Neurocognitive performance in drug dependent males and females with PTSD symptoms

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Abstract

Sex differences in neurobiological mechanisms of substance dependence are well documented but studies of sex differences in associated neurocognitive deficits have produced inconsistent results. PTSD is comorbid with substance dependence and frequently affects neurocognition. Thus, we investigated the effects of sex and PTSD symptoms on sustained attention and inhibition abilities among 126 female and 297 male substance dependent individuals (SDIs) using the Immediate Memory Test (IMT). Females with significant PTSD (PTSD+) symptoms demonstrated significantly impaired IMT performance relative to other participants. These results represent progress in efforts to delineate sex-specific risk factors for neurocognitive deficits among SDIs.

Recent literature has reported evidence of sex differences in neurobiological, behavioral, and environmental aspects of addiction (Fattore, Altea, & Fratta, 2008; Lynch, Roth, & Carroll, 2002; Tuchman, 2010; Wetherington, 2007). Although substance use disorders (SUDs) are more prevalent among males, females accelerate their drug use and transition to substance dependence more rapidly (Greenfield, Back, Lawson, & Brady, 2010). Recent investigators (Cahill, 2006; Wetherington, 2007) have emphasized the critical importance of detailed study of sex differences in addiction neuroscience. They note, for example, that neuroimaging studies have shown qualitatively different, and in some instances, opposing patterns of frontal and limbic activity in male and female substance dependent individuals (SDIs) (Kilts, Gross, Ely, & Drexler, 2004; Ray Li, Kosten, & Sinha, 2005; Volkow et al., 2011).

Several factors contribute to neurobiological mechanisms of sex differences in drug addiction, including cortisol and estrogen systems and their interactions with dopaminergic and serotonergic transmission (Fattore et al., 2008; Sava, McCaffrey, & Yurgelun-Todd, 2009; White, Justice, & de Wit, 2002). Given the profound effects these systems exert on brain-behavior relationships, it is reasonable to expect some sex differences in integrity of neurocognitive functions commonly affected by substance use disorders (Chambers, Garavan, & Bellgrove, 2009; Fernández-Serrano, Pérez-Garcia, Verdejo-García, 2011; Gruber, Silveri, & Yurgelun-Todd, 2007). Indeed, recent studies have shown significantly poorer performance among female compared with male SDIs on tests of complex decision-making (Van der Plas, Crone, van den Wildenberg, Tranel, & Bechara, 2009) and spatial working memory (Wang et al., 2007). Conversely, other studies demonstrated that male drug users showed poorer attention and recognition memory abilities than females (Rahman & Clarke, 2005) and that, compared with female

SDIs, male SDIs demonstrated poorer visual-spatial paired associate learning (Ersche, Clark, London, Robbins, & Sahakian, 2006). As a whole, the current literature indicates a need for detailed investigation of substance use characteristics and premorbid disorders as potential influences on the type and presence of sex differences in neurocognition among SDIs (see Sava et al., 2009, for a review).

Female SDIs are more commonly affected by comorbid psychiatric disorders (Tuchman, 2010), and therefore, when comparing male and female SDIs, it is important to consider specific neurocognitive risk factors that may interact with sex and have an effect on neurocognition in female SDIs. Thus, in the current study, we were interested in assessing neurocognition in SDIs with comorbid posttraumatic stress disorder (PTSD) because it is one of the most common comorbid disorders in SDIs (Brady, Back, & Coffey, 2004) and PTSD has shown the strongest association with substance dependence in individuals who did not also have a comorbid externalizing disorder such as ADHD (Hofmann, Richey, Kashdan, & McKnight, 2009). Also, compared with males, females are twice as likely to develop PTSD (Kessler, Sonnega, Bromet, Hughes, & Nelson, 1995). Furthermore, PTSD has been associated with dysfunction of neural circuitry that includes the hippocampus (Woodard et al., 2009), amygdala (Brohawn, Offringa, Pfaff, Hughes, & Shin, 2010), and prefrontal cortex (Liberzon & Sripada, 2008). Numerous studies have demonstrated impairment in sustained attention, working memory, verbal learning and inhibitory control (Vasterling et al., 2002) among different PTSD populations, including combat veterans, abuse survivors, and refugees/war victims (e.g., Qureshi et al., 2009). Still, the only study showing evidence of sex differences in neurocognitive features of PTSD suggested that PTSD symptoms were associated with executive functioning deficits in women but not men (Leskin & White, 2007). We found

no previous studies evaluating sex differences in the neurocognitive effects of comorbid substance dependence and PTSD.

