

The Relationship of TBI to PTSD:

The impact of multiple concussion on emotional, cognitive, and postconcussive symptoms in returning combat veterans

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Objectives

- ◉ Definitions: PTSD / TBI
- ◉ Effects of Combat Exposure on PTSD/TBI
- ◉ Influence of TBI on PTSD
- ◉ Influence of PTSD on TBI
- ◉ What really causes Persistent Postconcussive Sx?
- ◉ Implications for doctors and coaches

TRAUMATIC BRAIN INJURY (TBI)



OEF/OIF Statistics

- ◉ 19.5% reported probable TBI (RAND)
- ◉ Oct 2007, US Military – 20% of members have suffered mTBI from blows to the head or shockwaves caused by explosions
- ◉ 80% of TBI are closed head injury (CHI) (Arenofsky 2008)

Blast Concussion

- Close proximity to an explosion
- $\geq 300\text{m/sec}$ pressurized wave
- Secondary injury from head striking surface
- Frequent sub-concussive blows to the head
- Axonal Sheering/stretching
- White matter disruption



Prognosis

- Moderate/severe TBI can have lasting effects
- Concussion appears to resolve within hours or days.
 - But a second injury can cause more damage than would normally be expected, so physiological changes persist for some months s/p mTBI.

**2008 VA/DoD CLINICAL PRACTICE GUIDELINE
FOR MANAGEMENT OF
CONCUSSION/MILD TRAUMATIC BRAIN INJURY
(mTBI)**

Prepared by:

Department of Veterans Affairs /Department of Defense
Management of Concussion/mTBI Working Group

TBI Criteria	Mild	Moderate	Severe
Structural Imaging	Normal	Normal or Abnormal	Normal or Abnormal
Loss of Consciousness	0 - 30 minutes	>30 and < 24 hrs	>24 hours
Alteration of Mental Status	<i>A moment up to 24 hours</i> (dazed, confused, disoriented)	>1 and <7 days	> 7days
Post-traumatic amnesia	0 -1 day	<1 and > 7 days	> 7days
Glascow Coma Scale (1 st 24 hrs)	13-15	9-12	<9

Signs and Symptoms

- ◉ The most typical **signs and symptoms following concussion include:**
- ◉ a. **Physical:** headache, nausea, vomiting, dizziness, fatigue, blurred vision, sleep disturbance, sensitivity to light/noise, balance problems, transient neurological abnormalities
- ◉ b. **Cognitive:** attention, concentration, memory, speed of processing, judgment, executive control
- ◉ c. **Behavioral/emotional:** depression, anxiety, agitation, irritability, impulsivity, aggression.

Problems with Assessing PPCS

Symptoms of PCS and PTSD appear to be very similar (on the surface, and can often only be distinguished through thorough clinical interview).

PTSD	Category (as asked by PDHA)	PCSx
stress	HEADACHE	migrainous
insomnia	SLEEP	hypersomnia
reactive – consistent	IRRITABILITY	reactive-random labile
trauma generalization	AVOIDANT	focal cognitive effort
Change in preferences. Sensitive to light and sound.	SENSORY CHANGE	Loss of smell/taste Overwhelmed by sensory input
Feeling of instability	DIZZINESS	Balance / room spins
Can often rally effort; Due to thought intrusion and lack of sleep	MEMROY PROBLEMS	Difficulty rallying effort; Not only due to thought intrusion or lack of sleep

PDHA Assessment of mTBI

9.a. During this deployment, did you experience any of the following events? (Mark all that apply)

(1) Blast or explosion (*IED, RPG, land mine, grenade, etc.*)

(2) Vehicular accident/crash (*any vehicle, including aircraft*)

(3) Fragment wound or bullet wound above your shoulders

(4) Fall

(5) Other event (*for example, a sports injury to your head*).

Describe:

9.b. Did any of the following happen to you, or were you told happened to you, IMMEDIATELY after any of the event(s) you just noted in question 9.a.? (*Mark all that apply*)

(1) Lost consciousness or got "knocked out"

(2) Felt dazed, confused, or "saw stars"

(3) Didn't remember the event

(4) Had a concussion

(5) Had a head injury

PDHA Assessment of mTBI

9.c. Did any of the following problems begin or get worse after the event(s) you noted in question 9.a.? (Mark all that apply)

- (1) Memory problems or lapses**
- (2) Balance problems or dizziness**
- (3) Ringing in the ears**
- (4) Sensitivity to bright light**
- (5) Irritability**
- (6) Headaches**
- (7) Sleep problems**

9.d. In the past week, have you had any of the symptoms you indicated in 9.c.? (Mark all that apply)

