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Childhood Symptoms of ADHD and Impulsivity in Abstinent Heroin Users

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Abstract

Objectives—Heroin dependence is associated with deficits in impulsivity, which is also a core feature of ADHD. This study aimed to explore the association between childhood ADHD symptoms and cognitive/choice and motor/action impulsivity among abstinent individuals with a history of heroin dependence.

Methods—Thirty-two abstinent Bulgarian males with a history of heroin dependence participated in the study. Self-rated childhood ADHD symptoms were obtained using the Wender-Utah Rating Scale. Cognitive/choice impulsivity was measured using the Iowa Gambling Task (IGT), an index of impulsive decision-making and the Delayed Reward Discounting Task (DRDT), a measure of inter-temporal choice. Motor/action impulsivity was indexed with the Stop Signal Task (SST), a measure of response inhibition.

Results—Participants, whose average age was 27.66 years ($SD = 2.7$), had an average ADHD symptom score of 36.6 ($SD = 18.6$), roughly 7 years ($SD = 2.9$) of heroin use, and been abstinent for just over a year ($M = 402.5$ days, $SD = 223.8$). Linear regression analyses revealed that self-reported ADHD symptoms predicted impulsive decision-making (IGT), but not delay discounting (DRDT) or response inhibition (SST).

Conclusions—Self-reported childhood ADHD symptoms do not uniformly predict impulsivity among abstinent individuals with heroin dependence. Results suggest the IGT may be more sensitive to externalizing psychopathology among individuals with heroin dependence than other measures of impulsivity.

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Keywords

ADHD; heroin; impulsivity; decision-making; addiction; abstinence

Introduction

Impulsivity is a core feature of drug addiction and one of the main symptoms of attention deficit hyperactivity disorder (ADHD). Drug addiction and ADHD often co-occur (Wilens et al., 2011), such that between 11% and 35% of individuals with substance dependence have comorbid ADHD (Barkley & Brown, 2008). The literature has also consistently shown that impulsivity is one of the neurocognitive functions on which individuals with heroin dependence exhibit notable deficits (Kirby & Petry, 2004; Mintzer & Stitzer, 2002; Vassileva et al., 2007; Vassileva, Georgiev, Martin, Gonzalez, & Segalà, 2011).

The construct of impulsivity includes a variety of different components, most generally classified as cognitive/choice impulsivity and motor/action impulsivity (Bechara, Damasio, & Damasio, 2000; Hamilton et al., 2015a; 2015b). Cognitive/choice impulsivity reflects suboptimal choices in the face of delayed contingencies or potential rewards and is measured in the laboratory with decision-making and/or delay discounting paradigms (Hamilton et al., 2015b), on which individuals with heroin dependence have shown functional impairments (Bechara, 2005; Kirby & Petry, 2004). Motor/action impulsivity refers to the inability to inhibit a prepotent motor response (Dougherty et al., 2003), measured in the laboratory with response inhibition paradigms such as continuous performance tasks (Dougherty et al., 2003) or stop signal tasks (Logan & Cowan, 1994). Studies measuring motor impulsivity in individuals with heroin dependence are limited.

Impulsivity also figures prominently in ADHD, both as a core diagnostic symptom and as a central neuropsychological correlate. Adults with ADHD show deficits in cognitive and motor dimensions of impulsivity, including decision-making deficits, preferences for smaller immediate rewards over larger delayed rewards (Malloy-Diniz et al., 2007), and deficits in response inhibition (Nigg et al., 2005). ADHD symptoms have been linked to increased risk for developing substance use disorders (Barkley & Brown, 2008), decreased likelihood of achieving abstinence following methadone treatment (Kolpe & Carlson, 2007), and increased tendency to drop out of treatment (Carroll & Rounsaville, 1993).

