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CLINICAL RESEARCH ARTICLE
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Trauma on duty: cognitive functioning in police officers with and without posttraumatic stress disorder (PTSD)

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ABSTRACT

Background: Neuropsychological alterations co-occur with Posttraumatic Stress Disorder (PTSD); yet, the nature and magnitude of such alterations in police officers remains unknown despite their high level of trauma exposure.
Objective: The current research sought to examine (1) cognitive functioning among police officers with and without PTSD; (2) the clinical significance of their cognitive performance; and (3) the relationship between PTSD symptoms and cognition.
Method: Thirty-one police officers with PTSD were compared to thirty age- and sex-matched trauma-exposed officers without PTSD. Clinical assessment and self-report questionnaires established PTSD status. All participants underwent a neuropsychological evaluation.
Results: Police officers with PTSD displayed lower cognitive performance across several domains, notably executive functioning, verbal learning and memory, and lexical access, compared to controls. The neuropsychological decrements in the PTSD group were mild compared to normative data, with average performances falling within normal limits. Among officers with PTSD, higher levels of intrusion symptoms were associated with reduced efficacy in executive functioning, as well as attention and working memory. Moreover, increased intrusion and avoidance symptoms were associated with slower information processing speed.
Conclusion: Considering that even mild subclinical cognitive difficulties may affect their social and occupational functioning, it appears important to integrate neuropsychological assessments in the clinical management of police officers diagnosed with PTSD.

Trauma durante el servicio: Funcionamiento cognitivo en oficiales de policía con y sin Trastorno de Estrés Postraumático (TEPT)

Antecedentes: Pueden co-ocurrir alteraciones neuropsicológicas con el trastorno de estrés postraumático (TEPT); sin embargo, la naturaleza y magnitud de tales alteraciones en oficiales de policía aún no se conoce a pesar de su alto nivel de exposición al trauma.
Objetivo: La presente investigación buscó examinar (1) el funcionamiento cognitivo entre oficiales de policía con y sin TEPT; (2) la importancia clínica de su rendimiento cognitivo; y (3) la relación entre los síntomas de TEPT y la cognición.
Método: Treinta y un oficiales de policía con TEPT fueron comparados a treinta oficiales expuestos a trauma sin TEPT, emparejados por edad y sexo. El estado de TEPT fue establecido mediante evaluación clínica y cuestionarios de auto-reporte. Todos los participantes se sometieron a una evaluación neuropsicológica.
Resultados: Los oficiales de policía con TEPT desplegaron un menor rendimiento cognitivo a través de varios dominios, notablemente el funcionamiento ejecutivo, aprendizaje verbal y memoria, y acceso léxico, comparado con los controles. Las mermas neuropsicológicas en el grupo de TEPT fueron leves comparado con los datos normativos, con rendimientos promedio dentro de los límites normales. Entre los oficiales con TEPT, los mayores niveles de síntomas intrusivos se asociaron a una eficacia reducida en el funcionamiento cognitivo, así como también en la atención y en la memoria de trabajo. Más aún, los síntomas de intrusión y evitación aumentados se asociaron con una velocidad de procesamiento de la información más lenta.
Conclusión: Considerando que incluso leves dificultades cognitivas subclínicas pueden afectar a su funcionamiento social y ocupacional, parece ser importante integrar evaluaciones neurocognitivas en el manejo clínico de los oficiales de policía diagnosticados con TEPT.

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PALABRAS CLAVE
Trastorno de estrés postraumático; Trauma; Funcionamiento cognitivo; Oficiales de policía; Neuropsicología

关键词
创伤后应激障碍; 创伤; 认知功能; 警官; 神经心理学

HIGHLIGHTS
- We examined cognitive functioning in police officers with and without PTSD.
- Individuals in the PTSD group displayed lower cognitive performances relative to controls.
- Associations were found between symptom clusters and reduced cognitive functioning.

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Supplemental data for this article can be accessed here.

任职创伤:有无创伤后应激障碍 (PTSD) 的警官的认知功能

背景: 神经心理改变与创伤后应激障碍 (PTSD) 同时发生; 然而, 尽管警官有高度创伤暴露, 但他们的这些变化的性质和程度仍然未知。
目的: 当前研究试图考查 (1) 有无PTSD 的警官的认知功能; (2)其认知表现的临床意义; (3) PTSD症状与认知的关系。
方法: 将 31 名患有 PTSD 的警官与 30 名年龄和性别匹配的没有 PTSD 的创伤暴露的警官进行比较。临床评估和自我报告问卷确定了 PTSD 状态。所有参与者都接受了神经心理学评估。
结果: 相较于对照组, 患有 PTSD 的警官在多个领域表现出较低的认知表现, 尤其是执行功能, 语言学习和记忆以及词汇访问。相较于常模数据, PTSD 组的神经心理下降幅度较小, 平均表现在正常范围内。在患有 PTSD 的警官中, 更高水平的闯入症状与执行功能以及注意力和工作记忆的效率降低有关。此外, 升高的入侵和回避症状与更慢的信息加工速度相关。
结论: 考虑到即使是轻微亚临床认知困难也可能影响他们的社会和职业功能, 将神经心理学评估整合到被诊断患有 PTSD 警官的临床管理中似乎很重要

1. Introduction

From early on in their careers, police officers are routinely exposed to violent attacks, shootings, motor-vehicle accidents, death and serious injury (Buchanan, Stephens, & Long, 2001; Collins & Gibbs, 2003). Such exposure is associated with an increased risk of developing mental disorders, notably posttraumatic stress disorder (PTSD) (American Psychiatric Association, 2013; Carleton et al., 2020; Collins & Gibbs, 2003). A recent systematic review suggested that the prevalence of PTSD was elevated in police officers in comparison to the general population (Wagner et al., 2020), which comes as no surprise considering the level of traumatic exposure (Patterson, 2001). In addition to emotional and behavioural symptoms, PTSD has increasingly been associated with neurocognitive alterations studied through standardized neuropsychological testing (Lavoie, Roth, & Guay, 2013; Vasterling & Brailey, 2005). Meta-analytic findings suggest that individuals with PTSD manifest lower performance across several cognitive domains when compared to controls with or without trauma exposure (Johnsen & Asbjørnsen, 2008; Polak, Witteveen, Reitsma, & Olff, 2012; Scott et al., 2015). The cognitive domains most likely to be affected include information processing speed, attention and working memory, lexical access, verbal learning and memory, and executive functioning. Research has also identified negative associations between cognitive functioning and the severity (Qureshi et al., 2011) and duration (Emdad, Söndergaard, & Theorell, 2005) of PTSD symptomatology.

Such impairments, if present, may impact the ability of police officers to deal with critical incidents (Lansing, Amen, Hanks, & Rudy, 2005). However, current knowledge of the clinical significance and magnitude of cognitive impairments in police officers with PTSD is limited (Scott et al., 2015; Vasterling & Walt, 2019). Indeed, empirical evidence on cognitive functioning in at-risk populations stems from studies conducted with military personnel and few findings are compared to normative data. Therefore, caution must be taken when attempting to generalize such findings to police populations, considering that the type, duration, and context of traumatic events characterizing police work may greatly differ from the military setting (Stirman, 2008).

Investigations of cognitive functioning in police officers with PTSD are limited by several methodological shortcomings. Available data is composed mainly of police recruits (LeBlanc, Regehr, Jelley, & Barath, 2007) or trauma-exposed police officers without PTSD (Covey, Shucard, Violanti, Lee, & Shucard, 2013; Levy-Gigi, Richter-Levin, Okon-Singer, Kéri, & Bonanno, 2016) and to our knowledge, only one study (Lindauer, Olff, van Meijel, Carlier, & Gersons, 2006) has examined cognitive functioning in trauma-exposed police officers with and without PTSD using standardized testing. Results from this case-control study (Lindauer et al., 2006) revealed that officers with PTSD committed more repetition errors on a verbal learning task than controls. In addition, PTSD symptom severity was negatively correlated with immediate recall of verbal material. The two groups did not differ on an executive functioning task. However, the omission of other cognitive domains known to be affected by PTSD (e.g., working memory) (Scott et al., 2015) and the small sample size limit the interpretation of these findings.