Consistent with our goal to investigate sex differences in SUD and PTSD, we targeted executive control functions involving attention and inhibitory control as neurocognitive outcomes of interest as these are consistently impaired among patients with SUD (Fernández-Serrano, Pérez-Garcia, Verdejo-García, 2011; Perry & Carroll, 2008) and PTSD (Aupperle, Melrose, Stein, & Paulus, 2011; Falconer et al., 2007; Wu et al., 2010).

Thus, in the current study, we compared neurocognitive performance of male and female SDIs with and without significant PTSD symptoms using a modified Continuous Performance Task assessing both sustained attention and inhibitory control, the Immediate Memory Test (IMT; Dougherty, Marsh, & Mathias, 2002). Our primary goals were to examine the extent to which sustained attention and/or response inhibition are impaired among SDIs with significant symptoms of PTSD; and to determine if sex and PTSD exert distinct or additive effects on these outcomes. We compared four groups of SDIs: males without significant PTSD symptoms, males with significant PTSD symptoms, females without significant PTSD symptoms, and females with significant PTSD symptoms. We hypothesized that SDIs with significant PTSD symptoms would perform more poorly than SDIs without PTSD given that both PTSD patients and SDIs show difficulties with attention and inhibition abilities.

Method

Participants

The participants were 126 females and 297 males recruited from a large ongoing study of neurocognitive aspects of HIV and substance dependence. Participants were recruited from infectious disease and substance abuse clinics at the Jesse Brown VA Medical Center and the University of Illinois-Chicago, community substance dependence treatment programs, and by word of mouth. Inclusion criteria consisted of a history of cocaine or heroin dependence (see below for details). Exclusion criteria included a positive Breathalyzer test or rapid urine toxicology screen at time of testing, history of AIDS-defining or other central nervous system disease, schizophrenia, history of closed head injury with loss of consciousness greater than half an hour, seizure disorder, open head injury of any type, or current neuroleptic use. In order to assess attention and inhibition abilities in a larger and more representative sample of SDIs, we included participants who were both HIV+ and HIV-. Thirty one percent of participants were HIV+ and 19% were Hepatitis C seropositive. HIV serostatus was ELISA-verified in all instances.

Procedure

Assessment of Substance Abuse and Comorbid Diagnoses

All participants were administered the Structured Clinical Interview for DSM-IV (SCID-SAM; First, Spitzer, Gibbon & Williams, 2002) to verify history of substance dependence diagnosis. The majority of participants had a history of dependence on multiple substances: 69% participants had a positive history of alcohol dependence, 59% of cannabis dependence, 49% of opioid dependence, and 78% of cocaine dependence.

6

All participants completed the Addiction Severity Index (ASI; McLellan et al., 1985), a standardized measure commonly used in clinical evaluations of SDIs to estimate severity of drug and alcohol abuse, associated social problems, and medical issues. Additionally, participants completed a series of standardized paper and pencil measures of comorbid personality and psychological disorders. We assessed self-reported childhood symptoms of Attention Deficit Hyperactivity Disorder measured by the Wender Utah Rating Scale (WURS; Stein et al., 1995; Ward, Wender, & Reimherr, 1993). Estimated premorbid intelligence was measured using the Wechsler Test of Adult Reading, (WTAR; Wechsler, 2001), and symptoms of depression were assessed with the Beck Depression Inventory- Second Edition (BDI-II; Beck Steer, Ball, & Ranieri, 1996).

Post-Traumatic Stress Disorder Symptoms

All participants completed the PTSD Checklist – Civilian Version (PCL-C; Weathers, Litz, Herman, Huska, & Keane, 1993). The PCL-C is the most commonly used self-report measure of PTSD symptomatology (McDonald & Calhoun, 2010). Consistent with the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV; American Psychiatric Association), criteria for PTSD consists of seventeen symptoms and three symptom clusters. The PCL-C items were developed to represent the DSM-IV Criteria such that Cluster B represents DSM-IV criteria relating to reexperiencing symptoms, Cluster C relates to avoidance/numbing symptoms, and Cluster D relates to hyperarousal symptoms (Weathers et al., 1993). Using a recommended cutoff score of 50 (Bollinger, Cuevas, Vielhauer, Morgan, & Keane, 2008), 52 men and 28 women were classified as showing significant symptoms of PTSD. The final study groups consisted of: PTSD+ males (n = 52), PTSD- males (n = 245), PTSD+ females (n = 28), PTSD- females (n = 98).[1]

