

Specific Aspects of Executive Functioning Impacted in HIV and Cocaine Dependence

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Research

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Abstract

Background: Our study aimed to understand the effects of HIV and cocaine dependence (CD) on discrete aspects of executive functioning via the Stroop Color-Word Test and the Trail Making Test (TMT). We recruited 101 participants (26 HIV+/CD+; 18 HIV+/CD-; 30 HIV-/CD+; and 27 HIV-/CD-).

Methods: We utilized a series of 2 (HIV: yes/no) × 2 (Cocaine: yes/no) ANCOVA's while controlling for age and premorbid intelligence on the Stroop trials (i.e., color-naming, word reading, interference), and ANOVA's were used to test for group differences on TMT-A and TMT-B z-scores, the number of errors, and the B/A ratio score.

Results: We found a significant main effect of HIV on the Stroop Interference ($p = 0.012$) and the TMT B/A ratio ($p = 0.017$), these findings are consistent with difficulties in cognitive flexibility. On the Color-Naming and Interference trials, individuals with CD made significantly more errors than non-users ($p = 0.028$), demonstrating difficulties with inhibition.

Conclusions: Our results show HIV and CD are associated with different underlying cognitive processes which impact overall executive functioning. Understanding the different cognitive factors impacting executive functioning can help formulate tailored treatment recommendations and targeted interventions for people living with HIV and those with cocaine dependence.

Background

Individuals living with HIV commonly demonstrate a neuropsychological profile with prominent disturbances in executive functioning [1, 2, 3, 4, 5]. In addition to the cognitive impairment associated with HIV, there is a high rate of substance use disorders in the HIV population, making it difficult to determine which cognitive disturbances are due to HIV or illicit substances. Stimulants, such as cocaine, are the most commonly used class of substances in the HIV population [6, 7, 8]. Cocaine accelerates HIV progression [9, 10] making cocaine dependence in this population extremely dangerous. One of the major cognitive domains impacted by both HIV and cocaine is executive functioning [7, 8, 11].

Although many studies have examined executive functioning in the HIV and the cocaine dependence populations, there has been limited explanation as to the specific underlying cognitive processes impacting an individual's performance on formal executive functioning measures. There has been a lack of comparison between different executive functioning measures in individuals living with HIV who also have cocaine dependence. A recent systematic review and meta-analysis [12] pointed out the considerable differences within the conceptualization and measurement of executive functioning within the HIV population. Overall, there is a consensus that executive functioning impairments exist within both the HIV population and the cocaine dependence population. However, due to the comorbidity, we do not know if HIV and cocaine dependence impact different underlying cognitive processes involved in executive functioning.

Our study aimed to understand better and further delineate the underlying cognitive processes associated with HIV and cocaine dependence by examining two executive functioning measures that assess different aspects of executive functioning. One of the neuropsychological tests is the Stroop Color-Word Test (Stroop) [8, 13]. The Stroop has various versions, but they all include an Interference trial, which involves reading color words (e.g., red, green) printed in different colored ink. The Interference trial is where the “Stroop effect” is observed [14]. The Stroop effect is the delay in reaction time observed when incongruent words interfered with naming the ink's color. The Stroop task provides information regarding an individual's processing speed, visual scanning, inhibition, and sustained attention abilities. The existing literature examining performance on the Stroop in individuals living with HIV has shown mixed results. Some studies have shown similar performance on the Interference trial between HIV+ and HIV- individuals [2, 15, 16, 17]. Others have found that individuals living with HIV perform significantly worse on the Interference trial than individuals who are HIV- [4, 18, 19]. Within the literature on cocaine dependence, there has been greater consistency in demonstrating difficulties on the Interference trial and a higher number of response errors [11, 20, 21, 22].

The Trail Making Test (TMT) is another formal executive functioning measure. The TMT has two parts (i.e., TMT-A and TMT-B), TMT-A is a measure of processing speed and visual scanning, and TMT-B is a measure of cognitive set-shifting/cognitive flexibility. TMT differs from Stroop in multiple ways; the most notable is the reliance on fine-motor functioning. The existing literature within the HIV population has shown mixed findings. Some studies showed similar performances on TMT-B between HIV+ and HIV- groups [23, 24], whereas other studies have found that individuals who are HIV+ perform worse than individuals who are HIV- [18, 25, 26]. Multiple studies have found no difference in the TMT when comparing performances between individuals with cocaine dependence and without [27, 28]. Of note, the studies mentioned above did not control for motor speed, and since TMT requires the individual to draw lines as quickly as they can, an individual's fine-motor abilities can impact the time of task completion [29]. Therefore, many studies have suggested the need to utilize derived scores (i.e., B/A ratio), which minimize the effect of motor speed, resulting in a purer measure of executive functioning [30, 31].