- (1) Memory problems or lapses**
- (2) Balance problems or dizziness**
- (3) Ringing in the ears**
- (4) Sensitivity to bright light**
- (5) Irritability**
- (6) Headaches**
- (7) Sleep problems**

Measures of *Postconcussive Sx*

- **Neurobehavioral Symptom Inventory**
 - Cognitive
 - Sensory
 - Somatic
 - Vestibular
 - Total

Persistent Post-Concussive Syndrome (PPCS)

- In late or persistent PCS, symptoms last for over six months.
- • The **PCS cluster of symptoms is not unique to concussion** (occurs with many medical and psychiatric conditions as well as in normal individuals)
- • The **exact cluster of symptoms varies** substantially across concussion patients; therefore it does not meet criteria for a “syndrome.”

Persistent Postconcussive Sx

- PCS is seen in between **15% (DSM-IV) to 50% (WHO-ICD-10)** of persons with mTBI, depending on definitions (McCrea, 2003).
- **For all individuals with an initial mTBI, <5% may have persistent difficulties by 12 months (Iverson, 2007).**
- Physical symptoms dominate in the first 4 weeks after injury, whereas emotional disturbances predominate later (at 4 - 8 weeks) (Yang, 2007).

Persistent Postconcussive Sx

- ◉ Debate as to whether it is due to neurologic or psychological factors
- ◉ Well documented that persistent symptoms of mTBI are predicted by non-injury related factors such as premorbid psychosocial issues, psychological comorbidities, post-injury stressors, substance abuse and litigation
- ◉ But does that mean that PPCSx is NOT due to neurological injury?

Definitions: Posttraumatic Stress Disorder

DSM-IV

DSM-V

A. The person was exposed to one or more of the following event(s): death or threatened death, **actual or threatened serious injury, or actual or threatened sexual violation**, in one or more of the following ways:

- Experiencing the event(s) him/herself
- **Witnessing the event(s) occurring to others**
- **Learning that violent event(s) threatening death occurred to a close relative or friend;**
- **Experiencing repeated or extreme exposure to aversive details of the event(s) e.g., first responders**

B. Re-experiencing (**Intrusion symptoms**) associated with the traumatic event(s) (that began after the traumatic event(s)), as evidenced by 1 or more of the following:

- Spontaneous recurrent, involuntary, and intrusive distressing memories of the traumatic event(s).
- Recurrent distressing dreams related to event(s).
- Dissociative reactions (e.g., flashbacks) in which the individual feels/acts as if the trauma was recurring
- Intense psychological distress at exposure to cues that resemble an aspect of the traumatic event(s)
- Marked physiological reactions to reminders of the traumatic event(s)

C. Persistent avoidance of stimuli associated with the traumatic event(s) (that began after the traumatic event(s)), as evidenced by efforts to avoid 3 or more of the following (1 or more of the following in DSM-V):

- Avoids internal reminders (thoughts, feelings, or physical sensations) that arouse recollections of the traumatic event(s)
- Avoids external reminders (people, places, conversations, activities, objects, situations) that arouse recollections of the traumatic event(s).

D. Negative alterations in cognitions and mood that are associated with the traumatic event(s) (that began or worsened after the traumatic event(s)), as evidenced by 3 or more of the following

- Inability to remember an important aspect of the trauma
- Persistent and exaggerated negative expectations about one's self, others, or the world (e.g., "I am bad," "no one can be trusted," "the world is completely dangerous").
- Persistent distorted blame of self or others about the cause or consequences of the traumatic event(s)
- Pervasive negative emotions (fear, anger, guilt, shame)
- Diminished interest or participation in significant activities.
- Feeling of detachment or estrangement from others.
- Persistent inability to experience positive emotions

E. **Alterations** in arousal and reactivity that are associated with the traumatic event(s) (that began or worsened after the traumatic event(s)), as evidenced by 3 or more of the following:

- ◉ Irritable or aggressive behavior
- ◉ **Reckless or self-destructive behavior**
- ◉ Hypervigilance
- ◉ Exaggerated startle response
- ◉ Problems with concentration
- ◉ Sleep disturbance

- ◉ **F. Duration of the disturbance is more than one month.**
- ◉ **G. The disturbance causes impairment in social, occupational, or other important areas of functioning.**
- ◉ H. The disturbance is not due to the direct physiological effects of a substance (e.g., medication or alcohol) or a general medical condition (e.g., traumatic brain injury, coma).
- ◉ *Specify if:*
***With Delayed Onset:* if diagnostic threshold is not exceeded until 6 months or more after the event(s) (although onset of some symptoms may occur sooner than this).**

