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Neurocognitive and psychiatric dimensions of "hot" impulsivity, but not "cool" impulsivity, predict HIV sexual risk behaviors among drug users in protracted abstinence

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Abstract

Background—Impulsivity is an important risk factor for HIV risky drug and sexual behaviors. Research identifies "hot" (*i.e.*, affectively-mediated, reward-based) and "cool" (motoric, attentional, independent of context) neurocognitive and psychiatric dimensions of impulsivity, though the impact of specific drugs of abuse on these varieties of impulsivity remains an open question.

Objectives—The present study examined the associations of neurocognitive and psychiatric varieties of "hot" and "cool" impulsivity with measures of lifetime and recent sexual risk behaviors among users of different classes of drugs.

Methods—The study sample was comprised drug users in protracted (>1yr) abstinence: heroin monodependent (n=61), amphetamine monodependent (n=44), and polysubstance dependent (n=73). "Hot" impulsivity was operationalized via neurocognitive tasks of reward-based decision-making and symptoms of psychopathy. "Cool" impulsivity was operationalized via neurocognitive tasks of response inhibition and symptoms of ADHD.

Results—"Hot" impulsivity was associated with sexual risk behaviors among heroin and amphetamine users in protracted abstinence, whereas "cool" impulsivity was not associated with sexual risk behaviors among any drug-using group. Neurocognitive "hot" impulsivity was associated with recent (past 30-day) sexual risk behaviors, whereas psychopathy was associated with sexual risk behaviors during more remote time-periods (past 6 month and lifetime) and mediated the association between heroin dependence and past 6-month sexual risk behaviors.

Conclusion—Assessments and interventions aimed at reducing sexual risk behaviors among drug users should focus on "hot" neurocognitive and psychiatric dimensions of impulsivity, such

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as decision-making and psychopathy. “Cool” dimensions of impulsivity such as response inhibition and ADHD were not related to sexual risk behaviors among drug users in protracted abstinence.

Keywords

Impulsivity; Substance Dependence; Protracted Abstinence; HIV Risk Behavior; Externalizing Psychopathology; Decision-Making

Introduction

New cases of HIV infection continue to appear at an alarming rate worldwide, due in large part to high rates of sexual risk behaviors among at-risk populations (1,2). Resources for HIV treatment are scarce (3) and better characterization of factors influencing HIV risk behavior is needed to inform prevention efforts. Impulsivity, the “predisposition toward rapid, unplanned reactions to internal or external stimuli without regards to the negative consequences of these reactions” (4) is implicated in a wide variety of sexual risk behaviors. Impulsivity is a multidimensional construct with state-like neurocognitive manifestations, as well as more pervasive psychiatric manifestations in externalizing syndromes like attention deficit/hyperactivity disorder (ADHD) and psychopathy. These psychiatric syndromes are characterized by developmental manifestations of impulsivity that predict risk behaviors across the lifespan (5–7), whereas neurocognitive functioning is more state-dependent and may be more sensitive to imminent risk behavior.

Drug users often display psychiatric (8–10) and neurocognitive manifestations of impulsivity (11–14). The unique pharmacological properties of different classes of drugs may lead to differential expressions of impulsivity among users of different types of drugs (15–18); *e.g.* stimulant users demonstrate greater executive deficits (19–21) and higher levels of risk behavior (17,22–24) than opiate users, whereas opiate users are more impaired on tasks of decision-making and feedback learning (25–27). Two broad neurocognitive dimensions of impulsivity have been identified that are mediated by dissociable neurobiological substrates: “hot” impulsivity, an affectively-mediated preference for immediate gratification in the presence of anticipatory cues (28,29); and “cool” impulsivity, an affectively neutral tendency towards rapid, premature responses, regardless of context (14,30,31). These two dimensions are distinct in factor analyses (32–34) and are discriminately associated with different forms of externalizing psychopathology and related neural substrates. Specifically, “hot” impulsivity is associated with psychopathy and ventromedial orbitofrontal-limbic dysfunction (35–37) while “cool” impulsivity is associated with ADHD and inferior fronto-striato-cerebellar systems (34,37–39).