The purpose of the current study was to elucidate the complex interaction of ADHD and heroin dependence and their effects on cognition, by investigating whether the presence of ADHD symptoms would be associated with increased impulsivity, as measured by three laboratory tasks, in currently abstinent individuals with heroin dependence. We hypothesized that self-reported ADHD symptoms would be associated with more pronounced deficits in both cognitive/choice and motor/action impulsivity. We conducted the study in Bulgaria where there is a high prevalence of heroin addiction (Vassileva et al, 2011). Polysubstance dependence is not as common in Bulgaria as in the Western World (Vassileva et al, 2011), which allowed us to control for the confounding effects of polysubstance abuse on neurocognitive functioning.

Method

Participants

Participants included 32 currently abstinent males with heroin dependence meeting Diagnostic and Statistical Manual of Mental Disorders, 4th Edition (DSM-IV) criteria for past heroin dependence, who were tested at the Bulgarian Addictions Institute in Sofia, Bulgaria. All participants were able to speak and read Bulgarian and had a minimum of eight years of education. Written informed consent was obtained from all participants. The study was approved by the IRBs of the University of Illinois at Chicago (where the senior author was at that time) and St-Naum State University Hospital in Sofia, Bulgaria on behalf of the Bulgarian Addictions Institute. This study was part of a larger project examining impulsivity and HIV-risk behaviors among heroin users. None of the participants were HIV positive. At the time of the study, most participants had been abstinent for approximately one year (see Table 1). Although most of the participants had been diagnosed with heroin dependence only, a few participants had a past history of dependence on other substances. None of the participants met current DSM-IV criteria for dependence on any substance.

Abstinence from alcohol and drug use at the time of testing was verified by breathalyzer and urine toxicology screen. None of the participants were on opioid substitution therapy. Exclusion criteria included: positive urine toxicology screen or breathalyzer; current abuse or dependence on any substance; central nervous system illness or injury; history of psychotic or mood disorders; current psychotropic medication; and estimated intelligence quotient (IQ) below 80, as measured with the Raven's Progressive Matrices Test (Raven, 2000). We did not conduct a diagnostic interview for ADHD symptoms and, to the best of our knowledge, none of the participants had a formal diagnosis of ADHD.

Measures

Cognitive / Choice Impulsivity

Iowa Gambling Task (IGT): The IGT is a computerized task intended to measure real-world decision-making (Bechara, Damasio, Damasio & Anderson, 1994). Subjects are asked to choose between four decks of cards, two of which are advantageous and two are disadvantageous in terms of monetary gains or losses. Disadvantageous decks involve immediate large rewards but long-term monetary losses whereas advantageous decks give smaller immediate rewards but larger long-term monetary gains (Bechara et al., 1994). Participants are instructed to accumulate as much money as possible but are not informed of which decks are advantageous and which disadvantageous. A total of 100 trials were administered. The number of choices from the disadvantageous decks was subtracted from the number of choices from the advantageous decks, thereby yielding net scores which were used in the analyses. Scores below zero indicate that the participant chose primarily from the disadvantageous decks resulting in an overall net loss, whereas scores above zero indicated more advantageous choices and a net gain of money.

Delayed Reward Discounting Task (DRDT): We assessed delayed discounting with the Monetary-Choice Questionnaire (MCQ), a measure of inter-temporal choice (Kirby, Petry & Bickel, 1999). The MCQ consists of a set of 27 choices between smaller immediate rewards

available today and delayed rewards of small, medium, and large magnitude available at delays ranging from 7 to 186 days (Kirby et al., 1999).

Participants were given a 1-in-6 chance to receive an actual reward upon task completion (Kirby et al., 1999), which consisted of 1/10th of the value of one of their previous choices. Discount rate parameters were estimated from participants' patterns of choices across the nine questions in each of the three magnitude categories (Kirby et al., 1999). The discount rate was determined by k , a hyperbolic discount parameter that indexes how rapidly the participants' valuation of the reward declines as the delay interval increases. We estimated the value of k that would yield indifference between immediate and delayed rewards for each of the 27 questions using the following equation: $V = A/(1 + kD)$, where V is the present value of reward A available at delay D , and k is the discount rate parameter (Mazur, 1987).