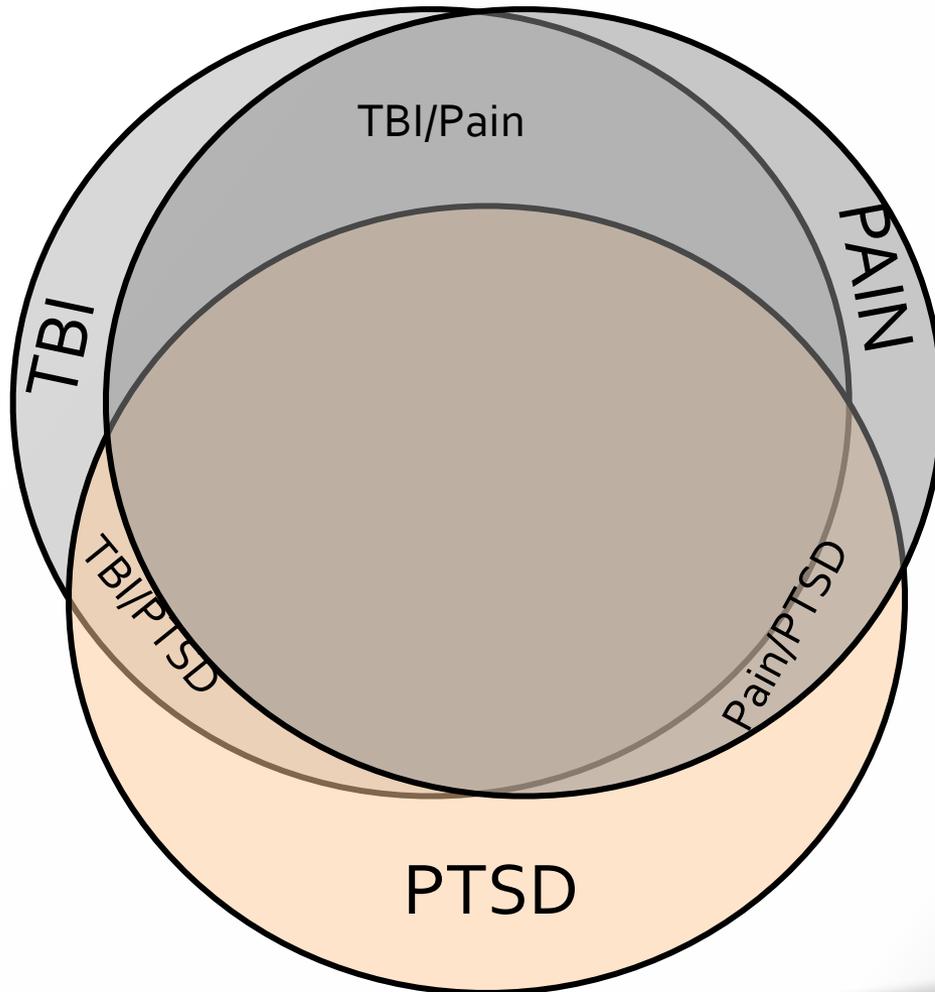
Quality of Life

- Quality of Life is rated about the same as cancer patients undergoing treatment
- About 7% of the US civilian population will develop PTSD in their lifetime, most often due to sexual assault, physical assault, MVA, or disaster
- 17% of Vietnam/OEF/OIF combat veterans develop PTSD
- 30% of those exposed to combat multiple times develop PTSD
- Less than 1/3 may experience remission within two years
- More than 70% of those who complete evidence-based treatment reduce their symptom severity by 30%, and about half no longer meet criterion for PTSD