Another significant factor impacting the consistency in the literature is the lack of control for polysubstance use, making it extremely challenging to determine which substance(s) may be impacting an individual's performance. Therefore, there is a significant need to fully understand the neuropsychological effects of “pure” cocaine dependence [20] which our study addresses explicitly. In the present study, we aimed to limit the number of potential confounding variables through strict exclusion and inclusion criteria. Our goal was to understand the effects of HIV and cocaine dependence on specific aspects of executive functions. Our sample consisted of four groups to examine the potential impact of both HIV and cocaine dependence. We included individuals living with HIV who have cocaine dependence (HIV+/CD+), individuals living with HIV who do not have cocaine dependence (HIV+/CD-), individuals without HIV who have cocaine dependence (HIV-/CD+) and lastly individuals with neither HIV nor cocaine dependence (HIV-/CD-).

Based on the existing literature, we hypothesized that individuals in the HIV+ groups (HIV+/CD+ and HIV+/CD-) would have impaired performance (i.e., taking significantly longer) on both the Stroop Interference and TMT-B. We also predicted that individuals with cocaine dependence (HIV+/CD+ and HIV-/CD+) would have a significantly impaired performance on the Stroop Interference (i.e., longer completion time), but intact performance on TMT-B. We also predicted a significant interaction between HIV and CD on the Stroop Interference, such that the HIV+/CD+ individuals would demonstrate the most significant impairment in their performance compared to all the other groups of individuals.

Methods

Sample

Our sample consisted of 101 participants, including 26 individuals who are HIV+ with cocaine dependence (HIV+/CD+), 18 individuals who are HIV+ without cocaine dependence (HIV+/CD-), 30 individuals who are HIV-negative with cocaine dependence (HIV-/CD+), and 27 individuals who are HIV-negative without cocaine dependence (HIV-/CD-).

Inclusion/Exclusion Criteria. All participants were required to be 21 to ensure complete cognitive development and a maximum age of 55 to limit potential aging effects. Participants had to be fluent in English, travel to the study visits, and provide informed consent. Exclusion criteria were as follows: a positive urine drug screen, current or lifetime DSM-IV diagnosis of schizophrenia or psychosis, AIDS-defining CD4 count (< 200), current or history of dementia or other AIDS-defining CNS disorders, history of a head injury with a loss of consciousness for more than 30 minutes, or vision problems that eyeglasses or contact lenses could not correct.

All individuals in the cocaine-dependent groups (i.e., HIV+/CD+, HIV-/CD+) were required to meet DSM-IV criteria for a diagnosis of cocaine dependence within the past two years. Exclusion criteria were a current or lifetime DSM-IV diagnosis of abuse or dependence on opioids or methamphetamine; DSM-IV diagnosis of dependence on any other illegal or prescription drug within the past five years; and DSM-IV diagnosis of alcohol dependence within the past year. The specific substance use criteria are consistent with the existing literature [8, 32, 33], which has demonstrated the specific amount of time following abstinence from a substance in which the substance continues to impact an individual both behaviorally and neurochemically.

HIV+ groups were required to be adherent to HIV medications for the past three months, as verified by the Medication Adherence Self-Report Inventory (MASRI), have a CD4 count >200, and have an undetectable HIV RNA viral load (<50 copies/mL). The specific criteria for those in the HIV+ groups were set in place to ensure that all individuals with HIV were asymptomatic, according to the Center of Disease Control and Prevention (CDC) and the World Health Organization (WHO) HIV disease severity staging system [34]. HIV-negative groups were required to provide documentation verifying that they were seronegative. For those unable to do so, a rapid oral HIV test was given to confirm their negative HIV status. Our aim with the extensive criteria was to ensure that other comorbidities could not better explain our findings. The HIV

specific criteria are consistent with previous studies that aimed at minimizing confounding factors potentially related to HIV-associated neurocognitive disorders [35].