Few studies have examined neurocognitive risk factors for HIV risk behavior. Available research indicates that premorbid global cognitive function (40) and decision-making (41–44) are associated with HIV risk behavior in HIV-seropositive drug users. Research focusing on psychiatric risk factors reveal associations with externalizing psychopathology: psychopathy is as a robust predictor of sexual risk behaviors (45,46), while ADHD correlates with sexual risk behaviors independently of antisocial traits (47). The extent to

which externalizing psychopathology and neurocognitive impulsivity differ in their contributions to HIV risk behavior among drug users is not well understood. Furthermore, high rates of polysubstance dependence among research samples (25,48,49) limit inferences regarding specific effects of different drug classes on impulsivity (50,51). Conducting research in Eastern Europe circumvents this methodological difficulty; despite high rates of drug use, mono-dependence is more common among Eastern European than Western drug users due to the relatively recent influx of black market heroin and proliferation of synthetic drug laboratories in Eastern Europe (52).

Although preliminary research has linked neurocognitive impulsivity to sexual risk behaviors among recently active drug users (41–44), no studies have examined such risk factors among drug users in protracted abstinence--a critical gap in the literature given evidence of persisting addiction-induced neuroadaptations and high risk for relapse and associated risk behaviors in protracted abstinence (53,54,55). To address these gaps, the present study examined how sexual risk behaviors were influenced by neurocognitive and psychiatric indices of "hot" and "cool" impulsivity. Study participants were Bulgarian mono-dependent heroin users, mono-dependent amphetamine users, and polysubstance users in protracted abstinence. Due to the protracted abstinence of the current sample, injection drug use data was not examined.

We hypothesized that lifetime dependence on any class of drugs would show positive associations with sexual risk behaviors, as would both neurocognitive and psychiatric measures of "hot" and "cool" impulsivity. Keeping with the putative state-trait distinction (i.e., neurocognitive functioning represents more state-dependent impulsivity, whereas psychiatric symptoms represent developmentally stable manifestations of trait impulsivity), we further hypothesized that neurocognitive impulsivity would be selectively associated with recent sexual risk behaviors, while psychiatric impulsivity was hypothesized to demonstrate selective associations with more distal sexual risk behaviors over the lifespan. Selective associations of "hot" versus "cool" psychiatric dimensions of impulsivity were not predicted due to conflicting findings in the literature and a paucity of research examining these factors in relation to sexual risk behaviors.

Methods

Participants

Participants were recruited for a larger study of impulsivity among stimulant and heroin users, advertised via flyers at addiction clinics and public locales in Sofia, Bulgaria. Participants were screened via telephone or on-site and provided informed consent. All drug users met criteria for lifetime dependence on heroin or amphetamines. Community adults with similar demographics who had no history of substance dependence were recruited as controls. Length of abstinence was indexed via self-report during clinical interviews. The majority of drug users reported being in protracted abstinence (*i.e.* DSM-IV "full sustained remission" for more than one year; see Table 1) at the time of testing, and only drug users in protracted abstinence were included in analyses.

Inclusion criteria were: a) age 18–50 years; b) 8th grade education; c) IQ > 75; d) no history of neurologic illness/serious TBI; e) no evidence of psychotic/thought disorders; f) negative alcohol Breathalyzer screen; and g) negative urine screen for opiates, cannabis, amphetamines, methamphetamines, benzodiazepines, barbiturates, cocaine, MDMA, and methadone. All participants were HIV-seronegative (determined by rapid HIV testing) and none were on opioid substitution therapy. The final sample (N = 281) consisted of 103 controls, 44 amphetamine users, 61 heroin users, and 73 polysubstance users (see Table 1).

Procedures

All self-report and interview measures were translated into Bulgarian by the senior author, a native Bulgarian speaker and author of the Bulgarian translation of a widely used English-language assessment instrument. All measures were back-translated into English by Bulgarian psychiatrists and psychologists.

The study protocol consisted of two 3.5-hour sessions, completed at the Bulgarian Addictions Institute. The first session was devoted to assessment of addictive disorders, externalizing psychopathology, and intelligence. The second session included neurocognitive testing and self-report assessments of externalizing and internalizing personality traits and psychopathology. Participants were paid 80 Bulgarian Leva (US$50) for participation. Procedures were approved by Institutional Review Boards of the University of Illinois at Chicago and the Medical University in Sofia on behalf of the Bulgarian Addictions Institute.

Measures

IQ was estimated via Raven's Progressive Matrices (57). History of DSM-IV substance dependence and duration of abstinence from substance dependence criteria (Table 1) were obtained via a Bulgarian translation of the substance abuse module from the SCID-I (58).