The Immediate Memory Task

The IMT is a computerized go-no go measure that resembles a Continuous Performance Test but with additional demands on inhibitory control, working memory, and sustained attention (Dougherty, Marsh, & Mathias, 2002). The task consisted of four 5-minute blocks with 300 trials per block and a 20-second break between each block. At the start of each trial, a 5-digit number (e.g., 58130) appeared for 500 milliseconds. After a stimulus offset period of 500 milliseconds, a second number appeared. Participants were instructed to press a response button when the two 5-digit numbers were identical (correct detection). Thirty three percent of the trials were go trials and 67% were no-go, which included catch trials (33%) or filler trials (34%). Catch targets differed from the cue by a single digit, and filler targets were completely novel. Both correct detections and commission errors (key press response on the catch trials) were recorded. The primary dependent variable was d', an index of ability to discriminate between correct targets and nontarget catch trials. d' *is* derived from signal detection theory (Dougherty et al., 2000), and is a measurement of the distance between the mean distribution for noise and mean distribution for signal combined with noise (Dougherty & Marsh, 2003). d' was calculated by the IMT software program (Dougherty & Marsh, 2003) with the following formula using a z-score transformation: $[z(1 − \text{proportion commission errors})] − [z(1 − \text{correct detections})]$. d' values ranged from 0 to 3.0 with lower values indicating poorer discriminability. Given evidence that sustained attention is indexed by correct detection rates and impulsivity is indexed by commission errors (Dougherty, Marsh, Moeller, Chokshi, & Rosen, 2000), we also investigated errors of commission and total correct detections separately to determine if sex and/or PTSD had different effect on sustained attention and impulsivity.

Results

Group Characteristics:

Prior to analyzing the IMT data we conducted an initial series of between-group (i.e., PTSD+ men, PTSD- men, PTSD women, PTSD- women) comparisons on demographic, substance abuse, and comorbid psychological variables. Table 1 shows the results of these group comparisons. There were no significant group differences in mean age, F (3, 419) = 1.34, p = .26, years of education, F (3, 419) = 1.44, p = .23, ethnic composition, χ^2 (3) = 1.34, p = .72, estimated premorbid intelligence (WTAR; F (3, 419) = 2.42, p = .07) or prevalence of positive hepatitis C virus (HCV; χ^2 (3) = 4.13, p = .25).

There was a marginally significant overall group difference in prevalence of a positive HIV serostatus, χ^2 (3) = 7.37, p = .06, although post-hoc comparisons showed no significant differences between specific groups. Still, given that HIV+ has well-documented effects on neurocognitive function (Martin et al., 2011), we included HIV serostatus as a covariate as our sample sizes were not sufficient to include HIV serostatus as an independent variable.

There were significant group differences in mean depressive symptoms with the BDI-II, F (3, 419) = 27.22, p < .001 and self-reported childhood symptoms of ADHD as measured by the WURS, F (3, 419) = 20.04, p < .001. Post hoc pair wise comparisons using the Bonferroni correction indicated that BDI-II scores were significantly higher for both PTSD+ males and PTSD+ females compared with PTSD- males and females (all *p's* < .001). Post hoc comparisons for WURS scores also revealed significantly higher scores for PTSD+ males and females compared with PTSD- males and females (*p's* < .001).

(Insert Table 1 about here)

Table 2 shows substance dependence characteristics for the four groups. There were no significant differences between participant groups in prevalence of past alcohol, cocaine or opioid dependence, but groups differed significantly in prevalence of past cannabis dependence, $\chi^2 (3) = 8.32$, $p < .05$. When post hoc comparisons were conducted with a Bonferroni correction, we found a significantly higher prevalence of cannabis dependence among the PTSD- males compared with PTSD- females ($p = .007$). There were no significant differences among participant groups for mean ASI Alcohol ($p = .26$) or Drug scores ($p = .15$). The distributions of years of substance use and days since last drug use were skewed to the right, so these variables were analyzed using Kruskal Wallis tests; results were nonsignificant for both tests (all p's $> .25$).