Procedure

The authors' Institutional Review Boards approved this study. Participants were recruited from local clinics (i.e., Chicago Developmental Center for AIDS Research (D-CFAR), the UIC Infectious Disease Clinic, Ruth M. Rothstein CORE Center) within the very focused 560-acre Illinois Medical District located in Chicago's Near West Side. Interested participants initiated contact with the study coordinator, who completed a phone screen with potential participants to assess for initial eligibility. If the individual met criteria based on the telephone screen and agreed to abstain from using any drugs or alcohol for 48 hours before their on-site screening, they were invited to schedule their first visit. At the beginning of the first visit, informed consent was obtained before completing any of the study procedures. The participant then completed a urine toxicology test and an alcohol breathalyzer test. If the individual did not pass the urine toxicology test or the alcohol breathalyzer test, the individual's visit ended and was rescheduled for a later date. If an individual passed the urine toxicology and breathalyzer procedures, the screening visit proceeded. Participants completed a series of clinical and demographic questionnaires to obtain information on demographics, medical history, psychiatric disorder history, drug use, and medication adherence (HIV+ groups). Participants also completed the Structured Clinical Interview for the DSM-IV-TR (SCID-IV-TR) and a fixed neuropsychological test battery. Participants were paid \$30 for their participation.

Measures

Screening Measures. All participants completed a brief demographic questionnaire and the full Structured Clinical Interview for DSM-IV-TR (SCID-IV-TR) [36] to determine any psychiatric diagnoses that would make them ineligible for the current study (see Inclusion/Exclusion Criteria). Module E of the SCID-IV-TR was explicitly utilized to determine specific current and lifetime substance abuse and dependence. Participants also completed the KMSK (Kreek – McHugh – Schluger – Kellogg Scale) to assess current (i.e., within the past month) and historical substance use (i.e., within their lifetime). The KMSK provides critical values, calculated from the participant's frequency (i.e., number of times used in past month and lifetime), amount of substance use or amount of money spent daily, and duration of use for each specific substance [37]. A urine toxicology screen and breathalyzer were also given as all individuals could not be under the influence of any substance at the time of testing.

Medical Record Review. All participants provided a release of information for medical records to be obtained that are related to our study aims. For participants who are HIV-positive, HIV variables including date of HIV diagnosis, most recent (within the past six months) CD4 count, HIV RNA viral load (copies/mL), and current list of medications were all recorded. Participants who were HIV-positive also completed a Medication Adherence Self-Report Inventory (MASRI) to assess adherence to their HIV medication. For participants who are HIV-negative, if they could not confirm their HIV status with medical

documentation within the past six months, participants were given the OraQuick® rapid HIV test to confirm their negative HIV status.

Neurocognitive Functioning. Trained research assistants administered a brief neuropsychological test battery to assess neurocognitive functioning. Two research assistants double scored all measures. To obtain an estimate of the participants' premorbid cognitive functioning, each participant completed the Wide Range Achievement Test, Fourth Edition: Word Reading subtest (WRAT-4: WR) [38]. On this task, participants were provided a sheet of increasingly difficult words and were asked to read as many words as possible. This task provided a well-validated way to estimate premorbid cognitive functioning [39].

To assess executive functioning, we utilized both the Stroop Color and Word Test (Stroop) as well as the Trail Making Test (TMT). The Stroop Color and Word Test, Comalli-Kaplan version [40], consists of three trials. The Color-Naming trial (Trial 1) and the Word-Reading trial (Trial 2) are primarily measures of attention and processing speed. The Interference trial (Trial 3) is primarily a measure of response inhibition and cognitive flexibility. Completion time for each trial was recorded in seconds, with the discontinue rule being four minutes on each of the three trials. The number of errors made on each of the trials was also recorded. Errors were defined as those mistakes that participants did not self-correct. The existing norms for the Stroop have been found to over pathologize African Americans [35], which is the majority of our sample. Because the Kaplan-Comalli version of the Stroop Color-Word Test does not have up-to-date published norms representative of this study's sample, we utilized the raw scores instead of converting the raw scores to demographically corrected z-scores.

The Trail Making Test (TMT) has two parts, TMT-A and TMT-B. TMT-A consists of 25 total numbered circles in which a person draws a line connecting each of the numbered circles in numerical order. TMT-B consists of both numbers (1-13) and letters (A-L) in which a person is to draw a line connecting numbers and letters in order switching from a number to a letter (i.e., 1-A-2-B-3-C). The participant's completion time was recorded in seconds. The number of errors made was also recorded. An additional derived ratio score (B/A) was computed to measure executive functioning more directly while controlling for the impact of visual-motor speed [30, 31]. The TMT-A primarily measures visual-motor processing speed, and TMT-B primarily measures cognitive switching [41, 42]. We utilized the Heaton norms, which took sex, age, race/ethnicity, and level of education into consideration to convert raw scores to demographically corrected z-scores [43].