HIV Sexual Risk Behavior—Practical knowledge about safe sexual practices and HIV risk reduction strategies was assessed by a 15-item self-report HIV knowledge scale (56). HIV risk behavior was indexed via the HIV Risk Behavior Scale (HRBS; 59) and the Risk Assessment Battery (RAB; 60). The RAB is a 24-item interviewer-completed scale assessing frequency and quantity of injection drug use (IDU) and sexual risk behaviors within the *past six months*. The HRBS is an 11-item interviewer-completed scale assessing IDU and sexual risk behaviors. We administered both the *past 30-day sexual risk behaviors* and *lifetime sexual risk behaviors* versions of the HRBS. We used both the HRBS and the RAB in order to capture three relatively distinct temporal phases of risk behavior: a) acute risk behavior (*i.e.* HRBS past 30-day); b) recent risk behavior (*i.e.* RAB past 6 months); and c) lifetime risk behavior (HRBS). Given that all drug user groups reported virtually no injection drug use over the past 30 days ($F(3, 276) = 0.96$, $p = .49$) or past 6 months ($F(2,175) = 0.38$, $p = .68$) and that amphetamine users reported virtually no lifetime injection drug use relative to controls ($t(145) = 0.10$, $p = .85$), IDU data was not analyzed.

Psychiatric Measures of Impulsivity—Psychiatric dimensions of "hot" impulsivity were operationalized by symptoms of psychopathy and were indexed using the Psychopathy

Checklist: Screening Version (PCL:SV; (61), a 12–item interviewer-completed scale based on a semi-structured interview. Interviews and psychopathy ratings were conducted by research assistants who were trained to reliability and supervised closely by the senior author, who has extensive clinical experience with psychopathy. A recent construct validation of the Bulgarian PCL:SV (62) supported an oblique two-factor structure, with Factor 1 (F1) reflecting affective and interpersonal aspects of psychopathy and Factor 2 (F2) encapsulating poor behavioral control and antisociality. Full-scale psychopathy scores were used as predictor variables.

Psychiatric dimensions of "cool" impulsivity were operationalized by childhood symptoms of ADHD and assessed via the 25-item version of the self-report Wender Utah Rating Scale (WURS; 63). Respondents were asked to retrospectively evaluate the presence and severity of childhood symptoms of ADHD (sample item: "As a child I had concentration problems, was easily distracted"). Total WURS scores were employed as predictor variables.

Neurocognitive Measures of "Hot" Impulsivity—To assess neurocognitive "hot" impulsivity, participants completed two decision-making tasks: the Iowa Gambling Task (IGT; 28) and the Cambridge Gambling Task (CGT; 64); and the Monetary Choice Questionnaire (65), a measure of delay discounting.

The IGT measures decision-making under uncertainty and requires trial-and-error learning. Examinees are presented with four decks of cards and instructed to select cards to maximize earnings. Decks A and B are associated with higher rewards but also higher occasional penalties. Selecting from Decks C and D yields lower rewards and lower occasional penalties and is a more advantageous long-term strategy. The performance measure used was total number of advantageous choices minus total number of disadvantageous choices.

The CGT assesses risky decision-making, which does not involve implicit learning. Examinees are presented with 10 boxes colored red or blue and are asked to guess whether a token is hidden under a red or a blue box. The ratios of red: blue boxes vary from 1:9 to 9:1 in pseudorandom order. Participants earn points based on correct performance. They also gamble points based on the confidence of their decisions, by selecting from an array of bets ranging from 5% to 95% of their earned points, presented in ascending and descending order. Three performance measures were selected based on their established sensitivity to risky decision-making among individuals with addictive disorders (66–70): a) quality of decision-making, the tendency to bet on the more likely outcome; b) risk adjustment, betting more when odds are better and less when odds are poorer; and c) delay aversion, or betting larger amounts earlier when wagers are presented in ascending order.

The Monetary Choice Questionnaire consists of 27 choices between smaller rewards available on the day of testing and larger rewards available from one week to six months in the future and captures the tendency to discount the value of delayed rewards. Analyses utilized the discount-rate parameter, k, determined using the hyperbolic discount function $V = A/[1 + kD]$, where V is the value of reward A available at delay D.

Neurocognitive Measures of "Cool" Impulsivity—Neurocognitive "cool" impulsivity was assessed using the Go/No-Go Task (GNGT; 71); the Immediate Memory Task (IMT; 30); and the Go-Stop Task (GST; 72).

