hr/>					
Addiction Severity Index (SD)					
Medical [†]	0.19 (0.29)	0.08 (0.13)	0.20 (0.27)	0.03 (0.09)	0.12 (0.25)
Employment ***	0.77 (0.06)	0.46 (0.37)	0.71 (0.29)	0.40 (0.30)	0.58 (0.32)
Alcohol ****	0.14 (0.16)	0.02 (0.04)	0.26 (0.20)	0.02 (0.04)	0.11 (0.18)
Drug ****	0.19 (0.12)	0.00 (0.00)	0.17 (0.08)	0.00 (0.00)	0.09 (0.12)
Legal *	0.17 (0.23)	0.04 (0.09)	0.04 (0.10)	0.01 (0.04)	0.07 (0.17)
Family ***	0.28 (0.26)	0.18 (0.16)	0.14 (0.17)	0.03 (0.06)	0.16 (0.21)
Psychiatric **	0.19 (0.19)	0.11 (0.13)	0.09 (0.15)	0.03 (0.05)	0.11 (0.16)

**** $P < 0.0001$,*** $P < 0.001$,** $P < 0.01$,* $P < 0.05$,[†] $P < 0.10$ by 1-way ANOVA (for Age), Chi² test (for Education and Axis I disorders), or Kruskal-Wallis test (for ASI and CTQ);

□ Asian or Pacific Islander

Table 2

Influence of cocaine dependence and childhood maltreatment on personality factor scores

Group personality factor scores, mean (SD, n)				
Personality factor	1 (cocaine+/ELS+)	2 (cocaine-/ELS+)	3 (cocaine+/ELS-)	4 (cocaine-/ELS-)
Neuroticism ^{****, a, e}	25.9 (7.9, 32)	20.8 (6.3, 13)	19.3 (6.7, 31)	15.6 (7.1, 17)
Extraversion	26.0 (7.2, 32)	28.7 (8.0, 13)	28.7 (7.9, 29)	30.6 (6.9, 17)
Openness ^{****, a, b, c, d}	23.2 (4.0, 33)	30.8 (6.8, 13)	24.4 (5.3, 29)	28.5 (5.1, 17)
Agreeableness ^{**, a}	27.3 (5.6, 34)	29.8 (9.1, 13)	30.8 (8.5, 29)	34.5 (6.7, 17)
Conscientiousness ^{**, a}	29.1 (7.7, 33)	34.8 (7.7, 13)	32.1 (8.4, 29)	37.0 (6.0, 17)

Significance of main effects of group was determined by one-way ANOVA (* $P < 0.05$, ** $P < 0.01$, **** $P < 0.0001$), followed by post-hoc analyses with a Bonferroni correction for 6 pair-wise comparisons ($P < 0.0083$).

Significant differences between groups are indicated by letters:

^a group 1 vs. 4;

^b group 1 vs. 2;

^c group 2 vs. 3;

^d group 3 vs. 4;

^e group 1 vs. 3.

Table 3

Multiple linear regression beta values defining the strength of association of cocaine dependence and ELS with personality factor scores.

	Neuroticism $P = 0.0007$ $R^2 = 0.2348$ $n = 92$	Openness $P < 0.001$ $R^2 = 0.2612$ $n = 92$	Agreeableness $P = 0.0304$ $R^2 = 0.1131$ $n = 93$	Conscientiousness $P = 0.0045$ $R^2 = 0.1764$ $n = 92$
Cocaine	5.15*	-3.99**	-4.52*	-5.33*
CTQ	0.12**	0.01	-0.07*	-0.03
Sex	-0.96	-----	-----	-----
Age	-----	-0.03	0.10	-0.16
Education	1.33	2.43 [†]	-0.80	-2.43
Employment	-2.06	0.79	-----	1.80
Income	0.78	-----	-----	-----

[†] $P < 0.10$,

* $P < 0.05$,

** $P < 0.01$;

----- indicates variable was excluded to improve the model

Table 4

Pearson correlation coefficients of personality factor scores

	Neuroticism	Extraversion	Openness	Agreeableness	Conscientiousness
Neuroticism	1				
Extraversion	−0.37***	1			
Openness	−0.20	0.24*	1		
Agreeableness	−0.55****	0.51****	0.28***	1	
Conscientiousness	−0.55****	0.52****	0.32***	0.59****	1

* $P < 0.05$,
** $P < 0.01$,
*** $P < 0.001$,
**** $P < 0.0001$

Table 5

Subject group odds of expressing each personality profile

Group (x-variable)	Profile (y-variable)	OR	p-value	fdr-adjusted p values ($\alpha=0.05$)	Interpretation
Cocaine+/ELS+	Open	0.19	0.034	0.107	
Cocaine-/ELS+	Open	8.28	0.001	0.019	Cocaine-/ELS+ subjects were 8.28 times more likely to express an Open (vs. other) profile.
Cocaine+/ELS-	Open	0.87	0.807	0.991	
Cocaine-/ELS-	Open	0.96	0.959	0.991	
Cocaine+/ELS+	Gregarious	0.21	0.019	0.074	
Cocaine-/ELS+	Gregarious	0.98	0.976	0.991	
Cocaine+/ELS-	Gregarious	0.99	0.991	0.991	
Cocaine-/ELS-	Gregarious	5.54	0.003	0.023	Control subjects were 5.54 times more likely to express a Greg (vs. other) profile.
Cocaine+/ELS+	Dysphoric	3.97	0.006	0.032	Cocaine+/ELS+ subjects were 3.97 times more likely to express a Dys (vs. other) profile.
Cocaine-/ELS+	Dysphoric	0.22	0.162	0.287	
Cocaine+/ELS-	Dysphoric	0.91	0.861	0.991	
Cocaine-/ELS-	Dysphoric	0.16	0.080	0.214	
Cocaine+/ELS+	Closed	2.00	0.123	0.282	
Cocaine-/ELS+	Closed	0.31	0.143	0.287	
Cocaine+/ELS-	Closed	1.19	0.713	0.991	
Cocaine-/ELS-	Closed	0.54	0.317	0.508	