The extent of neuropsychological alterations in police officers remains largely under-researched (Covey et al., 2013). There is an evident need for additional empirical research to evaluate the cognitive profile of this highly trauma-exposed population. Hence, the goals of the present study were to examine: (1) cognitive functioning in police officers with and without PTSD; (2) the clinical significance of their performance as it relates to normative data; and (3) the relationship between PTSD symptoms and cognitive functioning. Based on existing literature, we hypothesized that police officers with PTSD would perform more poorly than trauma-exposed officers without PTSD on the following domains: information processing speed, attention and working memory, lexical access, verbal learning and memory, and executive functioning. We also predicted a negative correlation between PTSD symptom severity and cognitive performance.

2. Method

2.1. Participants

This research was conducted as part of a larger placebo-controlled study comparing the efficacy and cost-effectiveness of reconsolidation blockade treatment with propranolol (Brunet et al., 2018) as an adjunct to treatment as usual for trauma- and stressor-related disorders in public safety personnel (NCT03152175). Only data and procedures related to the first assessment, which occurred prior to randomization, are presented here.

2.1.1. Inclusion and exclusion criteria

Inclusion criteria for both groups included the following: aged 18–65 years; fluent in French; current or previous employment in policing in Québec, Canada. Exclusion criteria for both groups included the following: previous diagnosis of a traumatic brain injury; past or present bipolar disorder; past or present psychotic disorder; current substance-related disorder; acute suicidal ideations; past or present diagnosis of a neurological or neurodevelopmental disorder; complex PTSD.

To be included in the PTSD group, treatment-seeking police officers had to meet criteria for current PTSD or other specified trauma- and stressor-related disorder as defined by the DSM-5 (American Psychiatric Association, 2013), and receive a score of at least 4 (moderately ill) on the Clinical Global Impressions – Severity Scale (Guy, 1976). The precipitating traumatic event had to be experienced during professional duties. Specific exclusion criteria for this group included the following: systolic blood pressure of less than 100 mm Hg; heart rate of less than 55 beats per minute; medical conditions that contraindicate propranolol administration; a medication that may interact adversely with propranolol; previous adverse reaction or non-compliance with a beta-blocker; fertile women who are not using an adequate contraceptive method; pregnancy; breastfeeding.

Non-treatment-seeking police officers included in the control group were also exposed to various work-related traumatic events and were matched to the closest fit in terms of age and sex to the PTSD group. Controls were excluded from the study if they had a past or current diagnosis of PTSD or a current diagnosis of depression or trauma- and stressor-related disorders.

2.1.2. Ethics approval and consent

The study was approved by the ethics committees of the Douglas Mental Health University Institute and the Université du Québec à Montréal. Regulatory approval for this study was provided by Health Canada. Participants provided written informed consent and received compensation for their participation.

2.2. Procedure

2.2.1. Recruitment and enrolment

Police officers in the PTSD group were recruited through advertisements offering psychological treatment (e.g. internal newsletters, flyers in police stations, presentations), referred by colleagues or psychologists involved in the police employee assistance programme, or word-of-mouth. Control subjects were also recruited via advertisements of research assessing cognitive functioning in police officers without PTSD or depression as well as through word-of-mouth. Candidates for the study were initially contacted by phone using a standardized screening interview. Potential participants were then invited for an in-person interview, during which eligibility for each group was confirmed through a clinical evaluation and self-report questionnaires.

2.3. Assessment

Assessments were completed in one of three sites: namely, at a psychology clinic in Québec City, at the Douglas Institute, or at the offices of the Montreal police employee assistance programme.

2.3.1. Clinical assessment and self-report questionnaires

Trauma- and stressor-related disorders (i.e. PTSD, Other specified trauma- and stressor-related disorder) and comorbid psychiatric conditions were assessed using the Mini International Neuropsychiatric Interview – Simplified (MINI-S; Version 1.0) (Sheehan et al., 1998). Four self-report questionnaires were also administered. DSM-5 (American Psychiatric Association, 2013) PTSD symptom severity in the past week was measured through the PTSD Checklist-5 (PCL-5) (Weathers et al., 2013). Symptoms of anxiety, depression and suicidal ideation were assessed using the Hopkins Symptom Checklist (HSCL-25) (Ventevogel et al., 2007). Policing-related stressors were measured through the Operational Police Stress Questionnaire (PSQ-Op) (McCreary & Thompson, 2006). Quality of life was assessed through the World Health Organization's Quality of Life-BREF (WHOQOL-BREF) questionnaire (Skevington, Lotfy, & O'Connell, 2004).

2.3.2. Neuropsychological testing

All participants completed a neuropsychological test battery comprising widely used standardized measures selected to assess the six cognitive domains most likely to be affected in individuals with PTSD (Scott et al., 2015). Neuropsychological testing was conducted by a licenced psychologist and two trained doctoral students. Processing speed was assessed using the Trail Making Test (TMT) Part A, the Wechsler Adult Intelligence Scale Fourth Edition (WAIS-IV) Digit Symbol Test and the Delis–Kaplan Executive Function System (D-KEFS) Color-Word Interference Test (CWIT), Conditions 1 and 2. The d2 Test of Attention – Revised, the first trial of the Rey Auditory Verbal Learning Test (RAVLT) and the Paced Auditory Serial Addition Test (PASAT) were used as measures of attention and working memory. Verbal learning and memory were evaluated using the RAVLT and the Wechsler Memory Scale (WMS-III) Logical Memory I and II. The TMT Part B, the Verbal Fluency Task (switching condition: vegetables-musical instruments) and the D-KEFS CWIT Conditions 3 and 4 were used to assess executive functioning. Finally, lexical access was measured by word-list generation using Verbal Fluency Tasks (phonemic: P; semantic: animals).

2.4. Data analysis

2.4.1. General statistical strategy and participants' characteristics

Data were analysed using SPSS 27 (Corp, 2020). Descriptive statistics (e.g. means and standard deviations) were tabulated for sociodemographic and clinical variables, self-report measures and neuropsychological test scores. Normal distribution of each neuropsychological and psychological variable was examined for both groups (PTSD vs. Trauma-exposed). Log transformations were applied to the four variables that violated the assumption of normality. Two-tailed independent *t*-tests and chi-square tests were used to explore possible between-group differences. Cohen's *d* or Phi were reported as a measure of effect size.

2.4.2. Composite scores and cognitive performance

Data collected from the neuropsychological assessment were combined into composite scores to reduce the number of variables. The subtests included in each composite score were selected according to their respective cognitive domain on an *a priori* clinical and theoretical basis (Scott et al., 2015). Raw scores for each cognitive test were standardized as z-scores. Individual scores for time variables were then reversed to ensure that a higher z-score represents better performance. Finally, the standardized scores were averaged to generate six composite scores. Confirmatory factor and reliability analyses (Cronbach's alpha) were conducted to verify the quality of four composite scores (i.e. information processing speed, attention and working memory, verbal memory, executive functioning) and to confirm their internal validity. The postulates underlying the factor analyses were examined and satisfied. The two other composite scores (i.e. lexical access and verbal learning) consisted of only two tests; therefore, correlations were performed to confirm statistical association between conceptually related variables. ANCOVAs were conducted with group (PTSD vs. Trauma-exposed) as the between-subjects factor, with each cognitive domain as the dependent variable, and with age and current depression status as covariates. Corrections for multiple comparisons were not applied as our hypotheses were formulated *a priori* (Brandt, 2007).