(Insert Table 2 about here)

In order to determine which comorbid variables should be used as covariates, we employed a separate linear regression analysis for each of the dependent variables (i.e., IMT d',) to assess the variance accounted for with BDI-II, WURS and history of cannabis dependence as predictor variables. We found that WURS scores contributed a significant amount of variance to IMT d' values (*Beta* = -0.15, $p < .05$) but BDI-II scores (*Beta* = -0.81, $p = .42$), previous cannabis dependence (*Beta* = -0.21, $p = .84$), and HIV serostatus did not (*Beta* = -008, p = .12). IMT correct detections were not predicted by WURS scores, (*Beta* = -0.10, $p = .07$), BDI-II scores, (*Beta* = 0.02, $p = .74$), cannabis dependence (*Beta* =0.01, $p = .98$), or HIV serostatus (*Beta* = -0.09, p = .07). IMT commission errors were not significantly predicted by WURS scores (*Beta* = .09, $p = .09$), previous cannabis dependence (*Beta* = 0.19, $p =.85$) or HIV serostatus (*Beta* = 0.03, p = .61), but were significantly predicted by BDI-II scores (*Beta* = .11, $p < .05$). Thus, due to the results of these regression analyses demonstrating that WURS and BDI-II

scores each significantly predicted one of the three IMT scores, both BDI-II and WURS scores were included as covariates. Thus, in summary, BDI-II, WURS, and HIV serostatus were included as covariates in all IMT analyses.

IMT Performance.

Figure 1 shows d' values for the four groups. Six participants' (two male PTSD+, two male PTSD-, one female PTSD+, and one female PTSD-) total errors exceeded two standard deviations above the mean. They were considered outliers and their data were not analyzed further. We conducted a full factorial 2 x 2 ANCOVA of d' values, with PTSD classification (PTSD+ vs. PTSD-) and Sex (male vs. female) as between-subjects variables with BDI-II scores, WURS scores, and HIV serostatus covaried. There were no significant main effects for PTSD, $F (1, 416) = 0.69, p = .41$, or Sex, $F (1, 416) = 0.19, p = .66$. In contrast, there was a statistically significant Sex by PTSD interaction, $F (1, 416) = 7.91, p = .005$. Simple main effects tests revealed that d' values were significantly higher in PTSD- females compared with PTSD+ females $F (1, 416) = 4.72, p < .05$, but there were no differences between PTSD+ and PTSD- males ($p = .13$). Additionally, d' values were significantly higher among PTSD- females compared with PTSD- males, $F (1, 416) = 6.77, p < .05$, and the decrement in d' performance for PTSD+ females represented a marginally significant difference compared with PTSD+ males, $F (1, 416) = 3.53, p = .07$. We then conducted an exploratory contrast, which revealed that PTSD+ females demonstrated significantly lower d' values compared with the three other participant groups, $F (3, 419) = 4.17, p = .006$.

(Insert Figure 1 about here)

11

To evaluate whether the interaction between PTSD and sex on d' was driven by correct detections or errors of commission, we analyzed mean percent correct detection collapsed over trial blocks. We found a marginally significant main effect for Sex, $F (1, 417) = 3.70$, $p = 0.055$ and a nonsignificant main effect for PTSD $F (1, 417) = 0.07$, $p = .80$. In contrast, we found a statistically significant sex by PTSD interaction, $F (1, 417) = 5.40$, $p < .05$. Simple main effects tests revealed significantly greater mean correct detection scores for PTSD+ males compared with PTSD+ females, $F (1,417) = 5.69$, $p < .05$. There were no significant differences between PTSD- males and females ($p = .66$) or between PTSD+ and PTSD- males ($p = .10$) or females ($p = .13$). See Figure 2a.

The ANCOVA for mean percentage commission errors collapsed across task blocks did not show significant main effects for Sex, $F (1,417) = 0.18$, $p = 0.68$, or PTSD, $F (1, 417) = 1.10$, $p = .30$, and no significant Sex by PTSD interaction, $F (1, 417) = 1.20$, $p = 0.27$. See Figure 2b.

(Insert Figure 2 about here)

Exploratory Analyses

PCL-C Cluster Scores.