Statistical Analysis

Chi-square tests were used to determine significant differences between categorical variables, and two-way analysis of variance (ANOVA) was used for all the continuous variables. For the HIV-positive participants, t-tests were used to determine if there were significant differences in the mean CD4 count, HIV RNA viral load (copies/mL), and years since HIV diagnosis. Levene's F test was used to determine if the variances between groups were equal.

A series of 2 (HIV+/HIV-) × 2 (CD+/CD-) analyses of covariance (ANCOVA's) were used to test for differences between groups on completion time and the number of errors on the Stroop (i.e., Color-Word Reading, Word Reading, Color-Word Interference) while controlling for age and premorbid IQ. Although premorbid IQ was not significantly different between groups, it was significantly correlated with our dependent variables, and therefore it was included along with age in our model. Since we utilized demographically corrected z-scores for the TMT, we did not need to include age as a covariate. Therefore, we conducted a series of analyses of variance (ANOVA's) to test the differences between groups on TMT-A and TMT-B z-scores, the number of errors, and the B/A ratio score. To further examine if the Stroop and TMT measures assessed similar underlying cognitive processes, we performed correlation analyses between the TMT and Stroop. To control for multiple comparisons, we utilized a Tukey's HSD correction to determine the significance of these omnibus tests. For all statistical analyses, we utilized the Statistical Package for the Social Sciences (SPSS) 24.0.

Results

Participant Characteristics

Demographic, HIV, and substance use characteristics for each of the four groups are shown in Table 1. The sample consisted of a total of 101 participants, 56 of whom were male, and 45 were female. Participants were mainly Black/African American (75.2%), with the rest of the population being White/Non-Hispanic (8.9%) or Hispanic/Other (15.8%). The mean level of education was 13.43 years (SD = 2.09), and the participant's age ranged from 22 to 55 years old (M = 42.12, SD = 9.42). There was a significant difference in age ($p = 0.002$) between groups, such that the HIV-/CD- group was significantly younger than those in the HIV+/CD+ group ($p = 0.001$). Premorbid IQ and years of formal education were similar between groups.

There were no significant differences in the severity of peak cocaine dependence or recent cocaine dependence in the two cocaine-dependent groups. Among participants who were HIV+, there were no significant differences in the number of years living with HIV, CD4 lymphocyte count, or HIV RNA viral load.

Neurocognitive Functioning

All mean raw and z-scores for both the Stroop and TMT are presented in Table 2. On the Stroop, we utilized raw scores while controlling for age and premorbid IQ, as the Comalli-Kaplan version does not have demographically corrected normative data that was representative of our population sample. The mean completion time for all three trials is presented in Figure 1. On the Color-Naming trial, there was no significant main effect on completion time of either HIV status ($p = 0.814$) or cocaine dependence ($p = 0.869$). On the Word-Reading trial, there was no significant main effect of either HIV status ($p = 0.229$) or cocaine dependence ($p = 0.852$). The Interference trial showed a significant main effect of HIV ($p = 0.012$), and a trend toward significance for cocaine dependence ($p = 0.061$). There was not a significant

HIV × Cocaine interaction on Color-Naming ($p = 0.420$), Word-Reading ($p = 0.873$), or Interference ($p = 0.551$).

We also assessed the number of errors made during each of the three trials. Errors were classified as the mistakes that participants did not self-correct. On the Color-Naming trial, there were no significant differences in the number of errors made. On the Word-Reading trial, there was a main effect of cocaine dependence ($p = 0.028$). There was again the main effect of cocaine dependence ($p = 0.046$) for errors on the Interference trial, with CD+ making more errors than CD-. There was no effect of HIV on number of errors made on the Color-Naming ($p = 0.132$), Word-Reading ($p = 0.982$), or Interference ($p = 0.071$) trials.