Clinically meaningful cognitive impairment was conceptualized as a performance at or below the 5th percentile (i.e. scaled score ≤5, z-score ≤ −1.64) relative to normative data on at least two of the tests included in a specific cognitive domain (Tanev, Federico, Terry, Clark, & Iverson, 2019). Raw scores were thus converted to scaled scores using age-corrected or age- and education-corrected norms. For additional clinical information, retention rates of memory tasks were computed and *t*-tests were performed on all individual neuropsychological tests. The Benjamini–Hochberg procedure (Benjamini & Hochberg, 1995) was used on *p*-values to adjust for the False Discovery Rate (FDR) within each cognitive domain.

2.4.3. Relationships between cognition and symptomatology

Partial correlations were performed within the PTSD group to determine whether symptom severity and specific symptom clusters were associated with alterations in neuropsychological performance, while controlling for current depression status and duration of PTSD. A multiple-imputation strategy was used to avoid biased estimates due to missing data from self-report questionnaires (i.e. PCL-5, HSCL-25, PSQ-op and WHOQOL-BREF) of four participants. Little's MCAR test (Little, 1988) indicated that data were missing completely at random. SPSS 27 generated five imputed datasets and analyses run on each dataset were pooled (Rubin, 1987). Baseline characteristics thought to be associated with cognitive functioning (i.e. years of education, age, sex), self-report questionnaires, current depression status, duration of PTSD, and clinical variables from the first treatment session (i.e. as part of the aforementioned larger study) were included in the imputation model as predictor variables. The original data are presented as the results were comparable to those obtained with the imputed values. The threshold of statistical significance was set at .05 for all analyses.

2.4.4. Exploratory analysis based on employment status

Among PTSD participants, we conducted exploratory *t*-tests and chi-square tests to verify whether group differences emerged on employment status when looking at baseline characteristics. Exploratory ANCOVAs were also performed, with employment status as the between-subjects factor while controlling for duration of PTSD and current depression status. Partial eta squared (η_p^2) is reported as a measure of effect size for the ANCOVAs.

3. Results

3.1. Sample and demographics

Ninety-two police officers were screened for study inclusion. Of these, 61 (36% women) were included in the study: 31 treatment-seeking participants with a diagnosis of either PTSD (n = 29) or Other specified trauma- and stressor-related disorder (i.e. subclinical PTSD; n = 2) and 30 trauma-exposed controls without PTSD.

Participants' ages ranged from 23 to 63 years with a mean of 40.2 years (SD = 8.8). There were no significant differences between the PTSD and the control groups in terms of age, sex and years of education (Table 1). Police officers with PTSD scored significantly higher on the following psychometric scales: PCL-5, HSCL-25, PSQ-op; and significantly lower on the physical, psychological, and social domains of the WHOQOL-BREF. Among PTSD participants, the precipitating traumatic event occurred on average 5.6 years (range: .3-33.8 years) prior to the screening visit. Current psychiatric comorbidity in the PTSD group included current depressive episode (n = 10), obsessive compulsive disorder (n = 3), panic disorder without agoraphobia (n = 4), agoraphobia (n = 1), generalized anxiety disorder (n = 5), alcohol use disorder (n = 5) and past depressive episode (n = 14) according to the MINI-S (Sheehan et al., 1998). None of the trauma-exposed controls endorsed a current psychiatric condition, but three met criteria for a past depressive episode. Because of the heterogeneity of psychiatric conditions in our sample, comorbidities other than depression were not included in the analyses.

3.2. Cognitive performance

Cognitive tests included in each composite score and relevant statistics are presented in Table 2. Only one participant, from the control group, did not complete two subtests (i.e. PASAT 2 and 3). ANCOVAs revealed statistically significant group effects in the domains of executive functioning (p = .002, η_p^2 = .15), lexical access (p = .001, η_p^2 = .19), verbal learning (p = .028, η_p^2= .08), and verbal memory (p = .034, η_p^2 = .08), wherein the PTSD group's scores were lower than the control group's (Figure 1). These differences remained significant when controlling for depression status, with a smaller yet moderate effect size found in the executive function (p = .037, η_p^2 = .07) domain. The PTSD group also showed lower performance in terms of information processing speed (p = .016, η_p^2 = .10); however, this group difference became non-significant after controlling for depression status (ps > .100). A considerable trend towards significance (p = .050, η_p^2 = .07) was also observed in the attention and working memory domain.

3.3. Impairment evaluation

As shown in Table 3, on average, trauma-exposed controls numerically outperformed participants in the PTSD group on all neuropsychological subtests. When adjusting for false discovery rate, statistically significant differences remained on the following tests: Condition 4 (flexibility) of the CWIT,

Table 1. Participants' characteristics.

	PTSD (n = 31)				Trauma-exposed controls (n = 30)					
Characteristics	*M*	*SD*	*n*	%	*M*	*SD*	*n*	%	*p*	Effect size Cohen's *d* or Phi
Sex (female)			11	35.4			11	36.7	.57	φ = .01
Age	40.77	8.53			39.67	9.09			.63	d = .13
Education (years)	14.52	1.23			14.55	1.06			.91	d = .03
Employment status (currently working)			14	45.2			29	97.7	<.01	φ = .57
Depression status			10	32.3			0	0	<.01	φ = .44
PCL-5 total score	38.04	15.00			5.21	5.87			<.01	d = 2.92
PCL-5 Cluster B	10.07	4.90			.80	1.10			<.01	d = 2.68
PCL-5 Cluster C	5.11	2.24			.48	1.24			<.01	d = 2.58
PCL-5 Cluster D	10.67	5.76			1.37	2.11			<.01	d = 2.19
PCL-5 Cluster E	12.19	5.19			2.47	2.69			<.01	d = 2.39
HSCL mean score	1.89	.54			1.21	.20			<.01	d = 1.75
PSQ-op mean score	3.31	1.23			2.35	.72			<.01	d = .98
Physical QOL	12.81	3.05			16.13	2.33			<.01	d = 1.24
Psychological QOL	11.95	3.30			15.67	1.82			<.01	d = 1.43
Social QOL	12.80	3.36			15.91	2.60			<.01	d = 1.05
Environmental QOL	15.14	2.21			15.75	1.70			.25	d = .31

Table 2. Cognitive composite scores.

Cognitive domain	Neuropsychological tests	Coefficient
Information processing speed	WAIS-IV Digit Symbol Test [total correct] D-KEFS CWIT color/reading [time] TMT A [time]	α = .78
Attention and working memory	PASAT – 2 and 3 [total] d2 Test of Attention [global performance] RAVLT [first recall A]	α = .77
Executive functions	D-KEFS CWIT inhibition/flexibility [time] D-KEFS Verbal Fluency Test: switching [total] TMT B [time]	α = .67
Lexical access	Verbal Fluency Tests: phonemic, semantic [total]	*r* = .37
Verbal learning	WMS-III LM subtest [total immediate recall] RAVLT [total learning: trial 1 to 5]	*r* = .27
Verbal memory	WMS-III LM subtest [delayed recall A and B] RAVLT [delayed recall]	α = .66

WAIS-IV = Wechsler Adult Intelligence Scale Fourth Edition; D-KEFS = Delis–Kaplan Executive Function System; CWIT = Color-Word Interference Test; TMT = Trail Making Test; PASAT = Paced Auditory Serial Addition Test; RAVLT = Rey Auditory Verbal Learning Test; LM = Logical Memory; α = Cronbach's α; *r* = Pearson's *r*

Part B of the TMT, Verbal Fluency Tasks (phonemic; semantic, switching) and the delayed recall of Story B comprised in the logical memory subtest (Table 3). No differences were observed in terms of retention rates for the memory tasks. Among the PTSD group, 48% showed no objective impairment on individual subtests, while the remaining exhibited deficits on an average of 1.5 subtests. Of these, only one participant showed clinically meaningful impairment on one cognitive domain.