We then conducted an exploratory series of comparisons of scores for each of the cluster scores on the PCL-C (Cluster B represents reexperiencing symptoms, Cluster C represents avoidance/numbing symptoms, and Cluster D relates to hyperarousal symptoms). As shown in Table 1, there were no significant differences between male and female PTSD+ participants in mean PCL-C Cluster B scores, $F (1, 78) = 0.02$, $p =$

.90, PCL-C Cluster C scores, $F (1, 78) = 1.89, p = .17$, PCL-C Cluster D scores, $F (1, 78) = 1.11, p = .30$, and PCL-C total scores, $F (1, 78) = 0.02, p = .89$.

We also conducted an exploratory hierarchical multiple regression analysis to evaluate potential sex-specific associations between PCL-C symptom clusters and d' values after accounting for the effects of sex and PCL-C independently. We entered sex as a predictor variable in Step 1, the three cluster subscores as a set in Step 2, and interactions between sex and each of the three cluster scores together in Step 3. None of the cluster scores significantly predicted d' values overall. However, the sex by Cluster C (i.e., avoidance/numbing) interaction significantly predicted d' values (Beta = -.21, $p <$ .05). Follow up analyses demonstrated that d' values were predicted significantly by Cluster C scores among female participants (Beta = -.30, $p < .01$), but not among male participants (Beta = -.03, $p = .64$). We found a similar significant sex by Cluster C interaction for correct detection scores (Beta = -.75, $p < .05$). Cluster C scores significantly predicted correct detection scores among female participants (Beta = -.27, $p < .01$), but not among male participants (Beta = -.09, $p = .14$).

Abuse history. Our study did not include detailed assessment of history of physical, sexual, or emotional trauma. However, for descriptive purposes we examined the association between d' values and self-reported prevalence of emotional, physical and sexual abuse from the Addiction Severity Index (ASI) for the PTSD+ groups. We found a significant sex difference in rates of self-reported sexual abuse, ($\chi^2 (1) = 5.54, p < .05$, males = 21%, females = 46%), but not self-reported emotional, $\chi^2 (1) = 0.16, p = .69$ or physical abuse, $\chi^2 (1) = 0.31, p = .58$. There were no significant relationships between any of the abuse variables and d' values (p's $> .72$).

Discussion

In this initial investigation, our primary goal was to compare performance of male and female SDIs with or without significant symptoms of PTSD on the IMT, a variant of the Continuous Performance Task that requires intact sustained attention and response inhibition for successful performance. More specifically, we sought to determine if sex or PTSD symptoms had additive or interactive effects on IMT performance. The primary analyses of overall performance (discriminability, indexed by d' values) showed no evidence of independent effects of sex or PTSD but revealed a significant sex by PTSD interaction. Specifically, the PTSD+ females performed significantly more poorly on the IMT than PTSD- females and showed a marginally significant ($p = .07$) impairment compared with PTSD+ males. Additionally, PTSD+ females demonstrated significantly more impairment in comparison to the other three participant groups. Separate analyses of components of IMT performance suggested that this effect was driven by the interactive effects of PTSD and sustained attention (i.e., measured by mean correct detections) rather than by impulsivity (i.e., measured by commission errors). Specifically, the PTSD+ females demonstrated a significant decrement in sustained attention compared with PTSD+ males. Finally, exploratory analyses of symptom clusters comprising the PTSD score revealed that symptoms of avoidance/numbing symptoms, rather than reexperiencing or hyperarousal, interacted with sex to influence cognitive performance. Thus, our findings of sex differences in task performance are suggestive of a specific deficit in sustained attention rather than a more general deficit in attentional control abilities involving inhibition. Participant groups were comparable in terms of demographic, substance abuse history, and confounding comborbidities were

covaried. Similarly, this interactive effect of sex and PTSD cannot be attributed to a more general pattern of sex differences in the relationship between psychopathology and neurocognition. Despite greater self-reported depression among the PTSD groups, there were no significant differences in depressive distress among PTSD+ males and females; additionally, self-reported depression and IMT performance were essentially uncorrelated.

Although not directly comparable, the literature on sex differences in stress responsivity includes a number of findings potentially germane to our results. For instance, Felmingham and colleagues (2010) reported that, compared with males, females with either a PTSD diagnosis or a history of trauma exposure showed greater brainstem activation when asked to discriminate between fearful and neutral facial expressions, suggesting that a lower arousal threshold exists among women with a history of traumatic stress. The investigators speculated that these findings might be due to a male advantage in inhibiting fearful arousal (Felmingham et al., 2010). Taken together, finding from this study as well as our current results suggest that intrusive effects of distress on cognition among women with PTSD might be associated with attentional mechanisms.

