The Impact of Multiple Concussions on Emotional Distress, Post-Concussive Symptoms, and Neurocognitive Functioning in Active Duty United States Marines Independent of Combat Exposure or Emotional Distress

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Disclaimer

- The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the US Department of Veterans Affairs, US Department of Defense or the US Government.

Background

- There have been several discrepancies between reports of persistent post-concussive symptoms (PPCS) in the literature which may have arisen from multiple factors:
  - Varied populations investigated
  - different levels of emotional comorbidity
  - clinical vs. non clinical setting
- Influence of number and recency of concussions has not been adequately assessed
- There is a large overlap in post-concussive symptoms with symptoms common in patients with depression and PTSD
- Little consensus as to the nature of persistent post-concussive symptoms in those with a previous concussion

Background

- Overlap in post-concussive symptoms with symptoms common in patients with depression and PTSD
  - –Deployment stress was associated with PPCS (Cooper,2011)
  - –Cognitive functioning declining across the deployment cycle independent of concussion (Vasterling, 2006).
- Short term effects of concussion
  - –Cognitive functioning can be impaired for the first few days after concussion (McCrea, 2003; Kennedy, 2003).
  - –Speed and accuracy decline across cognitive functions such as reaction time (Sosnoff, 2007) and delayed memory/executive functioning (Belanger, 2010).
- Emotional distress affects cognitive functioning
  - –-Cognitive performance is affected by the stress of having been in combat/deployed (Vasterling, 2006; Wesensten, 2010; Vasterling 2010)

Study Aims

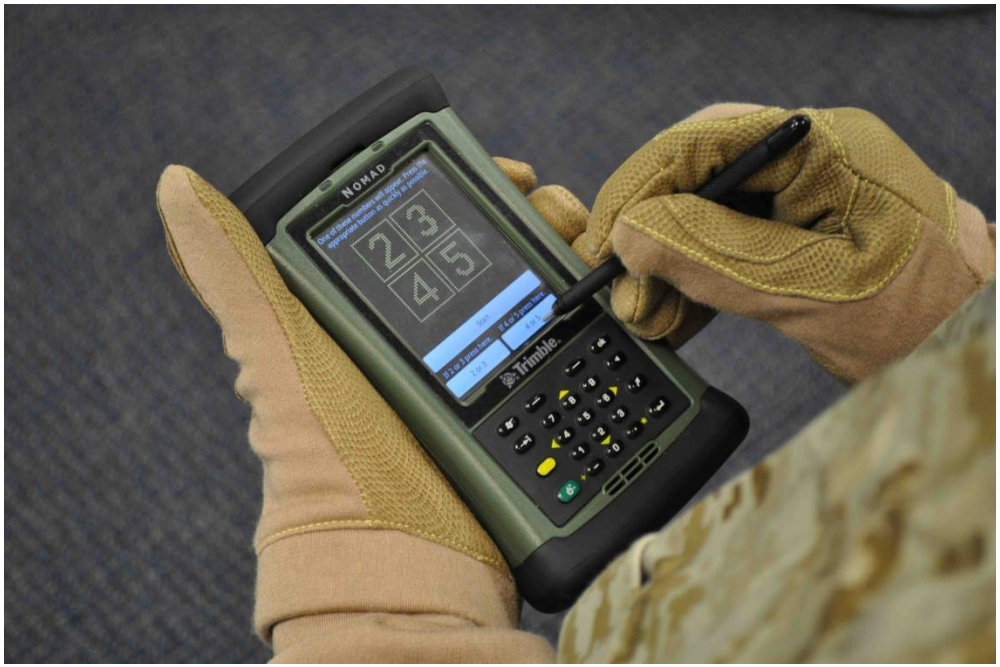
- To determine whether the recency and number of lifetime concussions had a sustained impact on emotional, somatic, and cognitive functioning in a sample of U.S. Marines, accounting for deployment stress and symptoms of depression and PTSD.