The GNGT is a measure of response inhibition where a series of two-element visual stimuli arrays are presented on a screen for 500ms and examinees are instructed to respond when the two elements are identical ("Go") and to inhibit responding when the stimuli are discrepant ("No-Go"). On "No-Go" trials, the position of the inhibitory element is random, requiring the examinee to scan both elements. The performance measure, *d′*, indexes the ability to discriminate between "Go" and "No-Go" stimuli.

The IMT is a modified continuous performance test of higher complexity and sensitivity. A series of five-digit numbers are shown for 500ms each, with examinees instructed to respond only if a stimulus is identical to the preceding display. The performance index, *d′,* measures the ability to discriminate between targets and non-targets.

The GST (70) is a stop-signal paradigm, which presents examinees with a series of five-digit numbers displayed for 500ms each. Examinees are instructed to respond when a stimulus is identical to the previous display ("Go") and to withhold responding when the stimulus matches, but then changes color from black to red ("Stop"). Stop-signals occurred at 50, 150, 250, or 350ms intervals from stimulus onset. The performance measure was the ratio of inhibition failures on "Stop trials" to correct responses on "Go" trials across the four stop-signal delays.

Statistical Plan

Variable skew and kurtosis were inspected for normality. Neurocognitive variables were converted to Z-scores based on total sample means and collapsed into two composites based on *a priori* theoretical distinctions between "hot" and "cool" impulsivity from the literature (32–34,37). The "hot" impulsivity composite included the IGT score, the three CGT parameters, and the delay discounting parameter *k*. The "cool" impulsivity composite included the discriminability parameters (*d'*) from the IMT and the GNGT and the mean inhibition ratio from the GST. To maintain consistency with psychiatric dimensions, the directionality of certain Z-scores was reversed for specific neurocognitive tasks (*i.e.* IGT; CGT decision-making/risk adjustment; all "cool" neurocognitive tasks) so that higher composite scores indicated more impulsive performance. A composite score was not computed for participants with missing data on any task forming that composite.

One-way ANOVAs, Mann-Whitney U tests, and chi-square tests were used to probe for group differences on demographic measures with follow-up Fisher's LSD and Exact tests were conducted when indicated. Hierarchical multiple linear regressions examined effects of drug type, impulsivity dimensions, and their interactions on sexual risk behaviors. Separate models were calculated for "hot" and "cool" impulsivity. Age, education, and gender were entered in Block 1 as control variables. Three dummy-coded drug user groups (heroin, amphetamine, polysubstance) were entered in Block 2, with control participants serving as references. The neurocognitive composite of either "hot" impulsivity and psychopathy or "cool" impulsivity and ADHD was entered in Block 3. The analyses were structured in this

fashion to control for the effects of previous substance dependence (Block 2) before entering impulsivity variables (Block 3), providing a relatively conservative test for determining the significance of impulsivity. Additionally, observing a change in significance from Block 2 to Block 3 would serve to indicate whether any observed effects of impulsivity represented incremental validity beyond effects of substance dependence. Finally, interactions of drug user groups with "hot" or "cool" impulsivity were entered in Block 4. See Table 2 for a correlation matrix of all variables used in analyses.

Results

Participant Characteristics

Participant demographics are presented in Table 1. Group differences (p's < .05) were observed for age, education, and estimated IQ. Knowledge of safe sexual practices was equivalent across groups (p's > .05), suggesting that differences in sexual risk behaviors could not be attributed to lack of knowledge about HIV and risk reduction strategies.

All groups reported equivalent past 30-day sexual risk behaviors. Heroin and polysubstance users reported greater levels of past 6-months sexual risk behaviors than controls (p's < .05), with a trend-level difference observed between amphetamine users and controls (p = .06). All drug user groups demonstrated elevated levels of lifetime sexual risk behaviors, with heroin and polysubstance users reporting higher levels of lifetime sexual risk behaviors than amphetamine users (p's < .05).

Drug users evidenced more psychopathic traits than controls, with heroin and polysubstance users exhibiting higher psychopathy than amphetamine users (p's < .05). All drug users reported equivalent levels of ADHD symptoms (p's > .10) that were elevated versus controls (p's < .05). There were no group differences on tasks of neurocognitive "hot" or "cool" impulsivity (p's > .05).