Definitions: *Comorbidity*

- ◉ Depression / Anger
- ◉ Insomnia
- ◉ Pain
- ◉ Substance Abuse

Post-deployment overlap in Sx

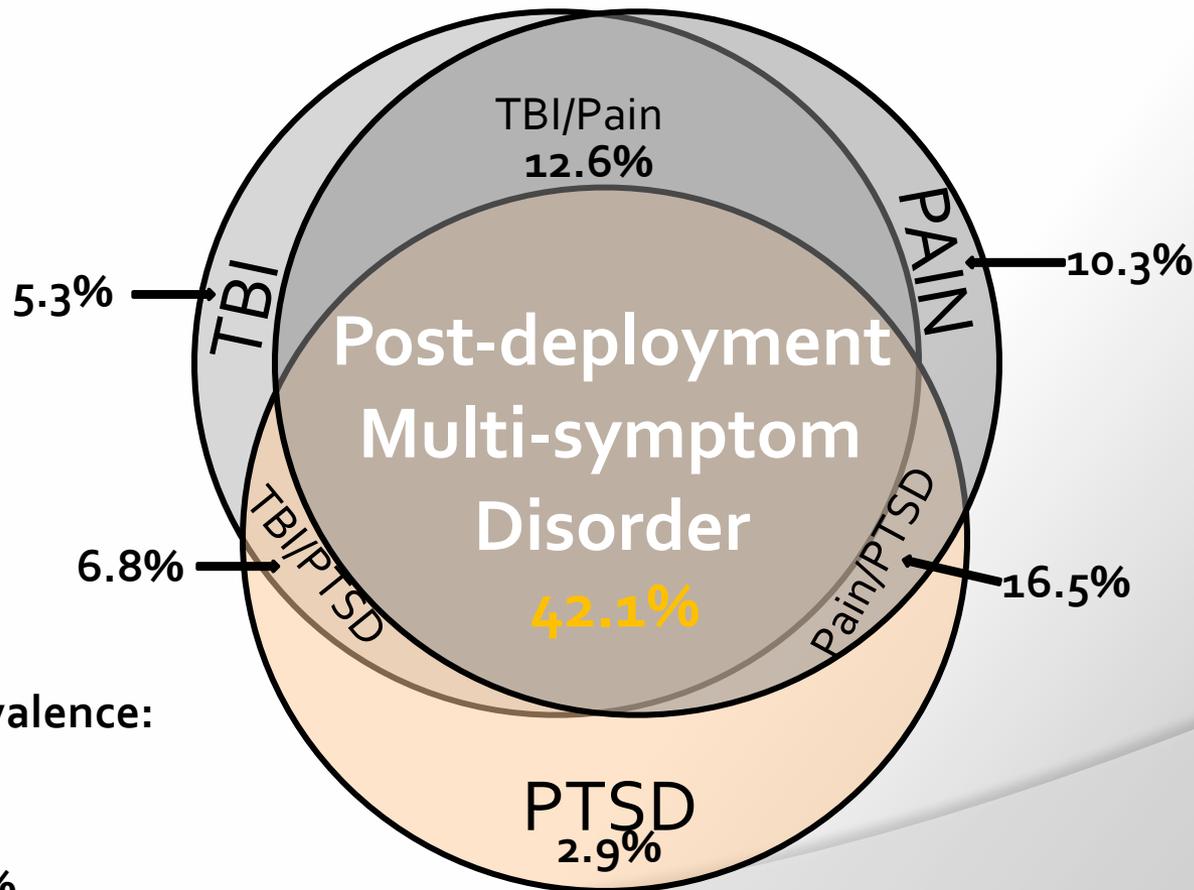


Combat veterans:
PTSD 18-30%
depending upon
number of deployments
20% PTSD/mTBI
(RAND, 2008)
38% PTSD&Pain
(Clark, 2008)
66% PTSD&Pain
(Shipherd, 2007)

OEF/OIF VA Clinic Sample

Lew, Otis, Tun, Kerns, Clark, & Cifu, 2009

Sample = 340 OEF/OIF outpatients at Boston VA



Overall prevalence:

Pain 81.5%

TBI 68.2%

PTSD 66.8%

Effects of Deployment on TBI

Scale	% of total	(N)	Never Deployed N=234	Previously Deployed N=98	Recently Deployed N=314	p-value alone / when CES is covariate
Any Concussion (25%)		645	54 (8%)	27 (4%)	88 (14%)	.39 (n.s.)
Lifetime Concussion Number (%):						.02 / n.s.
0	(76%)	494	193 (39%)	75 (15%)	226 (46%)	
1	(8%)	53	18 (34%)	10 (19%)	25 (47%)	
2	(6%)	40	11 (27%)	3 (1%)	26 (65%)	
3 or more	(9%)	59	12 (20%)	10 (17%)	37 (62%)	
Most Recently Concussed:						.04 / n.s.
> 6mo		136	39 (30%)	23 (17%)	74 (54%)	
< 6mo	(12%)	16	2 (12%)	0	14 (87%)	

Effects of Deployment on Distress

Scale	% of total	(N)	Never Deployed N=234	Previously Deployed N=98	Recently Deployed N=314	p-value alone / when CES is covariate
PCL-m		417	22.6 (8.5)	33.0 (16.0)	31.5 (13.6)	.000 / n.s.
% PCL>50	(10%)	42	3.2%	15.4%	12.0%	
PHQ-8		419	3.5 (4.5)	6.4 (6.5)	5.7 (5.0)	.001 / n.s.
% PHQ>10	(20%)	85	12.6%	23.1%	22.5%	
DSI-anger		644	1.1 (1.8)	1.6 (2.1)	2.2 (2.5)	.000 / n.s.
PSQI		327	4.6 (3.3)	(low N)	6.2 (3.6)	.006 / n.s.
%PSQI>11	(8%)	27	4.3%	8.1%	7.6%	
Co-morbid (2+ PCL>50; PHQ>10; PSQI>11; DSI>30)		37	4 1.7%	1 1%	32 10%	.000 / n.s.