3.4. Relationship between PTSD symptoms and cognition

Among PTSD participants, partial correlations revealed that current PTSD severity, as measured by the total score on the PCL-5, was not significantly correlated with any of the composite scores (Table 4). However, intrusion symptoms (i.e. subscores on cluster B) were significantly negatively correlated with the attention and working memory (r = −.51, $p < .010$), processing speed ($r = -.44$, $p = .030$) and executive functioning ($r = -.42$, $p = .039$) domains. Moreover, there was a significant negative correlation between avoidance symptoms (cluster C) and processing speed ($r = -.52$, $p = .008$). No other correlations were found to be significant.

3.5. Exploratory analysis based on employment status

Among the PTSD group, those who were not working (n = 17: 55%) scored significantly higher on the following variables: PTSD symptoms (PCL-5), anxiety and depressive symptoms (HSCL-25), and

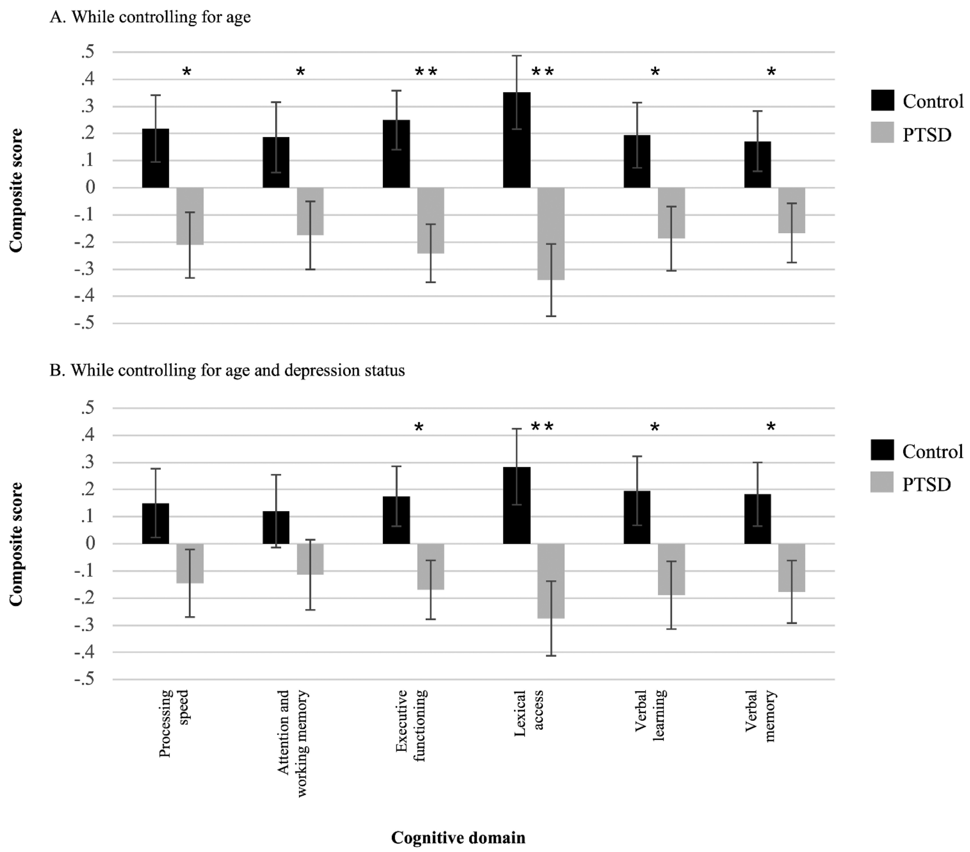

Figure 1. Group comparison by cognitive domain.[†]
[†]Estimated marginal means adjusting for the covariates are presented; Error bars represent standard error from the mean; asterisk (*) represent statistically significant between-group differences, *$p < .05$ **$p < .01$.

Table 3. Cognitive raw data and impairment per subtest.

Cognitive domain	PTSD (*n* = 31) Raw score *M*	*SD*	Impaired *n*	%	Trauma-exposed (*n* = 30) Raw score *M*	*SD*	Impaired *n*	%	P value *p*	*p'**	Effect size Cohen's *d*
Information processing speed											
TMT – Part A	23.29	6.48	0		20.13	6.34	0		.06	.08	.49
Digit Symbol Test	76.35	14.70	0		79.33	14.73	1	3	.43	.43	.20
CWIT – 1 (color)	27.71	4.86	0		25.43	3.66	0		.04	.08	.53
CWIT – 2 (word)	20.48	2.67	0		18.67	2.92	0		.01	.06	.62
Attention and working memory											
PASAT (3 s)†	46.55	8.85	4	13	50.79	7.51	2	7	.05	.20	.52
PASAT (2 s)†	36.32	8.45	1	3	39.41	7.78	0		.15	.20	.38
d2 Test of Attention	443.19	88.51	1	3	468.80	72.71	0		.22	.22	.32
RAVLT, first recall A	6.39	2.16	3	10	7.17	1.97	1	3	.15	.20	.38
Executive functions											
CWIT – 3 (inhibition)	49.32	10.45	0		44.50	9.48	0		.06	.06	.48
CWIT – 4 (flexibility)	54.13	11.64	0		48.43	8.24	0		.03	.05	.56
VF – switching	15.03	2.71	2	6	16.50	2.66	0		.04	.05	.55
TMT – Part B	58.81	21.71	4	13	48.63	13.14	0		.03	.05	.57
Lexical access											
VF – phonemic	14.94	3.81	4	13	17.17	2.94	0		.01	.01	.65
VF – semantic	21.29	4.20	4	13	24.77	4.68	1	3	<.01	<.01	.80
Verbal learning											
LM, total immediate	43.35	8.68	0		48.03	8.57	0		.04	.08	.54
RAVLT, total learning	55.52	6.81	0		57.77	6.37	0		.19	.19	.34
Verbal memory											
LM – Story A, delayed	13.61	3.49	0		14.50	3.44	0		.32	.32	.26
LM – Story B, delayed	14.68	3.94	0		17.07	3.12	0		.01	.03	.67
RAVLT, delayed	12.26	2.46	0		12.90	1.94	0		.26	.32	.29
Retention rates											
Logical Memory	88.65	9.80	0		91.00	9.61	0		.35	.70	.24
RAVLT	101.22	8.11	0		102.12	10.61	0		.71	.71	.10

Impairment on a single test is determined by performance at or below the 5th percentile (i.e., scaled score ≤ 5, z-score ≤ −1.64) *False Discovery Rate adjusted *p* value; LM = Logical Memory; RAVLT = Rey Auditory Verbal Learning Test; TMT = Trail Making Test; CWIT = Color-Word Interference Test; VF = Verbal fluency †A participant from the trauma-exposed group did not complete two subtests (i.e., PASAT 2 and 3) included in the attention and working memory composite score

Table 4. Partial correlations between cognitive domains and PTSD symptoms while controlling for duration of PTSD and depression status.