Motor / Action Impulsivity

Stop Signal Task (SST): The SST is a response inhibition task that measures the ability to inhibit inappropriate motor responses (Dougherty, 2003). The task consists of a series of 5-digit numbers presented on a computer screen for 500 msec. Participants were instructed to respond to a stimulus only if it was the same 5-digit number as the preceding one. However, participants were also told to withhold their response if the number turns red. The change from black to red (i.e., the stop signal) appeared at one of four delays after stimulus onset: 50, 150, 250, and 350 msec. The average of the percent successful inhibitions for each of the four delay intervals was used in the analyses.

Clinical Assessment

Wender-Utah Rating Scale (WURS): The WURS (Ward, Wender, & Reimherr, 1993) is a self-report questionnaire for retrospective assessment of childhood symptoms associated with ADHD. It is considered a sensitive instrument for identifying adults with ADHD. Answers to each item are measured on a 5-point scale ranging from 0 (*not at all or very slightly*) to 4 (*very much*). Scores for each item were added to obtain a total raw score. We used the 25-item short version of the instrument.

Data Analyses: To test the study hypotheses, we conducted three simple linear regression analyses, which employed the WURS Total Score as the ADHD predictor variable, and performance on one of the impulsivity measures - decision-making (IGT), delay discounting (DRDT), and response inhibition (SST) - as the outcome variable. When necessary, variables were transformed to ensure that assumptions of normality and homogeneity of variance were met. Outliers with scores greater than three standard deviations from the mean on any of the task indices were excluded.

Results

Demographic and Substance Use Characteristics

As seen in Table 1, participants had a mean age of 27.7 years ($SD = 2.7$) and approximately 13 years of education ($M = 12.5$, $SD = 1.6$). While on average participants had 7 years (SD

= 2.9) of heroin use, they currently had over a year of abstinence from heroin ($M = 402.5$ days, $SD = 223.8$). Most participants did not have a history of any other drug dependence, whereas other reported a history of cannabis dependence ($n = 11$, 34.4%), stimulant dependence ($n = 2$, 6.3%), and cocaine dependence ($n = 1$, 3.1%). ADHD symptom scores, as measured by the WURS (total scores range between 0 and 100), averaged 36.6 ($SD = 18.6$, range = 5 - 80).

Decision-Making (Iowa Gambling Task)

A regression analysis was used to test if the total score on the WURS predicted participants' performance on the IGT. The results of the regression indicated that the WURS explained 20% of the variance in the model ($R^2 = .202$, $F(1,30) = 7.61$, $p < .01$) and significantly predicted IGT performance ($\beta = -.45$, $SE = .123$, $p < .01$).

Delay Discounting (Delayed Rewards Discounting Task)

Because the assumption of normality was not met, data were logarithmically transformed, as typically done with this task. ADHD symptoms did not predict DRDT performance ($F(1,30) = .374$, $p = .545$).

Response Inhibition (Stop Signal Task)

One outlier with scores greater than three standard deviations from the mean was excluded from the analysis; therefore, the total number of participants for this task was 31. We performed a linear regression where the average of the four different stop signal delays in milliseconds (50, 150, 250, and 350) was the outcome variable. No statistically significant association was found, $F(1,29) = 1.752$, $p = .196$.

For descriptive characteristics of the data, please refer to Table 2.

Discussion

Our results indicate that childhood ADHD symptoms are not uniformly associated with neurocognitive dimensions of impulsivity in currently abstinent heroin addicts. Specifically, whereas reported childhood symptoms of ADHD were significantly associated with more impulsive and disadvantageous decision-making, they were not associated with delay discounting or response inhibition.

These findings are similar to two of our earlier findings with different samples of Bulgarian individuals with heroin dependence, wherein those with comorbid psychopathy exhibited more impulsive decision-making but had no deficits in delay discounting or response inhibition when compared to individual with heroin dependence but no psychopathy (Vassileva et al., 2007; 2011) and to a different study where abstinent heroin users demonstrated more impulsive decision making than non-drug using controls but not relative to abstinent stimulant users (Ahn et al., 2014). Our results suggest that the IGT may be sensitive to externalizing psychopathology but may not have sufficient disorder specificity.