Furthermore, there is some evidence that PTSD symptoms are more strongly associated with neurocognitive deficits among females compared with males. For instance, females with PTSD have shown significant differences in anterior cingulate cortex function relative to females without PTSD (Seedat, Videen, Kennedy, & Stein, 2005). Also, Leskin and White (2007) reported that PTSD symptoms such as reexperiencing, avoidance/numbing, and arousal showed a significant positive association with deficits in executive function among females but not males. Our finding of an association between poorer attention and increased self-reported avoidance symptoms

only in females is consistent with their results. This finding also raises the question of more generalized effects of avoidance symptoms on additional aspects of cognition among females such as episodic memory.

To our knowledge this study is the first to examine sex differences in neurocognition among SDIs with and without PTSD symptoms. This study does not permit causal attribution, the evidence indicates that the interaction between PTSD and participant sex was driven primarily by impairment in sustained attention rather than impulsivity. It may be speculated that women SDIs with PTSD might derive particular cognitive benefit from treatment of PTSD; conversely, substance dependence treatment with a cognitive remediation component (e.g., Bickel, Yi, Landers, Hill, & Baxter, 2011; Brady, Gray, & Tolliver, 2011) could also result in improvement in their PTSD symptoms. For example, interventions targeting executive functioning abilities and sustained attention (Aupperle et al., in press) might improve capacity limited effortful processing over more automatic responding as observed in SDIs (Aron & Paulus, 2007; Bechara, 2005; George & Koob, 2010) and PTSD patients. Future studies of potential interactive effects of sex and PTSD symptoms on additional cognitive domains, particularly episodic memory, could inform the development of effective treatment (Johnsen & Asbjornsen, 2008; Verfaeille & Vasterling, 2009).

The current findings that female PTSD+ SDIs demonstrate more neurocognitive impairment are clinically relevant, in that SDIs with untreated PTSD are more susceptible to poor substance abuse outcomes (Read, Brown, & Kahler, 2004). Additionally, research has demonstrated that neurocognitive abilities have been found to be associated with treatment retention and relapse prevention. For example, Turner and colleagues (2009) reported that impaired performance on a problem solving task was associated with

higher rates of treatment dropout among cocaine dependent individuals (Turner, LaRowe, Horner, Herron, & Malcolm, 2009). A separate investigation with opiate dependent individuals found that poorer decision making significantly predicated relapse at three month follow-up (Passetti, Clark, Mehta, Joyce, & King, 2008); additionally, higher relapse rates were found among cocaine users who showed memory impairment (Thus it will be critical to investigate if PTSD+ women with attention deficits might be at greater risk for relapse.

In summary, we found that comorbid PTSD symptoms were associated with deficits in discriminability and sustained attention in female but not male SDIs. We note that although our participants' PCLC scores met DSM-IV criteria for PTSD, they were not clinically diagnosed using clinical interview such as the SCID; additionally, more specific details of trauma history (age at which trauma occurred, type of trauma, and number of traumatic events) were not available, but it will be important to investigate potential associations between these variables and neurocognition among men and women. Nevertheless, our finding that, in female SDIs, PTSD is a risk factor for a deficit in sustained attention, represents an important step toward delineating sex-specific risk factors in neurocognition among SDIs. Further neurocognitive and neuroimaging studies as well as investigation of potential sex differences in stress reactivity and treatment development are needed to address these findings.

Footnotes

[1] Throughout this manuscript we use the term "PTSD+" to indicate that a participant obtained a score or 50 or greater on the PCL-C. This value is one of the more conservative cutoffs employed in the PTSD literature and indicates that symptom type and severity, although consistent with DSM-IV criteria are not independently diagnostic of PTSD.