On the TMT, demographically corrected z-scores were utilized (Heaton et al., 2004). On TMT-A, there was no main effect of either HIV ($p = 0.191$) or CD ($p = 0.177$), nor was there a significant HIV × Cocaine interaction ($p = 0.892$). On TMT-B, we again did not find a significant effect of either HIV ($p = 0.233$), CD ($p = 0.087$), or a significant HIV × Cocaine interaction ($p = 0.523$). When examining the TMT B/A ratio, there was a significant main effect of HIV ($p = 0.017$). There was no main effect of CD ($p = 0.503$), nor was there a significant HIV × Cocaine interaction ($p = 0.430$) on TMT B/A ratio. There were no significant differences among the groups in the number of errors made for either TMT-A or TMT-B. Lastly, we conducted Pearson bivariate correlations to examine the relationship between the derived scores on the TMT and Stroop. Notably, we did not find a significant correlation between TMT-B z-score and Stroop Interference completion time ($p = 0.62$), suggesting that these two measures assess different aspects of executive functioning.

Discussion

Our study examined the impact of HIV and cocaine dependence on aspects of executive functioning. Through the use of two neuropsychological tests, the Stroop Color-Word Test, and the Trail Making Test, we were able to assess different cognitive factors that can impact an individual's overall performance on formal measures of executive functioning. Overall, we found both HIV and cocaine dependence to be associated with executive dysfunction. Specifically, HIV was associated with problems with cognitive flexibility, while cocaine dependence was associated with problems with inhibitory control.

With the Stroop task, we found the HIV and CD populations to perform similarly on both the Color-Naming and Word-Reading trials. However, on the Interference trial, individuals living with HIV took significantly longer than individuals who were HIV-negative. The Interference trial is primarily a measure of response inhibition and cognitive flexibility. Through an examination of the two difference scores (i.e., Interference – Word Reading; Interference – Color Naming), we were able to determine that regardless of processing speed, individuals living with HIV still perform significantly worse than individuals who are HIV-negative. In addition to the completion time, we examined the completion accuracy on each of the Stroop trials. There was no impact of HIV status on the number of errors. In contrast, there was a significant impact of CD on the accuracy, such that individuals with CD made significantly more errors on the Word-Reading and Interference trials. The significant number of errors made by those with CD is indicative of difficulties

with inhibitory control, which is consistent with previous research [20, 22, 44]. This lack of inhibitory control is also commonly implicated in poor treatment compliance, treatment retention, and self-regulation in individuals who have cocaine dependence [44, 45, 46]. In substance dependence clinics, the Stroop has been used to determine treatment retention and abstinence from substances. They have found continued cocaine dependence resulted in decreased inhibition and thus greater difficulty in remaining abstinent from cocaine [20, 22], which is consistent with our findings that individuals with cocaine dependence have significant problems with inhibition.

On the TMT, we did not find a significant effect of either HIV or CD on TMT-A or TMT-B, consistent with other studies in which the proper normative data was utilized [24]. However, we did find a significant main effect of HIV on the derived TMT-B/A ratio score. The derived TMT-B/A ratio score is a more direct measure of executive functioning, primarily set-shifting/cognitive flexibility, as it controls for the impact of visual-motor speed [30, 31]. The significant effect of HIV on the TMT-B/A ratio score, along with the significant effect of HIV on the Stroop Interference trial, point to a shared underlying cognitive process being impacted in the HIV population, namely cognitive flexibility. This observed association between HIV status and cognitive flexibility problems adds to the existing literature that has shown impairments in cognitive flexibility on other neuropsychological assessments [12, 47, 48]. Our significant finding utilizing the B/A ratio highlights the need to utilize the TMT-B/A ratio score in future studies when investigating the TMT, as it can allow for a more sensitive measure of executive dysfunction.

By examining these two executive functioning measures, we could better understand the underlying cognitive processes likely impacting their overall performance on formal executive functioning measures. Knowing the cognitive processes impacting overall executive functioning is critical as it provides greater insight into the neural networks impacted by HIV and CD. Our findings support that individuals with CD have greater difficulty with inhibitory control. From a neurobiology perspective, the cocaine group's performance is reflective of disinhibition in the frontal lobe, which is also associated with the difficulties in abstaining from substances [49, 50, 51, 52]. For the individuals living with HIV, our findings reflect difficulties with cognitive flexibility. These findings add to the existing literature [47, 48] and additionally, significant cognitive flexibility problems are associated with medication nonadherence in the HIV population [49].