Effects of "Hot" Impulsivity on Sexual Risk Behaviors

Results of all "hot" impulsivity regressions are presented in Table 3. Neither demographics (Block 1 ΔR^2 = .02, p = .41) nor drug user type (Block 2 ΔR^2 = .04, p = .096) explained significant variance in *past 30-day sexual risk behaviors*. Block 3 explained significant variance (ΔR^2 = .04, p = .01) and demonstrated that neurocognitive "hot" impulsivity tasks explained unique variance in past 30-day sexual risk behaviors (β = .16, p = .03). Block 4 explained additional unique variance in past 30-day sexual risk behaviors (ΔR^2 = .08, p = .002). Polysubstance × psychopathy (β = −.48, p = .04) and polysubstance × neurocognitive "hot" impulsivity (β = −.18, p = .05) interactions were observed, with simple slope analyses indicating that neither psychopathy symptoms nor neurocognitive "hot" impulsivity task performance were associated with past 30-day sexual risk behaviors among polysubstance users (p's > .10).

Demographic variables did not account for variance in *past 6-month sexual risk behaviors* (Block 1 ΔR^2 = .04, p = .11). Block 2 explained unique variance in past 6-month sexual risk behaviors (ΔR^2 = .04, p = .03), driven by a main effect of heroin dependence (β = .25, p = .006). Additional unique variance was explained in Block 3 (ΔR^2 = .07, p < .001) due to a

main effect of psychopathy (β = .32, $p < .001$). Block 4 explained further unique variance ($\Delta R^2 = .06$, $p < .001$), driven by a significant polysubstance x psychopathy interaction; when followed up, this interaction indicated that psychopathy was not associated with past 6-month sexual risk behaviors among polysubstance users ($p = .003$, follow-up $p = .10$).

Variance in *lifetime* sexual risk behaviors was associated with substance dependence across all drug user types in Block 2 ($\Delta R^2 = .13$, $p < .001$): amphetamine (β = .29, $p < .001$); heroin (β = .35, $p < .001$); polysubstance (β = .31, $p < .001$). Block 3 explained additional unique variance in lifetime sexual risk behaviors ($\Delta R^2 = .06$, $p < .001$) due to a main effect of psychopathy (β = .32, $p < .001$). Block 4 accounted for additional unique variance ($\Delta R^2 = .05$, $p = .03$) due to amphetamine × psychopathy and polysubstance × psychopathy interactions (p's < .04); Follow-up testing indicated that psychopathy and lifetime sexual risk behaviors were uncorrelated among amphetamine and polysubstance users (p's > .10).

Effects of "Cool" Impulsivity on Sexual Risk Behaviors

Main effects of ADHD symptoms and neurocognitive "cool" impulsivity on measures of sexual risk behavior were non-significant (p's > .15); see Table 4. Although a polysubstance × "cool" impulsivity interaction was noted for past 30-day sexual risk behaviors, this effect was not investigated further due to the lack of significant variance explained by the regression model (Block 4 $\Delta R^2 = .02$, $p = .63$).

Post-hoc Analyses

Correlations between past-30 day sexual risk behaviors and individual hot neurocognitive measures were conducted to elucidate which specific neurocognitive processes appeared to drive the observed effect in regression models. Results indicated a significant, negative association of IGT ($r = -.14$, $p = .02$) and a marginally significant, negative correlation of CGT quality of decision-making ($r = -.12$, $p = .05$), indicating that common hot decision-making processes under both conditions of ambiguity (*i.e.* IGT) and explicit risk (*i.e.* CGT) contributed to the observed effect on past 30-day sexual risk behavior. By contrast, risk adjustment and delay aversion on the CGT and delay discounting were not associated with past-30 day sexual risk behavior (p's ≥.12).

Correlations between F1 and F2 of the PCL:SV and past 6-month and lifetime SRB were conducted to determine whether different factors of psychopathy appeared to drive the observed effects in regression models. Both factors of psychopathy were significantly associated with risk measures (past 6-month F1 $r = .22$, $p < .001$; F2 $r = .22$, $p < .001$; lifetime F1 $r = .31$, $p < .001$; F2 $r = .37$, $p < .001$).

The main effect of heroin dependence on past 6-month sexual risk behaviors observed in Block 2 became non-significant (β = .04, $p = .87$) after adding Block 3 containing psychopathy, indicating that psychopathy may partially mediate the relationship between heroin dependence and past 6-month sexual risk behaviors. A post-hoc test of mediation was computed using the PROCESS macro for SPSS (73). Results indicated significant effects of heroin dependence on psychopathy (β = 1.78, $p = .006$); an effect of psychopathy on sexual risk behaviors (β = .08, $p < .001$); and a direct effect of heroin dependence on sexual risk behaviors (β = .47, $p = .04$). Finally, a reduced indirect effect (β= .15, 95% CI .046-.305) of

heroin dependence on sexual risk behaviors was observed when controlling for psychopathy, indicating a partial mediating effect of psychopathy.