Effects of Deployment on Neurocognitive Functioning

Scale	% of total	(N)	Never Deployed N=234	Previously Deployed N=98	Recently Deployed N=314	p-value alone / when CES is covariate
SRT-TP	643		199.0 (26.9)	191.0 (29.3)	185.6 (35.2)	.000 / .001
PRT-TP	643		102.8 (13.7)	102.8 (13.6)	98.4 (15.9)	.001 / n.s.
GNG-TP	624		121.3 (16.5)	119.4 (18.9)	115.0 (21.1)	.001 / n.s.
Attention Composite (zTP)	620		.60 (2.1) 33.2	.26 (2.3)	-.40 (2.7)	.000 / n.s.
SPD-TP	397		(6.1)	31.4 (7.9)	31.1 (7.2)	.039 / n.s.
CDS-TP	417		47.7 (7.7)	49.2 (10.1)	45.9 (10.1)	n.s.
CDR-TP	381		57.3 (10.0)	60.5 (11.4)	56.0 (11.5)	n.s.
STN-TP	309		67.1 (14.4)	67.6 (18.8)	70.3 (15.4)	n.s.
Memory Composite (zTP)	290		.29 (2.2)	.63 (3.0)	.22 (2.5)	n.s.

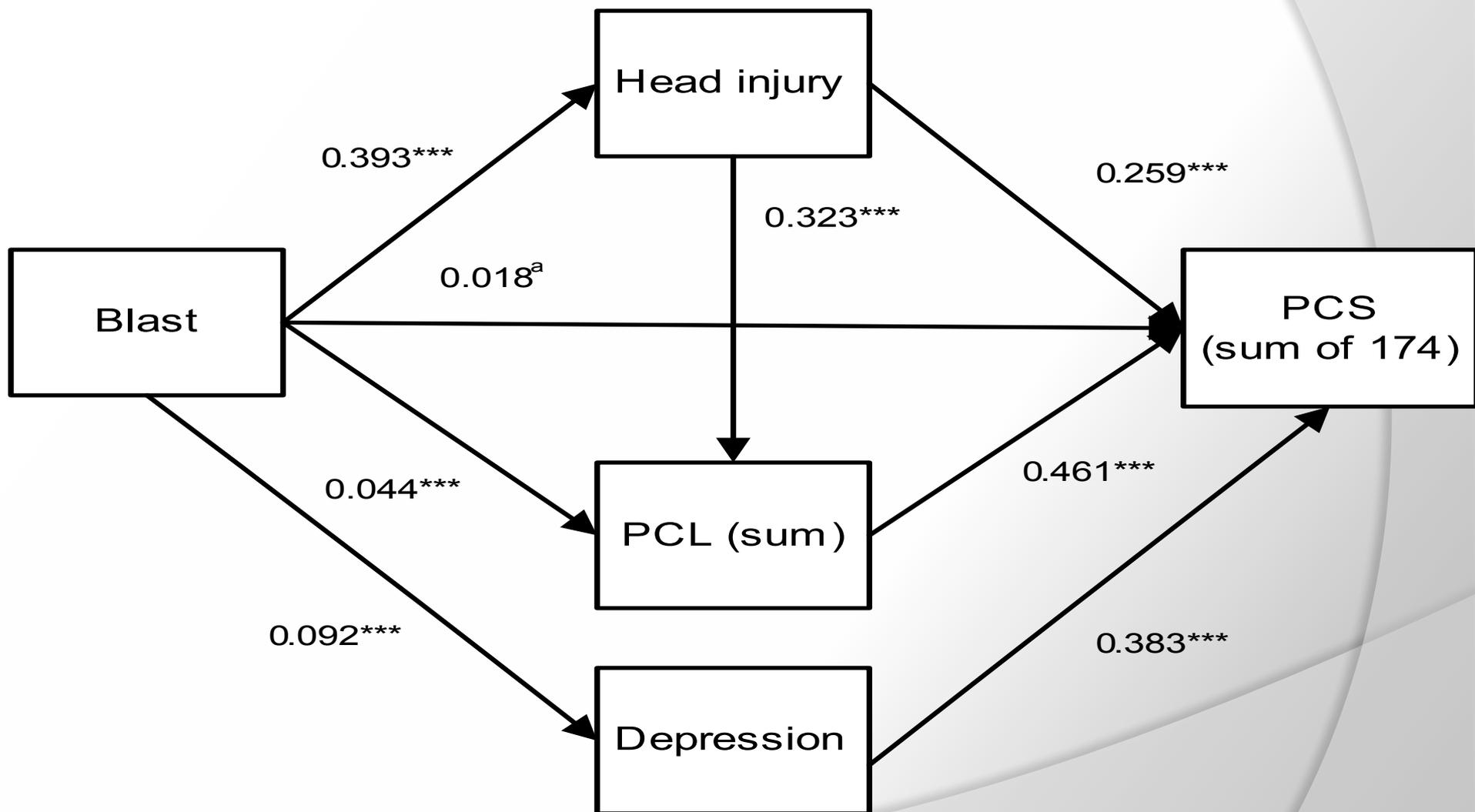
Effects of Deployment on Persistent Postconcussive Symptoms