Understanding the differences in these specific aspects of executive functioning can further aid in proper treatment planning. Knowing that individuals living with HIV have more difficulty with cognitive flexibility, providers can provide support in this area. For example, when talking with the patient, use clear statements, allow time to transition from one topic to another, and provide a supplementary written document in a bullet-point format so the individual can refer back to this information later. In addition to providing support, compensatory cognitive training and a useful recommendation for individuals living with HIV, their difficulties with attention are likely to impact them across many aspects of their daily lives. Compensatory cognitive training can provide these individuals with the understanding behind their cognitive difficulties, and learn key skills for effectively coping and navigating through their everyday life with the implementation of these compensatory strategies. Importantly, individuals living with HIV and

cocaine dependence are more likely to have difficulties with both cognitive flexibility and inhibitory control, requiring increased intervention in both of these domains. Through acknowledging these specific differences in these individuals' cognitive profiles, we can more adequately address these deficits and ultimately foster a more positive quality of life for these individuals.

A notable strength of this study is the comprehensive inclusion and exclusion criteria. Importantly, the participants were all adherent to their HIV medications within the past three months and had a CD4 count above 200. The above information was verified by reviewing their medical records and self-reports on the Medication Adherence Self-Report Inventory (MASRI). We conscientiously verified that the participants who were in the HIV+/CD+ group and the HIV-/CD+ group were not actively dependent on any other drugs aside from cocaine. We utilized multiple measures to verify current and historical substance use including a breathalyzer test, urine drug screening, KMSK, and the SCID-IV-TR substance abuse, Module E. The strict inclusion/exclusion criteria allowed us to examine the effects of cocaine in isolation and significantly reduce the number of confounding variables in our study. Additionally, our use of demographically corrected normative data and inclusion of the TMT B/A ratio score provided more accurate outcome measures and, therefore, a more accurate interpretation of findings.

In the present study, we did come across several limitations. First, the sample size within each of the four groups was relatively small and affected the power of statistical analyses. However, the small sample size was mainly due to the difficulty in recruiting participants that could abide by the strict eligibility requirements to limit confounding factors. Despite the smaller sample size, we still found the significant differences between the groups, and we can interpret our findings more confidently, given our strict inclusion/exclusion criteria. Second, although multiple measures to determine past substance use history were used, these measures were primarily based on the participants' self-report, aside from the urine toxicology and breathalyzer that were completed at the beginning of each study visit. Any unreported polysubstance dependency could alter neurocognitive task performance [16] and should be taken into consideration when interpreting the findings. The inclusion of an HIV-/CD+ group is a strength of our study as we were able to understand the effects of cocaine dependence without the confounding effects of other substances. However, on the other hand, this can also be viewed as a weakness in the generalization of our findings as not many individuals use cocaine in isolation [8, 16, 21, 52].

Future studies with larger sample sizes may allow for a higher power to examine the interaction between HIV and cocaine dependence. Researchers examining cognition in individuals with HIV+ and substance dependence should aim to maintain strict eligibility requirements regarding substance use to clarify the effects of particular substances and their possible combined effects with HIV. Additionally, the field would greatly benefit from a standardized battery in which there are demographically corrected normative data that would allow for a more accurate comparison between studies and aid in early detection of cognitive impairment.

Declarations

Ethics approval and consent to participate

This study was approved by the University of Illinois at Chicago's Institutional Review Board (IRB) Protocol number 2014 – 0701.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Authors' contributions

SN led the data collection, statistical analyses, and data interpretation. SN, AL, and AS prepared the draft of the manuscript. MW and SY are responsible for the study concept and design, and led all phases of manuscript preparation. AJ, LL, TCN, and AF reviewed/edited the manuscript. AF aided in recruitment of research participants. All authors have approved the final article submission.

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Tables

Table 1. Demographic, HIV, and Cocaine Dependence Characteristics across Groups (N = 101)