Study Methods

- *Cohort Characteristics*
  - –646 U.S. Marines
  - –234 never deployed, 98 previously deployed, 314 recently deployed
- *Testing (Defense Automated Neurobehavioral Assessment)*
  - –369 received DANA Standard battery
  - –227 received DANA Brief battery
  - –N=419, PCL-M, PSQI, DSI, SPD, CDS, CDD, STN
  - –N=646, CES, PHQ-8, SRT, PRT, GNG

DANA Rapid

- Simple Reaction Time
- Choice Reaction (Go/No Go)
- Procedural Reaction Time



DANA Brief

- Simple Reaction Time
- Code Substitution
- Procedural Reaction Time
- Spatial Processing
- Choice Reaction (Go/No Go)
- Code Substitution Delayed
- Simple Reaction Time
- PHQ-8

DANA Standard

- Simple Reaction Time
- Code Substitution
- Procedural Reaction Time
- Spatial Processing
- Code Substitution Delayed
- Choice Reaction (Go/No Go)
- Sternberg Memory Search
- Simple Reaction Time
- CES
- PHQ-8
- PSQI
- PCL-M
- DSI

Abbreviations

- **CES**- Combat Exposure Survey
- **CDD**- Code Substitution-Delayed Memory
- **CDS**- Code Substitution
- **DSI**- Deployment Symptom Inventory
- **GNG**- Go/No Go
- **PCL-M**- Post-Traumatic Stress Disorder Check List (Military Version)
- **PHQ-8**- Patient Health Questionnaire (minus suicide question)
- **PSQI**- Pittsburgh Sleep Quality Index
- **PRT**- Procedural Reaction Time
- **SPD**- Spatial Rotation Discrimination
- **STN**- Sternberg Memory Test
- **SRT**- Simple Reaction Time

Results

- 25% at least 1 previous concussion in lifetime
- 7% two previous concussions
- 9% three or more concussions
- Deployment status and CES scores correlated with number and recency of concussions, PCL-M, PHQ-8, DSI-Anger, DSI-total, PSQI, and the majority of neurocognitive tests with moderate to large effect sizes

Effects of Concussion on Emotional Symptoms

- *At least one earlier concussion*
  - Associated with emotional distress with small effect size (PCL-M, PHQ-8 and DSI-Anger)
- *Multiple and recent concussions*
  - Associated with emotional distress with stronger effect size (PCL-M, PHQ-8 and DSI-Anger)
- *3 or more lifetime concussions*
  - More than doubled the odds of reaching clinical cutoff scores for PTSD and depression
  - 4 times the odds of anger problems

TABLE 1. INFLUENCE OF CONCUSSION HISTORY ON EMOTIONAL TESTS

		Emotional tests (with all covariates included)					
		PCL-M		*PHQ-8*		*DSI-Anger*	
	N	*Mean (SD)*	p *value (ES)*	*Mean (SD)*	p *value (ES)*	*Mean (SD)*	p *value (ES)*
Any past concussion:							
No	300	27.7 (11.8)		4.8 (4.9)		1.6 (2.2)	
Yes	116	34.2 (15.4)	0.000(m)	6.3 (5.3)	0.021(s)*	2.6 (2.2)	0.002(s)*
Never	305	27.5 (11.7)		4.7 (4.9)		1.46 (2.1)	
>6 mos. ago	98	33.6 (14.8)		6.0 (5.1)		2.27 (2.4)	
<6 mos. ago	15	42.1 (17.6)	0.000(m)	9.9 (5.5)	0.001(s)*	4.31 (3.3)	0.000 (m)*
0	305	27.5 (11.7)		4.7 (4.9)		1.6 (2.2)	
1	36	32.2 (13.4)		5.7 (4.0)		2.0 (2.5)	
2	33	31.2 (14.6)		5.3 (5.1)		2.4 (2.9)	
3+	43	39.4 (16.9)	0.000 (m)	8.3 (5.4)	0.004(s)*	3.5 (2.7)	0.001(m)
0–1 vs. 3+ > [criteria]	387		0.000 OR=2.48 [PCL-M >50]		0.027 OR=2.19 [PHQ-8 >10]		0.001 OR=4.36 [DSI-Anger >1SD]