Discussion

To our knowledge, the present study is the first to demonstrate that neurocognitive and psychiatric dimensions of "hot" impulsivity, but not "cool" impulsivity, selectively predict sexual risk behaviors among drug users in protracted abstinence. Additionally, we believe that our findings are the first to indicate that neurocognitive "hot" impulsivity shows selective associations with recent (*i.e.* past 30-day) sexual risk behaviors across drug users in protracted abstinence, whereas a measure of externalizing psychopathology characterized by "hot" impulsivity (*i.e.* psychopathy) had differential associations with sexual risk behaviors across the lifespan. Finally, our findings demonstrated that psychopathy mediates associations of prior heroin dependence and sexual risk behaviors during the withdrawal and early abstinence periods (*i.e.* past 6-months) of the addiction cycle.

Effects of "hot" neurocognitive impulsivity and psychopathy on sexual risk behaviors were observed after controlling for history of drug dependence, suggesting that both neurocognitive and psychiatric indices of affective impulsivity provide incremental utility towards predicting sexual risk behaviors across different stages of the addiction cycle. Neurocognitive "hot" impulsivity was selectively associated with past-30 day sexual risk behaviors across both amphetamine and heroin users in protracted abstinence, similar to associations between "hot" neurocognitive impulsivity and sexual risk behaviors observed among HIV-seropositive and seronegative drug users with more recent substance use (41–44). Additionally, the association of psychopathy with sexual risk behaviors among heroin users in protracted abstinence is similar to previous findings in active methadone maintenance patients (46,74–76) suggesting that the link between psychiatric "hot" impulsivity and sexual risk behaviors persists in protracted abstinence. This is supported by the mediating effect of psychopathy on the association between history of heroin dependence and past 6-month sexual risk behaviors observed in the present sample. In contrast, psychopathy was not associated with sexual risk behaviors among polysubstance users in protracted abstinence after controlling for history of substance dependence. This result may be influenced by confounding of psychopathy and the tendency to misuse multiple drugs (77), such that controlling for polysubstance dependence may also parcel out variance associated with psychopathy. Among amphetamine users in protracted abstinence, psychopathy was associated with past 6-month sexual risk behaviors, but this relationship was not observed for lifetime sexual risk behaviors. Speculatively, relatively acute effects of amphetamine dependence may have been associated with sexual risk behaviors during periods of active use, whereas psychopathy may have emerged as a more pronounced risk factor during a more recent (i.e. past year) period of abstinence from amphetamines.

Impaired performance on neurocognitive tasks of impulsivity has been consistently documented among individuals in the acute and early abstinence stages of addiction (11,78–81). By contrast, the current sample of drug users in protracted abstinence was unimpaired on composite indices of impulsivity tasks. However, previous analyses have indicated significant group differences on individual neurocognitive measures in this population

(51,82) and computational modeling has revealed that distinct neurocognitive processes underlie "hot" decision-making performance in heroin versus amphetamine users in protracted abstinence (82).

Limitations

The present cross-sectional study has several limitations. Although statistically controlled for, systematic demographic differences may have influenced results. Secondly, the WURS depends on retrospective recall of ADHD symptoms in childhood. Third, psychopathy's relationship to sexual risk behaviors may be explained only in part by impulsivity, as evidenced by significant correlations between both F1 and F2 with sexual risk behaviors. Fourth, cultural differences may influence results, although cross-cultural validity has been established for psychopathy (62,83) and ADHD (84). Finally, the findings from this Eastern European sample of drug users may not necessarily generalize to all cultures.

Conclusions

Drug users continue to engage in sexual risk behaviors despite being in protracted abstinence, posing an ongoing public health risk, which appears to be driven in part by neurocognitive "hot" impulsivity and psychopathic traits. Risk behavior interventions within this population may benefit from cognitive remediation for "hot" impulsivity (*e.g.* 85,86) and interventions targeting psychopathy (*e.g.* 87–91). Future studies should systematically examine the relationships of neurocognitive impulsivity, externalizing psychopathology and sexual risk behaviors across different stages of the addiction cycle, including protracted abstinence. More precise neural correlates of "hot" impulsivity measures should be investigated via neuroimaging, as identifying substrates of "hot" impulsivity may provide incremental utility in predicting risk behavior and response to intervention.