Cognitive domain	PTSD symptom severity measured with the PCL-5: Total score	Cluster B	Cluster C	Cluster D	Cluster E
Information processing speed	−.24	−.44*	−.52**	.18	−.15
Attention and working memory	−.38	−.51**	−.26	−.05	−.38
Executive functions	−.28	−.42*	−.30	>.01	−.23
Lexical access	.03	−.06	−.04	.23	−.07
Verbal learning	−.29	−.39	−.02	−.07	−.34
Verbal memory	−.07	−.19	.16	.03	−.11

The association is statistically significant, *$p < .05$. **$p < .01$; Cohen's guidelines (1988) can be used to interpret the magnitude of these correlations (small: $r = .10$; medium: $r = .30$; large: $r = .50$)

occupational stress (PSQ-op), and presented significantly higher rates of comorbid depression than the trauma-exposed officers who were currently working (Supplementary Table S1). They also showed a significantly lower cognitive performance in the executive functioning domain ($M = -.54$, $SD = .73$) when compared to those currently working ($n = 14$, $M = .08$, $SD = .47$), with large effect sizes [$F(1, 29) = 6.38$, $p = .018$, $\eta_p^2 = .19$] when controlling for duration of PTSD. Large effect sizes were also observed for the attention and working memory domain [$F(1, 29) = 3.72$, $p = .064$, $\eta_p^2 = .12$], without reaching statistical significance. When depression status was controlled for, the large effect size observed in the executive functioning domain was no longer significant [$F(1, 29) = 3.10$, $p = .090$, $\eta_p^2 = .10$] (Supplementary Table S2).

4. Discussion

The current study is the first comprehensive evaluation of cognitive functioning in police officers with and without PTSD and bears clinically meaningful implications for this trauma-exposed population (Scott et al., 2015).

When compared to trauma-exposed officers without PTSD, police officers with PTSD displayed lower cognitive performances across several domains, notably executive functioning, verbal learning and memory, and lexical access. These results remained significant even after controlling for depression, suggesting that the between-group differences observed in our study surpass the established effect of depression on cognition (Burriss, Ayers, Ginsberg, & Powell, 2008; Olff, Polak, Witteveen, & Denys, 2014; Vasterling et al., 2002). However, the group difference found in the processing speed domain was no longer significant when controlling for depression. The contribution of comorbid depression to slower processing speed is unsurprising, as reduced psychomotor speed is often considered a central feature of depression (Bennabi, Vandel, Papaxanthis, Pozzo, & Haffen, 2013). As previously reported in the literature (Nijdam, Gersons, & Olff, 2013), the comorbidity of depression and PTSD appears to have a cumulative negative impact on cognitive functioning in police officers.

Contrary to our hypothesis, results were inconclusive on the attention and working memory domain, where a small effect-size difference that did not reach statistical significance was found. Even when performance is similar to controls, abnormal neural network activation during working memory tasks have been found in participants with PTSD, suggesting compensatory recruitment of cognitive resources (Moores et al., 2008).

In our study, police officers with PTSD also displayed lower performance in the domain of lexical access. Research in the field of PTSD has yielded inconsistent findings with respect to lexical access weakness (Lavoie et al., 2013). Interestingly, one study indicated that individuals with PTSD performing within normal range on a verbal fluency task show decreased activation of the prefrontal cortex during the task (Matsuo et al., 2003). Hypoactivity in these regions has been documented in individuals with PTSD in response to cognitive demands and have been related to impairments in fear extinction, contextual encoding and emotional regulation (Garfinkel et al., 2014; Liberzon & Abelson, 2016; Scott et al., 2015). Thus, our results may partly reflect abnormal activity of overlapping neurocircuitry implicated in the pathophysiology of PTSD, as well as in key cognitive functions (e.g. attention, working memory) required in efficient verbal fluency.

Although the current results reveal a reduced performance on tasks requiring both the acquisition and recall of verbal information in the PTSD group, retention rates were similar in police officers with and without PTSD. Indeed, individuals in both groups exhibited a minimal loss of learned information over time. Consistent with previous research, our findings suggest that memory problems in individuals with PTSD are specifically related to slightly reduced encoding capacities of verbal information, thus affecting learning and retrieval (Johnsen & Asbjørnsen, 2008; Samuelson et al., 2006; Vasterling & Brailey, 2005). Upon examining memory subtest performance, we did not observe the expected benefit of context on the encoding of verbal information, with more robust group-differences found in the story recall task. This counter-intuitive finding is consistent with recent neurobiological PTSD models, which propose altered contextual processing as a central mechanism contributing to a broad range of symptoms (Liberzon & Abelson, 2016). This diminished capacity to use contextual information (Garfinkel et al., 2014) could partly explain why context did not facilitate encoding, although this hypothesis remains to be empirically studied.

4.1. Relationships between cognition and symptomatology

Within our PTSD group, difficulties on the attention and working memory and executive functioning domains were associated with higher levels of intrusion symptoms, even when controlling for potentially confounding variables such as PTSD chronicity. Uncontrollable recurring intrusive thoughts have been associated with reduced activation and connectivity of specific brain regions (i.e. prefrontal cortex) and circuits implicated in efficient attention, working memory and executive functioning (Fenster, Lebois, Ressler, & Suh, 2018; Vasterling & Brailey, 2005). As described in information-processing research, individuals with PTSD also exhibit an attentional bias to trauma-related cognitions, another mechanism that may disrupt voluntary attention and other cognitive processes (Kolb, 1987; Litz et al., 1996). Our findings are in line with the established role of executive functions in cognitive control over traumatic thoughts and the regulation of affective responses (Aupperle, Melrose, Stein, & Paulus, 2012). Further, our results reveal that more severe intrusion and avoidance symptoms in individuals with PTSD are both associated with reduced processing speed. Active avoidance of traumatic memories and distressing emotions are thought to further usurp cognitive resources and lead to reduced processing speed (Morey et al., 2009; Scott et al., 2015; Shucard, McCabe, & Szymanski, 2008).

4.2. Clinical significance of findings

From a clinical perspective, the neuropsychological decrements found in our PTSD group are quite mild when compared to normative data, with average performances falling within normal limits. Only one participant in the PTSD group exhibited clinically meaningful impairments on a single cognitive domain. A closer look at the clinical profile revealed that this participant was diagnosed with comorbid depression and was not currently working. Thus, caution must be taken when reporting and concluding from findings in PTSD populations, as significant group differences on raw scores might not translate into cognitive impairments as defined by clinicians (e.g. neuropsychologists) (Haaland, Sadek, Keller, & Castillo, 2016; Scott et al., 2015; Vasterling & Walt, 2019). As it was suggested by Scott and colleagues (2015), among certain individuals with PTSD, a cognitive performance within the normal range might represent a relative decline from their premorbid level of functioning and may negatively impact their daily activities. Currently, pre-trauma cognitive fragilities in executive function and verbal learning are considered as a risk factor to the development of PTSD (Gilbertson et al., 2006; Marx, Doron-Lamarca, Proctor, & Vasterling, 2009; Parslow & Jorm, 2007); conversely, prospective studies suggest that cognitive functioning is further affected after the development of the disorder (Vasterling et al., 2018). While premorbid cognitive functioning fragilities may partly account for the observed group differences, the cross-sectional nature of the current study limits any conclusions regarding the contribution of premorbid cognitive functioning to current neuropsychological profile. Nonetheless, it has been proposed that even minimal decreases in cognitive functioning could lead to substantial functional difficulties, especially in highly demanding work environments (Chaytor & Schmitter-Edgecombe, 2003; Scott et al., 2015). Interestingly, we found that police officers with PTSD who were not currently working displayed lower executive functioning, with depression status significantly contributing to the altered cognitive profile. These results are in line with previous studies showing that lower performance in domains of executive functioning, verbal learning and memory appear to be strong predictors of social and occupational functioning within PTSD samples (Geuze, Vermetten, de Kloet, Hijman, & Westenberg, 2009; Wrocklage et al., 2016).