Effects of Concussion on Post-Concussive Symptoms

- Continuous variables analyzed: DSI and PSQI
- Covariates included: CES, PCL-M, and PHQ-8
- DSI – at least one previous concussion
  - Related to DSI-somatic symptoms with a small effect size
- PSQI – at least one previous concussion was associated with sleep problems
- Findings likely due to multiple concussions, not just one

Effects of Concussion on Post-Concussive Symptoms

- *Recency of concussion*
  - –Associated with DSI-sensory, DSI-somatic, DSI-vestibular, and PSQI
- *Number of concussions*
  - –Associated with DSI-somatic, DSI-vestibular, and PSQI
- *Three or more concussions*
  - –Associated with DSI-sensory, DSI-somatic, and DSI-vestibular
- Two concussions only associated with PSQI

Effects of Concussion on Post-Concussive Symptoms

- Recency of concussion and number of concussions with previous deployment, CES, PCL-M and PHQ-8 covariates found significant interactions for:
  - DSI-cognitive, DSI-sensory, DSI-somatic, and DSI-total
- Above interactions for those with three or more concussions with the most recent within 6 months reported more distress than those with none or one concussion in the more distant past

Effects of Concussion on Post-Concussive Symptoms

- Three or more concussions compared to one or no concussions
  - Predicted abnormal DSI-Sensory and DSI-vestibular
  - Without covariates all DSI subscales were significant

Effects of Concussion on Post-Concussive Symptoms

- Independent of deployment, CES, PCL-M and PHQ-8 were not related to post-concussive reporting with the exception of insomnia (PSQI)
- Recency of concussion, number of concussions (3 or more), and interactions between number and recency were associated with worse post-concussive symptom reporting

TABLE 2. INFLUENCE OF CONCUSSION HISTORY ON POST-CONCUSSIVE TESTS

		Post-concussive tests (with all covariates included)												
		DSI-Cognitive		*DSI-Sensory*		*DSI-Somatic*		*DSI-Vestibular*		*DSI-Total*		*PSQ-I*		
	N	*M(SD)*	p(*ES*)	*M(SD)*	p(*ES*)	*M(SD)*	p(*ES*)	*M(SD)*	p(*ES*)	*M(SD)*	p(*ES*)	*N*	*M(SD)*	p(*ES*)
Any past concussion:														
No	300	.38(.47)		.13(.25)		.36(.33)		.15(.31)		.37(.36)		256	5.3(3.2)	
Yes	116	.57(.55)	n.s.*	.25(.40)	n.s.*	.55(.44)	.018(s)*	.30(.47)	n.s.*	.56(.46)	n.s.*	99	7.8(4.1)	.000(m)
Never	305	.38(.46)		.12(.25)		.36(33)		.15(.30)		.34(.35)		257	5.3(3.2)	
>6 mos. ago	137	.56(.52)		.21(.35)		.52(.41)		.25(.43)		.51(.42)		84	7.6(4.1)	
<6 mos. ago	16	.76(.70)	n.s.*	.53(.57)	.004(s)*	.86(.37)	.007(s)*	.59(.36)	.002(s)*	.82(.53)	n.s.*	15	8.7(3.9)	.002(m)
0	305	.38(.46)		.12(.25)		.36(.33)		.15(.30)		.37(.37)		257	5.3(3.2)	
1	36	.48(.47)		.19(.30)		.46(.39)		.21(.38)		.47(.40)		28	7.4(.4.0)	
2	33	.57(.55)		.18(.35)		.50(.44)		.21(.37)		.53(.46)		29	7.8(4.0)	
3+	43	.69(.58)	n.s.*	.37(.47)	n.s.*	.71(.43)	.027(s)*	.45(.57)	.047(s)*	.70(.48)	n.s.*	43	8.0(.4.2)	.001(m)
0–1	341	.38(.46)		.13(.25)		.37(.33)		.15(.31)		.38(.37)		285	5.5(3.3)	
Vs.3+	43	.71(.49)	n.s.*	.38(.47)	.004(s)*	.71(.43)	.003(s)*	.46(.57)	.003(s)*	.71(.40)	n.s.*	43	8.0(4.3)	n.s.*