	HIV+/CD+	HIV+/CD-	HIV-/CD+	HIV-/CD-	Statistic
	(<i>n</i> = 26)	(<i>n</i> = 18)	(<i>n</i> = 30)	(<i>n</i> = 27)	
Age (M) (SD)	45.54 (6.76)	42.11 (7.10)	41.87 (9.66)	38.15 (11.14)	$F(3, 97) = 5.22, p = 0.002$
Years of Education (M) (SD)	13.00 (1.72)	12.89 (1.71)	13.20 (2.38)	14.44 (2.03)	$F(3, 97) = 0.71, p = 0.55$
Premorbid IQ (M) (SD)	89.00 (10.84)	89.22 (14.89)	93.83 (13.48)	97.44 (11.87)	$F(3, 97) = 1.38, p = 0.25$
Sex (%)					$\chi^2(3) = 5.58, p = 0.13$
Male	18 (69.2)	6 (33.3)	17 (56.7)	15 (55.6)	
Female	8 (30.8)	12 (66.7)	13 (43.3)	12 (44.4)	
Race/ethnicity (n) (%)					$\chi^2(6) = 11.51, p = 0.07$
Black/African American	23 (88.5%)	17 (94.4%)	20 (66.7%)	16 (59.3)	
White, non-Hispanic	1 (3.8%)	1 (5.6%)	3 (10.0%)	4 (14.8)	
Hispanic/Latino	2 (7.7%)	0 (0%)	7 (23.3%)	7 (25.9)	
HIV Characteristics (M) (SD)					
Years Living with HIV	16.58 (9.41)	16.13 (7.93)			$t(38) = 0.16, p = 0.87$
Current CD4 cell count	615.68 (272.18)	585.14 (242.64)			$t(34) = 0.34, p = 0.74$
HIV RNA Viral Load (copies/mL)	49.00 (2.69)	48.67 (3.94)			$t(38) = 0.32, p = 0.75$
Cocaine Dependence Characteristics					$\chi^2(2) = 0.573, p = 0.751$
Cocaine Dependence within	11		15		

the past month (%)	(42.31%)	(51.72%)	
Cocaine Dependence within the Past Year (%)	12 (46.15%)	13 (44.83%)	
Cocaine Dependence within the past 2 Years (%)	3 (11.54%)	2 (3.45%)	
Age first used cocaine (M) (SD)	25.19 (8.66)	22.44 (5.43)	t(51) = 1.39, p = 0.17
KMSK Scores			
Cocaine Peak (M) (SD)	19.38 (8.95)	15.52 (7.47)	t(53) = 1.75, p = 0.09
Cocaine Recent (M) (SD)	4.46 (7.12)	5.14 (5.29)	t(53) = -0.40, p = 0.69

Note: All values are means unless indicated otherwise. $N = 101$. HIV Characteristics are based on 39 participants' medical records out of the 44 individuals due to the inability to gain access to medical records to confirm other participants reported lab values.

KMSK = Kreek-McHugh-Schluger-Kellogg scale.

Table 2. Raw Scores and Z-scores for each of the neurocognitive measures ($N = 101$)

	Mean (SD)			
	HIV+/CD+ (n = 26)	HIV+/CD- (n = 18)	HIV-/CD+ (n = 30)	HIV-/CD- (n = 27)
Trail Making Test				
TMT-A z-score	-0.16 (0.93)	-0.46 (0.76)	0.07 (0.98)	-0.17 (1.10)
TMT-A Errors	0.19 (0.40)	0.22 (0.43)	0.10 (0.31)	0.07 (0.27)
TMT-B z-score	-0.04 (1.18)	-0.63 (1.34)	-0.50 (1.13)	-0.77 (1.31)
TMT-B Errors	1.04 (1.82)	1.22 (1.87)	1.33 (1.52)	1.44 (2.33)
TMT-B/A (Ratio)	2.90 (0.34)	3.22 (0.39)	3.85 (0.30)	3.66 (0.33)
Stroop Color Word Test				
Stroop Color Naming	71.45 (20.80)	68.05 (14.51)	67.78 (14.81)	70.00 (19.37)
Stroop Color Naming Errors	1.30 (3.08)	0.35 (0.71)	2.17 (4.07)	1.29 (1.58)
Stroop Word Reading	52.56 (14.42)	52.49 (10.32)	50.04 (10.53)	49.24 (11.77)
Stroop Word Reading Errors	1.00 (1.84)	0.27 (0.78)	0.87 (1.53)	0.41 (0.53)
Stroop Interference	167.90 (96.73)	138.85 (26.06)	130.45 (36.11)	115.08 (31.41)
Stroop Interference Errors	3.44 (5.82)	2.15 (3.54)	6.18 (6.81)	3.28 (4.37)
Stroop Int – Color Naming	100.31 (97.89)	71.11 (23.34)	62.37 (30.01)	41.82 (24.26)
Stroop Int – Word Reading	119.27 (99.00)	86.94 (24.98)	80.03 (33.53)	62.07 (22.88)