While a neuropsychological assessment is not a diagnostic tool for PTSD, results from the present study highlight the utility of integrating such an assessment in the clinical management of police officers with PTSD. Early research suggests that cognitive functioning in PTSD may play a role in predicting treatment response, more precisely reduced executive functions and verbal learning capacities are thought to impede treatment outcomes (Haaland et al., 2016; Nijdam, de Vries, Gersons, & Olff, 2015; Scott et al., 2017; Wild & Gur, 2008). Clinical information gathered during neuropsychological evaluations can therefore help clarify the various contributing factors (e.g. sleep, depression, premorbid functioning) to an individual's cognitive profile. This may therefore allow psychotherapeutic interventions to be tailored based on the neuropsychological recommendations in order to maximize treatment efficacy, such as the use of internal or external compensatory strategies (e.g. writing notes during therapy sessions, using alarms to facilitate homework completion). Taking into account both psychological and cognitive challenges could lead to a refinement of work accommodations that employers currently put in on the basis of a PTSD diagnosis, such as adapting the officer's current tasks or temporarily providing them with another position within the police service (Marchand, Nadeau, Beaulieu-Prévost, Boyer, & Martin, 2015; Plat et al., 2013).

5. Study limitations and strengths

There are a few limitations to highlight when considering the current study. A larger sample may allow stronger statistical power to detect subtle differences in cognitive functioning between officers with PTSD who are working and those who are on sick leave. However, the current sample size and subsequent statistical power were sufficient to conduct our main analyses. Further, a more comprehensive evaluation of sleep would be informative, since sleep disturbances associated with shift work (Gerber, Hartmann, Brand, Holsboer-Trachsler, & Pühse, 2010) might alter cognition in both groups.

Nevertheless, this study has a number of experimental strengths and fills several important empirical gaps in the literature. Interestingly, prior meta-analytic findings (Kalechstein, Newton, & Van Gorp, 2003) in various clinical samples indicate that the use of composite scores might be more predictive of vocational status relative to the subtests that comprise them. This procedure allowed us to enhance our study's ecological validity and reduce the risk of Type I error (Levin et al., 2013). It is possible that a trauma-unexposed comparison group might have resulted in more robust between-group differences, as prolonged and repeated exposure to traumatic events is itself associated with alterations in cognitive performance (Kinlein, Wilson, & Karatsoreos, 2015; Vasterling et al., 2006). Thus, the comparable work context between our groups, as well as controlling for depression status, allowed for greater precision in the estimation of the specific cognitive profile associated with PTSD.

6. Conclusion

In summary, our results support the premise that PTSD, and not simply the effect of repeated trauma or comorbid depression, is associated with mild impairments on several domains of cognitive functioning among police officers. Furthermore, the comorbidity of depression and PTSD appears to have a cumulative negative impact on cognitive performance, accounting for the group differences in information processing speed. From a clinical perspective, our study adds valuable information on the clinical significance of previous neuropsychological findings. Police officers with PTSD exhibited relatively mild neuropsychological decrements, with cognitive performances falling within normal limits. Moreover, our results further clarify the relationship between

PTSD symptom clusters and cognition in officers with PTSD. While higher levels of intrusion symptoms were associated with reduced efficacy in executive functioning, attention, and working memory, avoidance and intrusion symptoms were both associated with slower processing speed.

These considerations illustrate the need for research on comprehensive clinical assessments including the best predictors (e.g. neuropsychological testing, performance-based approach, functional assessment) associated with occupational functioning. Considering that even mild subclinical cognitive difficulties experienced by police officers with PTSD may affect their social and occupational functioning, systematically including neuropsychological assessments appears to be important in the clinical management of police officers diagnosed with PTSD, particularly in this profession which requires significant cognitive load. Such research is not only essential for defining best assessment practices, but also paramount in establishing safe working conditions and promoting public safety. Ultimately, such studies will allow for more individualized therapeutic interventions and occupational reintroduction.

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Availability of data

Participants of this study did not agree for their data to be shared publicly, so supporting data is not available to protect personal identities.

Disclosure statement

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References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: American Psychiatric Association.

Aupperle, R. L., Melrose, A. J., Stein, M. B., & Paulus, M. P. (2012). Executive function and PTSD: Disengaging from trauma. *Neuropharmacology*, *62*(2), 686–694. doi:10.1016/j.neuropharm.2011.02.008

Benjamini, Y., & Hochberg, Y. (1995). Controlling the false discovery rate: A practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society Series B*, *57*(1), 289–300. doi:10.1111/j.2517-6161.1995.tb02031.x.

Bennabi, D., Vandel, P., Papaxanthis, C., Pozzo, T., & Haffen, E. (2013). Psychomotor retardation in depression: A systematic review of diagnostic, pathophysiologic, and therapeutic implications. *BioMed Research International*, *2013*, 1–18. doi:10.1155/2013/158746

Brandt, J. (2007). 2005 INS Presidential Address: Neuropsychological Crimes and Misdemeanors. *The Clinical Neuropsychologist*, *21*(4), 553–568. doi:10.1080/13854040600770800

Brunet, A., Saumier, D., Liu, A., Streiner, D. L., Tremblay, J., & Pitman, R. K. (2018). Reduction of PTSD symptoms with pre-reactivation propranolol therapy: A Randomized controlled trial. *American Journal of Psychiatry*, *175*(5), 427–433. doi:10.1176/appi.ajp.2017.17050481.

Buchanan, G., Stephens, C., & Long, N. (2001). Traumatic events of new recruits and serving police. *Australasian Journal of Disaster and Trauma Studies*, *5*(2). http://trauma.massey.ac.nz/issues/2001-2/buchanan.htm

Burriss, L., Ayers, E., Ginsberg, J., & Powell, D. A. (2008). Learning and memory impairment in PTSD: Relationship to depression. *Depression and Anxiety*, *25*(2), 149–157. doi:10.1002/da.20291

Carleton, R. N., Afifi, T. O., Taillieu, T., Turner, S., Mason, J. E., Ricciardelli, R., . . . Krakauer, R. L. (2020). Assessing the relative impact of diverse stressors among public safety personnel. *International Journal of Environmental Research and Public Health*, *17*(4), 1234. doi:10.3390/ijerph17041234

Chaytor, N., & Schmitter-Edgecombe, M. (2003). The ecological validity of neuropsychological tests: A review of the literature on everyday cognitive skills. *Neuropsychology Review*, *13*(4), 181–197. doi:10.1023/B:NERV.0000009483.91468.fb

Collins, P. A., & Gibbs, A. C. (2003). Stress in police officers: A study of the origins, prevalence and severity of stress-related symptoms within a county police force. *Occupational Medicine*, *53*(4), 256–264. doi:10.1093/occmed/kqg061

Corp, I. (2020). IBM SPSS statistics for Macintosh. *Version 27.0.*

Covey, T. J., Shucard, J. L., Violanti, J. M., Lee, J., & Shucard, D. W. (2013). The effects of exposure to traumatic stressors on inhibitory control in police officers: A dense electrode array study using a Go/NoGo continuous performance task. *International Journal of Psychophysiology*, *87*(3), 363–375. doi:10.1016/j.ijpsycho.2013.03.009

Emdad, R., Söndergaard, H. P., & Theorell, T. (2005). Learning problems, impaired short-term memory, and general intelligence in relation to severity and duration of disease in posttraumatic stress disorder patients. *Stress, Trauma, and Crisis*, *8*(1), 25–43. doi:10.1080/15434610590913612

Fenster, R. J., Lebois, L. A. M., Ressler, K. J., & Suh, J. (2018). Brain circuit dysfunction in posttraumatic stress disorder: From mouse to man. *Nature Reviews Neuroscience*, *19*(9), 535–551. doi:10.1038/s41583-018-0039-7

Garfinkel, S. N., Abelson, J. L., King, A. P., Sripada, R. K., Wang, X., Gaines, L. M., & Liberzon, I. (2014). Impaired contextual modulation of memories in PTSD: An fMRI and psychophysiological study of extinction retention and fear renewal. *Journal of Neuroscience*, *34*(40), 13435–13443. doi:10.1523/JNEUROSCI.4287-13.2014