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Table 1

Demographic characteristics for sample of participants

_____
_____

| | Men | | Women | | | | |
	PTSD-	PTSD+	PTSD-	PTSD+	Test Statistic	*p*	Group Differences
n	245	52	98	28			
Age (in years)	42.6 (8.2)	42.3 (9.1)	40.6 (7.7)	42.0 (7.7)	$F = 1.34$	.26	
Education (in years)	11.6 (1.8)	11.7 (1.6)	11.6 (2.0)	10.9 (1.4)	$F = 1.44$	.23	
Estimated IQ	90.4 (12.1)	90.3 (11.8)	91.3 (11.2)	84.6 (9.5)	$F = 2.42$	.07	
Ethnicity/race, %							
Afr Amer	84	87	80	82	$\chi^2 = 1.34$	.72	
Hispanic	3	6	2	4	$\chi^2 = 1.48$	.68	
Caucasian	12	6	17	11	$\chi^2 = 4.35$	.23	
Other	1	2	1	4	$\chi^2 = 1.91$	.59	
HIV +, %	26	37	38	43	$\chi^2 = 7.37$	.06	
Hepatitis C, %	19	17	15	32	$\chi^2 = 4.13$	.25	
BDI-II Total Score	9.5 (8.6)	18.6 (9.2)	10.1 (7.3)	20.4 (11.0)	$F = 27.22$	<.001	b,d > a,c
WURS	30.6 (18.2)	45.5 (17.7)	27.4 (18.6)	50.0 (23.0)	$F = 20.04$	<.001	b,d > a,c
PCL-C							
Cluster B		16.8 (3.7)		16.9 (3.3)	F = 0.02	.90	
Cluster C		24.6 (3.9)		23.3 (4.7)	F = 1.89	.17	
Cluster D		17.1 (3.5)		18.1 (4.7)	F = 204.0	.30	

Note. Entries are means; standard deviations are in parentheses. Estimated IQ = Wechsler Test of Adult Reading Full Scale IQ estimation; HIV = human immunodeficiency virus; BDI-II = Beck Depression Inventory II; WURS = Wender-Utah Rating Scale; PCL-C = PTSD Checklist – Civilian Version. For description of group differences: a = Men PTSD-, b= Men PTSD+, c = Women PTSD-, d = Women PTSD+

Table 2
Substance use characteristics of study sample

	Men		Women			
	PTSD-	PTSD+	PTSD-	PTSD+	Test Statistic	p
Addiction Severity Index						
Alcohol	.14 (.11)	.14 (.10)	.12 (.09)	.17 (.09)	$F = 1.35$	.26
Drug	.07 (.04)	.08 (.05)	.06 (.04)	.08 (.04)	$F = 1.81$	.15
Years of substance use						
Alcohol	20.5 (10.3)	19.2 (10.5)	19.0 (9.5)	19.3 (6.7)	$F = 0.65$	.59
Cocaine	13.7 (8.2)	12.8 (8.8)	14.6 (8.2)	13.0 (7.1)	$F = 0.59$	.62
Opioids	13.5 (9.4)	17.1 (11.0)	14.4 (9.4)	12.8 (6.8)	$F = 1.18$	.32
Cannabis	12.9 (9.4)	13.7 (9.4)	11.1 (9.2)	11.6 (8.4)	$F = 1.16$	.33
Days since last use (median, IQR`)						
Alcohol	192 (1035)	150 (2437)	240 (1289)	167 (678)	$\chi^2 = 0.60$	.90
Cocaine	300 (1050)	156 (2081)	261 (1352)	274 (1299)	$\chi^2 = 1.19$	.76
Opioids	260 (1351)	639 (2292)	190 (528)	212 (1065)	$\chi^2 = 4.16$	.25
Cannabis	1558 (6752)	1643 (7128)	3468 (6935)	1347 (6034)	$\chi^2 = 2.60$	.46
Past dependence (%)						
Alcohol	68	69	71	71	$\chi^2 = 0.53$	.91
Cocaine	78	79	81	78	$\chi^2 = 0.40$	.94
Opioids	47	44	52	61	$\chi^2 = 2.78$	.43
Cannabis	63	65	47	57	$\chi^2 = 8.32$	.04
IDU (%)	24	13	21	37	$\chi^2 = 6.28$	.10

Note. Entries are means; standard deviations are in parentheses. IQR = interquartile range; IDU = Injection drug user.

Figure Legend.

Figure 1. IMT d' values and SE by PTSD classification and sex. *p < .01

Figure 2. IMT performance by PTSD classification and sex for: A) IMT mean percentage correct detections and SE, B) IMT mean percentage commission errors and SE. * p < .05