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Am J Drug Alcohol Abuse. Author manuscript; available in PMC 2017 March 01.

Table 1

Participant group characteristics.

	Controls (*n* = 103)	Amphetamine (*n* = 44)	Heroin (*n* = 61)	Polysubstance (*n* = 73)	Significance Testing
Age (*M, SD*)	24.5[a] (4.8)	22.5[b] (3.3)	29.1[c] (4.5)	26.8[d] (5.3)	$F = 20.6^{**}$
Education (*M, SD*)	13.6[a] (2.4)	12.5[b] (1.8)	12.8[b] (2.4)	12.9[b] (2.2)	$F = 3.1^{*}$
Ravens IQ (*M, SD*)	108.6[a] (14.0)	109.6[a] (11.9)	103.1[b] (13.5)	106.0[a,b] (12.8)	$F = 3.0^{*}$
Sex (*# men, %*)	78 [76]	31 [70]	47 [77]	64 [88]	$\chi^2 = 5.8$
DSM-IV Lifetime Substance Dependence (*#, %*)					
Amphetamine	0	44 [100]	0	45 [62]	$OR = 1.6^{**}$
Heroin	0	0	61 [100]	38 [52]	$OR = 1.9^{**}$
Alcohol	0	0	0	24 [33]	--
Cannabis	0	0	0	56 [77]	--
Cocaine	0	0	0	5 [7]	--
Hallucinogens	0	0	0	5 [7]	--
Sedatives	0	0	0	9 [12]	--
Days since last met dependence criteria (*Mdn, IQR*)					
Amphetamine	--	639 {1075}	--	639 {1095}	$U = 228$
Heroin	--	--	730 {1035}	545 {588}	$U = 360$
Sexual Risk Behaviors (*M, SD*)					
RAB Past 6 month	2.6[a] (1.7)	3.1[b] (1.6)	3.5[b] (1.9)	3.2[b] (1.9)	$F = 4.3^{**}$
HRBS Past 30 day	3.2 (2.8)	3.0 (2.5)	4.1 (2.7)	9.8 (3.7)	$F = 2.0$
HRBS Lifetime	8.6[a] (3.9)	10.6[b] (3.8)	12.4[c] (4.0)	12.6[c] (4.0)	$F = 18.5^{**}$
SRB Knowledge	11.7 (2.1)	10.9 (2.2)	11.9 (2.1)	11.7 (2.2)	$F = 2.3$
Externalizing Psychopathology (*M, SD*)					
PCL:SV	4.8[a] (3.9)	9.0[b] (4.4)	12.7[c] (4.8)	12.3[c] (4.8)	$F = 60.0^{**}$
WURS	21.5[a] (12.1)	28.3[b] (13.4)	31.2[b] (15.8)	33.3[b] (16.6)	$F = 11.3^{**}$
Neurocognitive Impulsivity Composites (Z-scores; *M, SD*)					
"Hot" Impulsivity	–0.2 (0.9)	0.1 (0.92)	0.2 (1.0)	–0.1 (0.9)	$F = 1.8$
	$n = 72$	$n = 31$	$n = 54$	$n = 51$	
"Cool" Impulsivity	–0.3 (1.9)	0.3 (1.9)	0.3 (1.6)	0.2 (2.2)	$F = 1.6$

	Controls (*n* = 103)	Amphetamine (*n* = 44)	Heroin (*n* = 61)	Polysubstance (*n* = 73)	Significance Testing
	n = 77	*n* = 39	*n* = 54	*n* = 55	

Note. Identical superscripts indicate that group values do not differ statistically;

*$p < .05$;

**$p < .01$;

RAB = Risk Assessment Battery; HRBS = HIV Risk Behavior Scale; SRB = Sexual Risk Behavior; PCL:SV = Psychopathy Checklist: Screening Version; WURS = Wender Utah Rating Scale

Am J Drug Alcohol Abuse. Author manuscript; available in PMC 2017 March 01.

Am J Drug Alcohol Abuse. Author manuscript; available in PMC 2017 March 01.

Table 2

Correlation matrix of variables used for analyses.