Gerber, M., Hartmann, T., Brand, S., Holsboer-Trachsler, E., & Pühse, U. (2010). The relationship between shift work, perceived stress, sleep and health in Swiss police officers. *Journal of Criminal Justice*, *38*(6), 1167–1175. doi:10.1016/j.jcrimjus.2010.09.005

Geuze, E., Vermetten, E., de Kloet, C. S., Hijman, R., & Westenberg, H. G. M. (2009). Neuropsychological performance is related to current social and occupational functioning in veterans with posttraumatic stress disorder. *Depression and Anxiety*, *26*(1), 7–15. doi:10.1002/da.20476

Gilbertson, M. W., Paulus, L. A., Williston, S. K., Gurvits, T. V., Lasko, N. B., Pitman, R. K., & Orr, S. P. (2006). Neurocognitive function in monozygotic twins discordant for combat exposure: Relationship to posttraumatic stress disorder. *Journal of Abnormal Psychology*, *115*(3), 484–495. doi:10.1037/0021-843X.115.3.484

Guy, W. (1976). *ECDEU assessment manual for psychopharmacology*. Washington (DC): US Department of Health, Education, and Welfare.

Haaland, K. Y., Sadek, J. R., Keller, J. E., & Castillo, D. T. (2016). Neurocognitive correlates of successful treatment of PTSD in female veterans. *Journal of the International Neuropsychological Society*, *22*(6), 643–651. doi:10.1017/S1355617716000424

Johnsen, G. E., & Asbjørnsen, A. E. (2008). Consistent impaired verbal memory in PTSD: A meta-analysis. *Journal of Affective Disorders*, *111*(1), 74–82. doi:10.1016/j.jad.2008.02.007

Kalechstein, A. D., Newton, T. F., & Van Gorp, W. G. (2003). Neurocognitive functioning is associated ith employment status: A quantitative review. *Journal of Clinical and Experimental Neuropsychology*, *25*(8), 1186–1191. doi:10.1076/jcen.25.8.1186.16723

Kinlein, S. A., Wilson, C. D., & Karatsoreos, I. N. (2015). Dysregulated hypothalamic–pituitary–adrenal axis function contributes to altered endocrine and neurobehavioral responses to acute stress. *Frontiers in Psychiatry*, *6*(31), 1–9. doi:10.3389/fpsyt.2015.00031

Kolb, L. C. (1987). A neuropsychological hypothesis explaining posttraumatic stress disorders. *American Journal of Psychiatry*, *144*(8), 989–995. doi:10.1176/ajp.144.8.989.

Lansing, K., Amen, D. G., Hanks, C., & Rudy, L. (2005). High-resolution brain SPECT imaging and eye movement desensitization and reprocessing in police officers with PTSD. *The Journal of Neuropsychiatry and Clinical Neurosciences*, *17*(4), 526–532. doi:10.1176/jnp.17.4.526

Lavoie, M. E., Roth, R. M., & Guay, S. (2013). Posttraumatic stress disorder. In C. A. Noggle & R. S. Dean (Eds.), *The Neuropsychology of Psychopathology* (pp. 287–306). New York: Springer Publishing Company.

LeBlanc, V. R., Regehr, C., Jelley, R. B., & Barath, I. (2007). Does posttraumatic stress disorder (PTSD) affect performance? *Journal of Nervous and Mental Disease*, *195*(8), 701–704. doi:10.1097/NMD.0b013e31811f4481

Levin, H. S., Li, X., McCauley, S. R., Hanten, G., Wilde, E. A., & Swank, P. (2013). Neuropsychological outcome of mTBI: A principal component analysis approach. *Journal of Neurotrauma*, *30*(8), 625–632. doi:10.1089/neu.2012.2627

Levy-Gigi, E., Richter-Levin, G., Okon-Singer, H., Kéri, S., & Bonanno, G. A. (2016). The hidden price and possible benefit of repeated traumatic exposure. *Stress*, *19*(1), 1–7. doi:10.3109/10253890.2015.1113523

Liberzon, I., & Abelson, J. L. (2016). Context processing and the neurobiology of posttraumatic stress disorder. *Neuron*, *92*(1), 14–30. doi:10.1016/j.neuron.2016.09.039

Lindauer, R. J., Olff, M., van Meijel, E. P., Carlier, I. V. E., & Gersons, B. P. R. (2006). Cortisol, learning, memory, and attention in relation to smaller hippocampal volume in police officers with posttraumatic stress disorder. *Biological Psychiatry*, *59*(2), 171–177. doi:10.1016/j.biopsych.2005.06.033

Little, R. J. A. (1988). A test of missing completely at random for multivariate data with missing values. *Journal of the American Statistical Association*, *83*(404), 1198–1202. doi:10.1080/01621459.1988.10478722

Litz, B. T., Weathers, F. W., Monaco, V., Herman, D. S., Wulfsohn, M., Marx, B., & Keane, T. M. (1996). Attention, arousal, and memory in posttraumatic stress disorder. *Journal of Traumatic Stress*, *9*(3), 497–519. doi:10.1002/jts.2490090308

Marchand, A., Nadeau, C., Beaulieu-Prévost, D., Boyer, R., & Martin, M. (2015). Predictors of posttraumatic stress disorder among police officers: A prospective study. *Psychological Trauma: Theory, Research, Practice, and Policy*, *7*(3), 212–221. doi:10.1037/a0038780

Marx, B. P., Doron-Lamarca, S., Proctor, S. P., & Vasterling, J. J. (2009). The influence of pre-deployment neurocognitive functioning on post-deployment PTSD symptom outcomes among Iraq-deployed Army soldiers. *Journal of the International Neuropsychological Society*, *15*(6), 840–852. doi:10.1017/S1355617709990488

Matsuo, K., Taneichi, K., Matsumoto, A., Ohtani, T., Yamasue, H., Sakano, Y., … Kato, T. (2003). Hypoactivation of the prefrontal cortex during verbal fluency test in PTSD: A near-infrared spectroscopy study. *Psychiatry Research: Neuroimaging*, *124*(1), 1–10. doi:10.1016/S0925-4927(03)00093-3

McCreary, D. R., & Thompson, M. M. (2006). Development of two reliable and valid measures of stressors in policing: The operational and organizational police stress questionnaires. *International Journal of Stress Management*, *13*(4), 494–518. doi:10.1037/1072-5245.13.4.494

Moores, K. A., Clark, C. R., McFarlane, A. C., Brown, G. C., Puce, A., & Taylor, D. J. (2008). Abnormal recruitment of working memory updating networks during maintenance of trauma-neutral information in posttraumatic stress disorder. *Psychiatry Research: Neuroimaging*, *163*(2), 156–170. doi:10.1016/j.pscychresns.2007.08.011

Morey, R. A., Dolcos, F., Petty, C. M., Cooper, D. A., Hayes, J. P., LaBar, K. S., & McCarthy, G. (2009). The role of trauma-related distractors on neural systems for working memory and emotion processing in posttraumatic stress disorder. *Journal of Psychiatric Research*, *43*(8), 809–817. doi:10.1016/j.jpsychires.2008.10.014

Nijdam, M. J., De Vries, G.-J., Gersons, B. P., & Olff, M. (2015). Response to psychotherapy for posttraumatic stress disorder: The role of pretreatment verbal memory performance. *The Journal of Clinical Psychiatry*, *76*(8), e1023–e1028. doi:10.4088/JCP.14m09438

Nijdam, M. J., Gersons, B. P. R., & Olff, M. (2013). The role of major depression in neurocognitive functioning in patients with posttraumatic stress disorder. *European Journal of Psychotraumatology*, *4*(1), 19979. doi:10.3402/ejpt.v4i0.19979