Research findings with ADHD and delay discounting have not been very consistent. According to some authors (Winstanley et al., 2006), there may be two types of ADHD,

those with an altered motivational style comprised of individuals with ADHD who are strongly averse to delays, and those with a disordered thought and action pathway characterized by greater inhibitory dysregulation. It is plausible that our sample of abstinent individuals with heroin dependence and ADHD was comprised predominantly of individuals characterized by greater inhibitory dysregulation but higher tolerance to delays.

With regards to response inhibition or motor impulsivity, our results showed no influence of ADHD symptoms on the SST, which is in line with previous research (Downey, Stelson, Pomerlau, & Giordani, 1997). A plausible explanation would be the often noted reduction of hyperactivity and impulsivity symptoms in adults with ADHD, in contrast with the persistence of inattention and working memory deficits that are more prominent in adulthood (Vassileva & Fischer, 2003).

Our study has several limitations that should be noted. We did not conduct a diagnostic interview for ADHD symptoms, so the presence of ADHD symptoms is only based on retrospective self-report on the WURS. In addition, the WURS does not differentiate between different subtypes of ADHD nor does it assess for current symptoms of ADHD. Therefore, we do not know how many of the participants would meet current criteria for ADHD. Also, the lack of a control group with no heroin use prevented us from investigating whether the performance of the participants was impaired relative to people who do not use drugs. Participants in the study were currently abstinent and results may not generalize to individuals with heroin dependence who are actively using. It is possible that individuals with heroin dependence who are able to achieve and maintain abstinence for a year are less impulsive than those unable to maintain long-term abstinence. Finally, participants in our study were recruited and tested in Bulgaria. Although the tasks utilized had limited reliance on language skills, the impact of cultural differences should be considered as a possible limitation, particularly with regards to the generalizability of the results.

In conclusion, self-report childhood ADHD symptoms in currently abstinent individuals with a history of heroin dependence were associated with more impulsive and disadvantageous decision-making. Therefore, the presence of ADHD symptoms may exacerbate decision-making deficits in this population, which may account in part for the disadvantageous behaviors that are associated with substance abuse. Identifying the relationship between longstanding ADHD symptoms and cognitive impairments among individuals with substance use disorders may have important implications for treatment compliance and relapse prevention. Although our results help better characterize neurocognitive functioning in this understudied population, future research is required to explore the associations of ADHD and dimensions of impulsivity in people actively using various drugs and in those who are abstinent.

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Table 1
Demographic and substance use characteristics of participants (N = 32)

	M (SD)
Age	27.66 (2.7)
Years of education	12.5 (1.6)
Estimated IQ	104.6 (11.9)
WURS Total Score	36.6 (18.6)
Length of abstinence (Days since last used heroin)	402.5 (223.8)
Years of heroin use	7.1 (2.9)
	n (%)
History of past substance dependence:	
- alcohol (%)	0
- cannabis (%)	11 (34.4)
- stimulants (%)	2 (6.3)
- cocaine (%)	1 (3.1)
- sedatives (%)	0 (0)
- hallucinogens (%)	0 (0)

Note. IQ = intelligent quotient, WURS = Wender Utah Rating Scale.

Table 2
Means and Standard Deviations for the Iowa Gambling Task, Delayed Rewards
Discounting Task, and Stop Signal Task

	N=32
IGT Total net score (advantageous decks-disadvantageous decks)	-3.25 (14.31)
DRDT Average discount rate of small, medium, and large magnitude rewards	-1.29 (.49)
SST Total number of successful response inhibitions	52.42 (9.22)

Note. IGT = Iowa Gambling Task; DRDT = Delayed Reward Discounting Task; SST = Stop Signal Task.