Figures

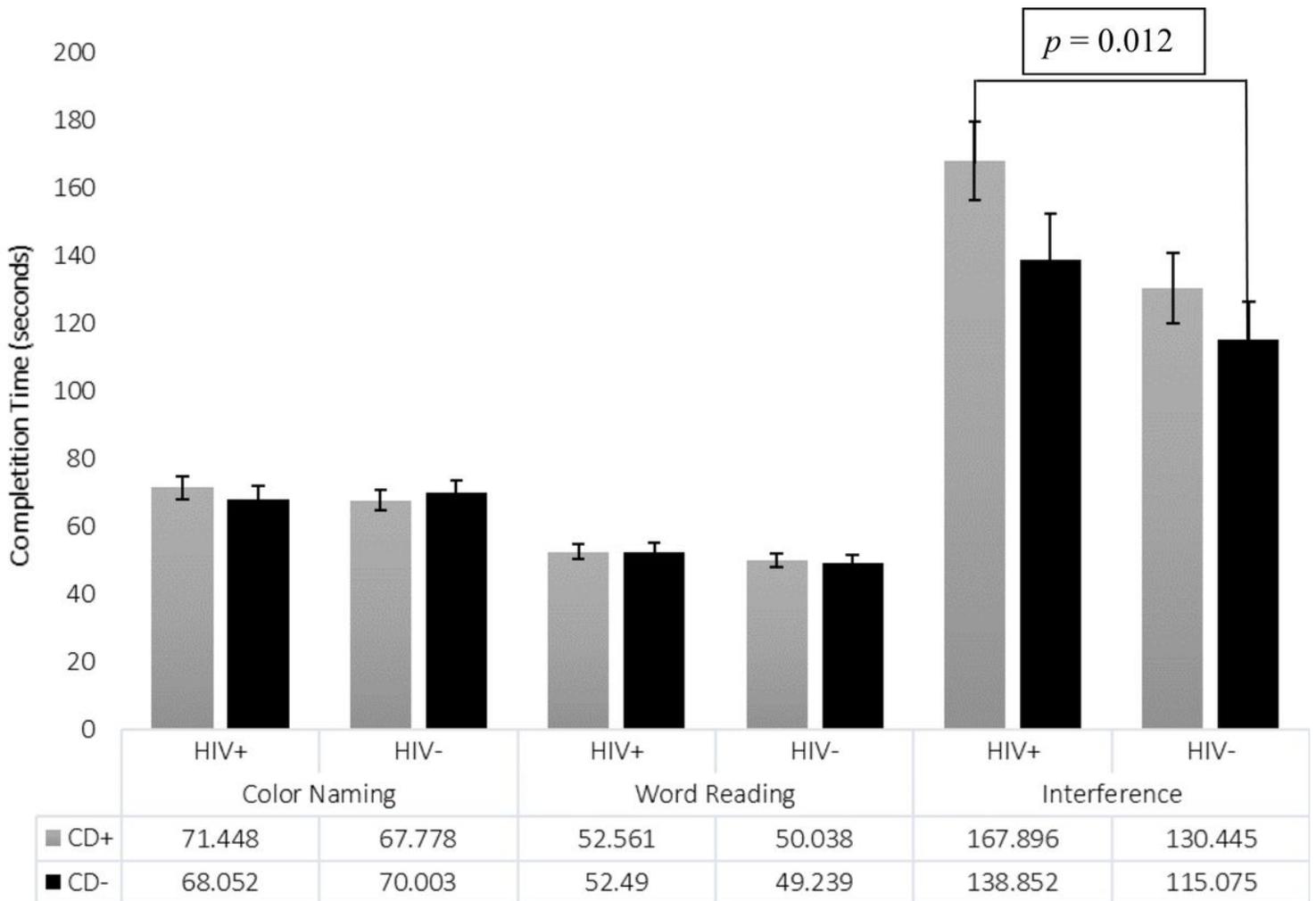


Figure 1

Mean Completion Time of All Three Trials of Stroop Task. The mean completion time in seconds for each of the three Stroop trials is shown for each group (N = 101). Standard errors are represented in the figure by the error bars attached to each column. Post hoc analyses using Tukey's HSD correction for multiple comparisons indicated a significant difference between the HIV+/CD+ and HIV-/CD- ($p = 0.012$) on the Interference trial individuals in the HIV+/CD+ group took significantly longer to complete the Interference Trial than individuals in the HIV-/CD- group.