Scale	% of total	(N)	Never Deployed N=234	Previously Deployed N=98	Recently Deployed N=314	p-value alone / when CES is covariate
DSI-Cognitive	644		.27 (.37)	.40 (.44)	.48 (.52)	.000 / .014
DSI-Sensory	644		.12 (.25)	.23 (.33)	.18 (.41)	.007 / n.s.
DSI-Somatic	644		.29 (.30)	.44 (.34)	.45 (.38)	.000 / n.s.
DSI-Vestibular	644		.12 (.28)	.24 (.35)	.21 (.39)	.005 / n.s.
DSI-TOTAL	617		.28 (.31)	.42 (.36)	.46 (.42)	.000 / n.s.

Relationship of PTSD to mTBI

- Military Health Behavior Survey in 29,000 AD Service Members
- Psychophysiological Assessment in Treatment in 39 AD Sailors/Marines with PTSD
- Neurobehavioral Assessment of 645 2MEF Marines

Predictors of PPCS: 4000 OEF/OIF blast exposed during recent deployment; 1400 endorsed concussion



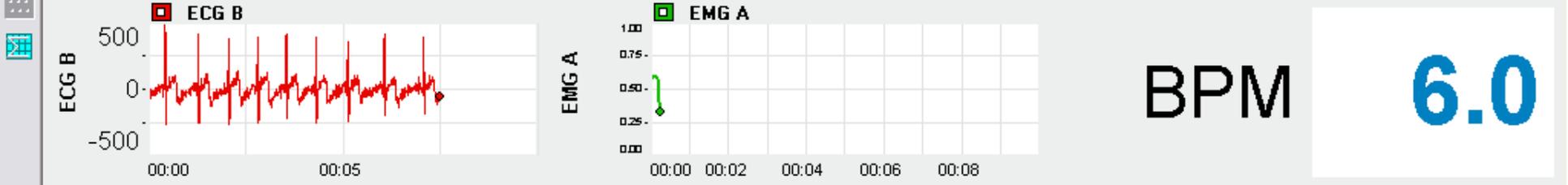
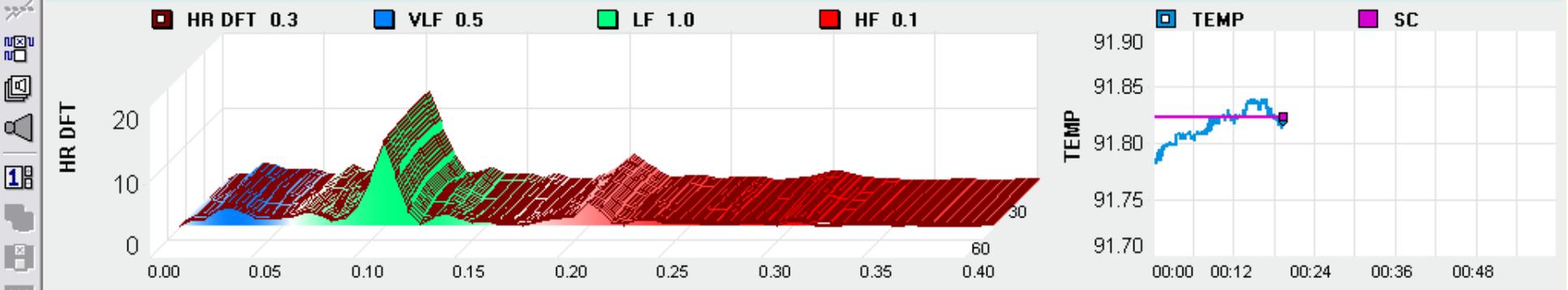