Effects of Concussion on Neurocognitive Functioning

- *Single Concussion*
  - Associated with delayed SRT-TP and PRT-TP (without covariates)
    - Not associated with neurocognitive outcomes when PTSD, PHQ, and deployment experience were taken into account.
- *Recency of Concussion*
  - Effects of concussion within 6 months compared with previously or never concussed was significant for delayed SRT-TP and PRT-TP (without covariates)

Effects of Concussion on Neurocognitive Functioning

- *Multiple lifelong concussions*
  - Associated with delayed SRT-TP (PCL-M and PHQ-8 as covariates)
  - Marginally associated (without covariates) with:
    - PRT-TP
    - GNG-%
    - CDS-TP

Effects of Concussion on Neurocognitive Functioning

- *3 or more lifetime concussions*
  - Largest difference among outcomes
  - Significant difference, with all covariates included, for SRT-TP, GNG-%, PRT-TP, and CDS-TP
  - No interaction with recency of concussion
  - Worse performance on neurocognitive tasks involving simple attention and simple discrimination skills, such as SRT-TP, GNG-%, and SPD-TP

Effects of Concussion on Neurocognitive Functioning

- *3 or more Lifetime concussions*
  - Neurocognitive decrement in SRT-TP, PRT-TP, and GNG-%
  - Simple Measures of neurocognitive functioning are sensitive to the effects of three or more concussions, independent of emotional and deployment covariates

TABLE 4. EFFECT OF THREE OR MORE LIFETIME CONCUSSIONS ON NEUROCOGNITIVE FUNCTIONING

Variables in the equations

SRT-TP	*B*	*S.E.*	*Wald*	*df*	*Sig.*	*Exp(B)*
Step 2[b]						
Conc_Count_01_v_3plus(1)	−.902	.385	5.477	1	.019	2.174
PCL0SCORE	−.027	.010	7.053	1	.008	1.027
Constant	2.236	.414	29.136	1	.000	9.355

a. Variable(s) entered on step 1: PCL0SCORE.
b. Variable(s) entered on step 2: Conc_Count_01_v_3plus.

PRT-TP	*B*	*S.E.*	*Wald*	*df*	*Sig.*	*Exp(B)*
Step 1[a]						
Conc_Count_01_v_3plus(1)	.675	.333	4.113	1	.043	1.964
Constant	.048	.166	.084	1	.772	1.049

a. Variable(s) entered on step 1: Conc_Count_01_v_3plus.

GNG-%Correct	*B*	*S.E.*	*Wald*	*df*	*Sig.*	*Exp(B)*
Step 1[a]						
Conc_Count_01_v_3plus(1)	1.037	.468	4.901	1	.027	2.819
Constant	−2.156	.234	84.805	1	.000	.116

Conclusions

- Recent deployment, higher CES, PCL-M and PHQ8 had an effect on:
  - Number and recency of concussion
  - Emotional distress
  - Post-concussive symptom reporting
  - Neurocognitive tasks
    - Speed of response slowed
    - But NOT memory-dependent tasks

Conclusions

- Having three or more concussions was related to worse scores for:
  - Depression
  - PTSD
  - Anger
  - Post-concussive sensory, somatic, and vestibular symptoms

Conclusions

- Tests within this neurobehavioral battery, especially those relying on attention and simple discrimination should be given to military members to aid in detecting problems early so they can get the necessary care
- Concussive and psychological factors frequently co-occur, enhance symptoms and cause challenges in diagnosis and treatment

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Questions?

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