	Demographic Variables			Sexual Risk Behaviors			Externalizing Psychopathology		Neurocognitive Impulsivity Composites	
	Age	**Sex**	**Edu**	**RAB 6mo**	**HRBS 30d**	**HRBS Lifetime**	**PCL:SV**	**WURS**	**"Hot"**	**"Cool"**
Demographics										
Age	--	-.21**	.20**	.17**	.11	.31**	.22**	.13*	−.10	−.13*
Sex	−.21**	--	.15*	.02	.01	−.14*	−.31**	−.11	.01	.12
Edu	.20**	.15*	--	.08	−.004	.01	−.21**	−.11	−.27	−.17*
Sexual Risk Behavior										
RAB 6mo	.17**	.02	.08	--	.45**	.41**	.23**	.18**	.13	.01
HRBS 30d	.11	.01	−.004	.45**	--	.23**	.16**	.04	.17*	.08
HRBS	.31**	−.14*	.01	.41**	.23*	--	.43**	.18**	−.03	−.04
Externalizing Psychopathology										
PCL:SV	.22**	−.31**	−.21**	.23**	.16**	.43**	--	.43**	.18**	.14*
WURS	.13*	−.11	−.11	.18**	.04	.18**	.43**	--	−.02	.004
Neurocognitive Impulsivity Composites										
"Hot"	−.10	.01	−.27**	.13	.17*	−.03	.18**	.03	--	.25**
"Cool"	−.13*	.12	−.17*	.01	.08	−.04	.14*	.000	.25**	--

Note.

*$p \leq .05$;

**$p < .01$;

Edu = Years of Education; Sex codied 1 = male, 2 = female; RAB = Risk Assessment Battery; 6mo = past 6 months; HRBS = HIV Risk Behavior Scale; 30d = past 30 days; PCL:SV= Psychopathy Checklist: Screening Version; WURS = Wender Utah Rating Scale

Table 3

Hierarchical multiple linear regressions examining the effects of drug user type, psychopathic personality features, and "hot" neurocognitive impulsivity on sexual risk behavior.

	Past 30-day Sexual Risk Behaviors		Past 6-month Sexual Risk Behaviors		Lifetime Sexual Risk Behaviors	
	ΔR^2	β	ΔR^2	β	ΔR^2	β
Step 1: Control Variables	.02		.04		.16**	
Step 2: Drug User Groups	.04		.04*		.13**	
Amphetamine		.08		.12		.29**
Heroin		.22*		.25**		.36**
Polysubstance		.02		.14		.31**
Step 3: Main Effects of Psychopathy and "Hot" Impulsivity Composite	.04*		.07**		.06**	
PCL:SV		.12		.32**		.32**
"Hot" Impulsivity		.16*		.07		−.06
Step 4: Drug User Group Interactions with Psychopathy and "Hot" Impulsivity Composite	.08**		.06*		.05*	
Amphetamine × PCL:SV		−.31		−.32		−.34*
Amphetamine × "Hot" Impulsivity		.04		−.002		.02
Heroin × PCL:SV		−.01		−.39		−.33
Heroin × Hot" Impulsivity		−.13		−.06		−.05
Polysubstance × PCL:SV		−.48*		−.67**		−.61**
Polysubstance × Hot" Impulsivity		−.18*		−.08		−.04

Note.

* $p \leq .05$;

** $p < .01$;

PCL:SV = Psychopathy Checklist: Screening Version

Table 4

Hierarchical multiple linear regressions examining the effects of drug user type, ADHD symptoms, and "cool" neurocognitive impulsivity on sexual risk behavior.

	Past 30-day Sexual Risk Behaviors		Past 6-month Sexual Risk Behaviors		Lifetime Sexual Risk Behaviors	
	ΔR^2	β	ΔR^2	β	ΔR^2	β
Step 1: Control Variables	.02		.03		.14**	
Step 2: Drug User Groups	.01		.03		.11**	
Amphetamine		.05		.12		.25**
Heroin		.14		.17		.31**
Polysubstance		.06		.20*		.34**
Step 3: Main Effects of ADHD and "Cool" Impulsivity	.01		.01		.01	
WURS		−.01		.06		.09
"Cool" Impulsivity		.08		.05		−.04
Step 4: Drug User Group Interactions with ADHD and "Cool" Impulsivity Composite	.03		.05		.02	
Amphetamine × WURS		−.14		.07		−.04
Amphetamine × "Cool" Impulsivity		.04		.15		.10
Heroin × WURS		−.18		−.22		.24
Heroin × "Cool" Impulsivity		−.02		.08		−.08
Polysubstance × WURS		−.43		−.39		.002
Polysubstance × "Cool" Impulsivity		−.09*		−.01		−.01

Note.

* $p < .05$;

** $p < .01$;

WURS = Wender Utah Rating Scale total score