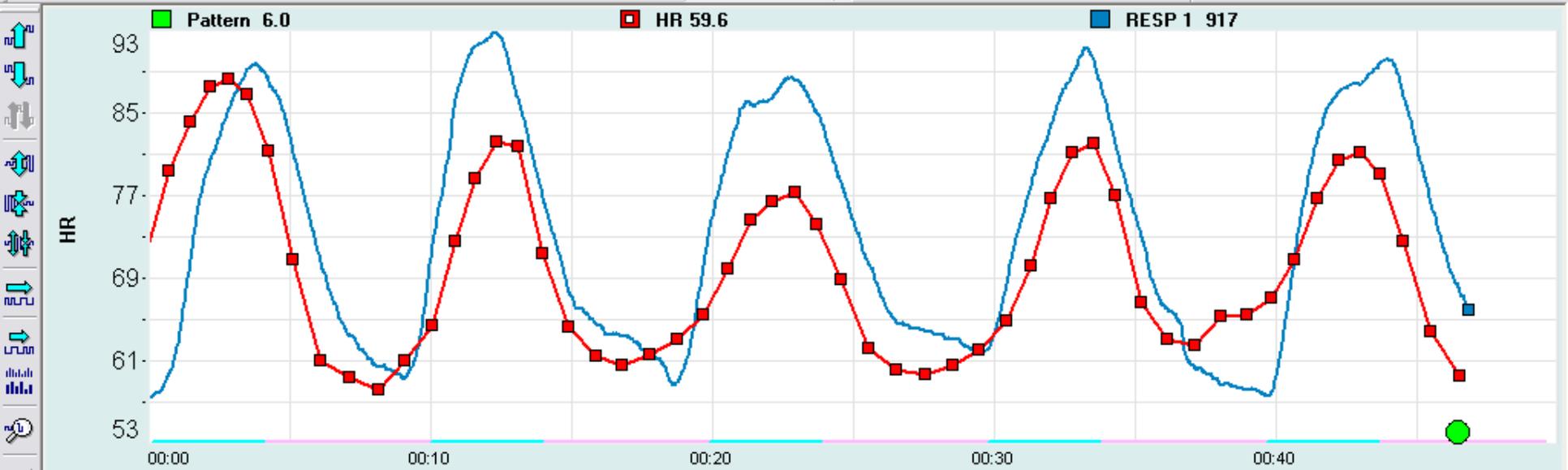
HeadInj: indicator of any head-related injury; Dep: binary indicator of possible depression
Gender, Age, Service, Race/Ethnicity and Paygrade were included as controls.

Psychophysiology of Polytrauma

- ◉ 39 Sailors/Marines with PTSD
- ◉ 19 reported concussion
- ◉ Baseline assessment
- ◉ Follow-up after PTSD Treatment
 - Stress Inoculation Training
 - Meditation enhanced exposure therapy

Study Design

- Three conditions were assessed at Study Baseline and Follow-up:
 - 5” **Rest** (sit quietly as we make sure the equipment is working)
 - 5” **Stress Recall** (what are the most troubling thoughts and feelings you have associated with your combat experience?)
 - 5” **Recuperation** (put those thoughts out of your mind and rest as comfortably as you can)