Olff, M., Polak, A. R., Witteveen, A. B., & Denys, D. (2014). Executive function in posttraumatic stress disorder (PTSD) and the influence of comorbid depression. *Neurobiology of Learning and Memory*, *112*, 114–121. doi:10.1016/j.nlm.2014.01.003

Parslow, R. A., & Jorm, A. F. (2007). Pretrauma and Posttrauma Neurocognitive Functioning and PTSD Symptoms in a Community Sample of Young Adults. *American Journal of Psychiatry*, *164*(3), 509–515. doi:10.1176/ajp.2007.164.3.509

Patterson, G. T. (2001). The relationship between demographic variables and exposure to traumatic incidents among police officers. *Australasian Journal of Disaster and Trauma Studies*, *2*(1). http://trauma.massey.ac.nz/issues/2001-2/patterson2.htm

Plat, M.-C. J., Westerveld, G. J., Hutter, R. C., Olff, M., Frings-Dresen, M. H. W., & Sluiter, J. K. (2013). Return to work: Police personnel and PTSD. *Work*, *46*(1), 107–111. doi:10.3233/WOR-121578

Polak, A. R., Witteveen, A. B., Reitsma, J. B., & Olff, M. (2012). The role of executive function in posttraumatic stress disorder: A systematic review. *Journal of Affective Disorders*, *141*(1), 11–21. doi:10.1016/j.jad.2012.01.001

Qureshi, S. U., Long, M. E., Bradshaw, M. R., Pyne, J. M., Magruder, K. M., Kimbrell, T., … Kunik, M. E. (2011). Does PTSD Impair Cognition Beyond the Effect of Trauma? *Journal of Neuropsychiatry and Clinical Neurosciences*, *23*(1), 16–28. doi:10.1176/appi.neuropsych.23.1.16

Rubin, D. B. (1987). *Multiple imputation for survey nonresponse*. New York (NY): Wiley.

Samuelson, K. W., Neylan, T. C., Metzler, T. J., Lenoci, M., Rothlind, J., Henn-Haase, C., … Marmar, C. R. (2006). Neuropsychological functioning in posttraumatic stress disorder and alcohol abuse. *Neuropsychology*, *20*(6), 716–726. doi:10.1037/0894-4105.20.6.716

Scott, J. C., Harb, G., Brownlow, J. A., Greene, J., Gur, R. C., & Ross, R. J. (2017). Verbal memory functioning moderates psychotherapy treatment response for PTSD-Related nightmares. *Behaviour Research and Therapy*, *91*, 24–32. doi:10.1016/j.brat.2017.01.004

Scott, J. C., Matt, G. E., Wrocklage, K. M., Crnich, C., Jordan, J., Southwick, S. M., … Schweinsburg, B. C. (2015). A quantitative meta-analysis of neurocognitive functioning in posttraumatic stress disorder. *Psychological Bulletin*, *141*(1), 105–140. doi:10.1037/a0038039

Sheehan, D. V., Lecrubier, Y., Sheehan, K. H., Amorim, P., Janavs, J., Weiller, E., … Dunbar, G. C. (1998). The Mini-International Neuropsychiatric Interview (MINI): the development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. *Journal of Clinical Psychiatry, 59*(20), 22–33. http://www.psychiatrist.com/JCP/article/Pages/1998/v59s20/v59s2005.aspx

Shucard, J. L., McCabe, D. C., & Szymanski, H. (2008). An event-related potential study of attention deficits in posttraumatic stress disorder during auditory and visual Go/NoGo continuous performance tasks. *Biological Psychology*, *79*(2), 223–233. doi:10.1016/j.biopsycho.2008.05.005

Skevington, S. M., Lotfy, M., & O'Connell, K. A. (2004). The World Health Organization's WHOQOL-BREF quality of life assessment: psychometric properties and results of the international field trial. A report from the WHOQOL group. *Quality of life Research*, *13*(2), 299–310. doi:10.1023/B:QURE.0000018486.91360.00

Stirman, S. W. (2008). The applicability of randomized controlled trials of psychosocial treatments for PTSD to a veteran population. *Journal of Psychiatric Practice*, *14*(4), 199–208. doi:10.1097/01.pra.0000327309.58411.e0

Tanev, K. S., Federico, L. E., Terry, D. P., Clark, E. L., & Iverson, G. L. (2019). Cognitive impairment and predicting response to treatment in an intensive clinical program for post-9/11 veterans with posttraumatic stress disorder. *Journal of Neuropsychiatry and Clinical Neurosciences*, *31*(4), 337–345. doi:10.1176/appi.neuropsych.18090208

Vasterling, J. J., & Brailey, K. (2005). Neuropsychological findings in adults with PTSD. In J. J. Vasterling & C. Brewin (Eds.), *Neuropsychology of PTSD: Biological, cognitive, and clinical perspectives* (pp. 178–207). New York (NY): Guilford Press.

Vasterling, J. J., & Walt, G. S. (2019). Neuropsychology of Posttraumatic Stress Disorder. In M. L. Alosco & R. A. Stern (Eds.), *The Oxford Handbook of Adult Cognitive Disorders* (pp. 274–290). New York (NY): Oxford University Press.

Vasterling, J. J., Aslan, M., Lee, L. O., Proctor, S. P., Ko, J., Jacob, S., & Concato, J. (2018). Longitudinal associations among posttraumatic stress disorder symptoms, traumatic brain injury, and neurocognitive functioning in army soldiers deployed to the Iraq War. *Journal of the International Neuropsychological Society*, *24*(4), 311–323. doi:10.1017/S1355617717001059

Vasterling, J. J., Duke, L. M., Brailey, K., Constans, J. I., Allain, A. N., & Sutker, P. B. (2002). Attention, learning, and memory performances and intellectual resources in Vietnam veterans: PTSD and no disorder comparisons. *Neuropsychology*, *16*(1), 5–14. doi:10.1037/0894-4105.16.1.5

Vasterling, J. J., Proctor, S. P., Amoroso, P., Kane, R., Heeren, T., & White, R. F. (2006). Neuropsychological outcomes of army personnel following deployment to the Iraq War. *JAMA*, *296*(5), 519–529. doi:10.1001/jama.296.5.519

Ventevogel, P., De Vries, G., Scholte, W. F., Shinwari, N. R., Faiz, H., Nassery, R., … Olff, M. (2007). Properties of the Hopkins Symptom Checklist-25 (HSCL-25) and the Self-Reporting Questionnaire (SRQ-20) as screening instruments used in primary care in Afghanistan. *Social Psychiatry and Psychiatric Epidemiology*, *42*(4), 328–335. doi:10.1007/s00127-007-0161-8

Wagner, S. L., White, N., Fyfe, T., Matthews, L. R., Randall, C., Regehr, C., … Carey, M. G. (2020). Systematic review of posttraumatic stress disorder in police officers following routine work-related critical incident exposure. *American Journal of Industrial Medicine*, *63*(7), 600–615. doi:10.1002/ajim.23120

Weathers, F., Litz, B., Keane, T., Palmieri, T., Marx, B., & Schnurr, P. (2013). *The PTSD Checklist for DSM-5 (PCL-5)*. Scale available from the National Center for PTSD at www.ptsd.va.gov .

Wild, J., & Gur, R. C. (2008). Verbal memory and treatment response in posttraumatic stress disorder. *The British Journal of Psychiatry*, *193*(3), 254–255. doi:10.1192/bjp.bp.107.045922

Wrocklage, K. M., Schweinsburg, B. C., Krystal, J. H., Trejo, M., Roy, A., Weisser, V., & Scott, J. C. (2016). Neuropsychological functioning in veterans with posttraumatic stress disorder: Associations with performance validity, comorbidities, and functional outcomes. *Journal of the International Neuropsychological Society*, *22*(4), 399–411. doi:10.1017/S1355617716000059