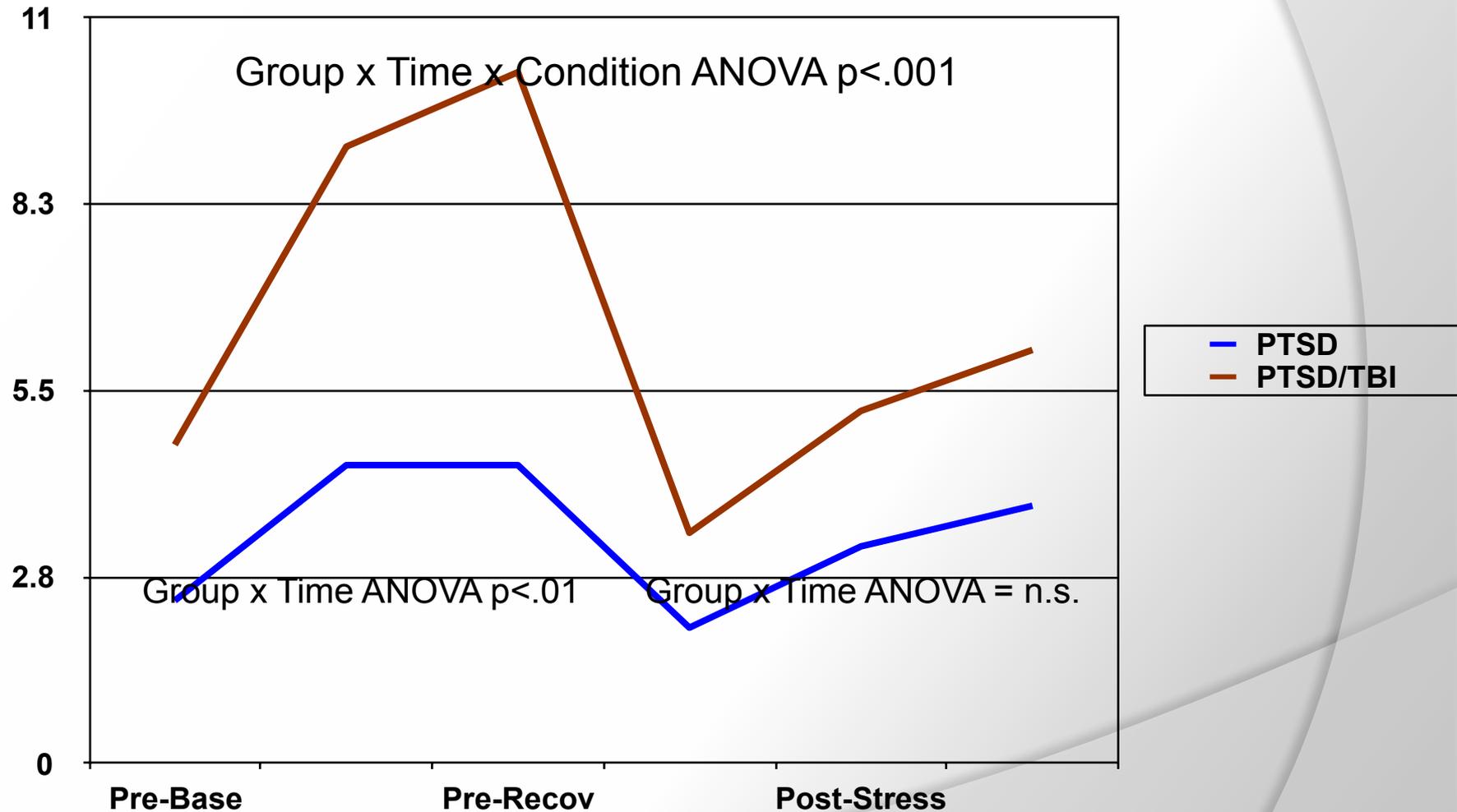
BPM 6.0

Analyzed by PTSD Separated *with or without* Prior Concussion

- PCL-m Scores were not significantly different for those with or without concussion
- Regression analysis revealed that *prior to treatment*:
 - the more effects of blast (exposure, dazed and confused, memory loss) ($p < .01$)
 - the greater the autonomic dysregulation (SC and HRV)
 - the less likely to be able to recover, compared to those with no blast exposure
- Exposure treatment with arousal control eliminated these differences

SC Reactivity per condition for

PTSD vs PTSD/mTBI patients Pre vs Post Tx



Neurobehavioral Assessment of 646 US Marines

DANA: Defense Automated Neurobehavioral Assessment

- DOD (BUMED/USAMRMC) supported the development of a tool that would provide specialty information to generalist providers to aid in their clinical decision making.
- Develop a portable (field-deployable) device
 - that is user-friendly
 - self-contained for assessment and reporting
 - includes standard and brief self-report measures
- Used the tool to explore the effect of deployment, concussion, PTSD/Depression and other factors on neuropsychological functioning

Collaborators:

- ◉ **Joseph Bleiberg, PhD, ABPP-CNP**
 - DOD National Intrepid Center of Excellence - NICOE
- ◉ **CDR Jack Tsao, MD, PhD**
 - DOD US Navy Bureau of Medicine and Surgery
- ◉ **Cori Lathan, PhD**
 - Anthrotronix Incorporated: Lindsay Long, Charlotte Safos, James Drane, Jonathan Farris, Jack Vice
- ◉ Advisory Board: stakeholders from Navy, Army, USAF, DVBIC, USUHS, VA, Corpsman, University and AD neuropsychologist researchers
- ◉ Research and Administrative Support
- ◉ **Funding through CDMRP, BUMED, USAMRMC, VA**

Platform

- Android OS
- Java Implementation
- Stylus or Touch Screen
- Current Device - NOMAD
- Final Device - TBD



Batteries:

DANA Rapid

- within 24 hours following concussion
- to support corpsman's/medic's disposition

DANA Brief

- f/u to concussion assessment (after 24 hours)
- when the Medic suspects impairment from any cause (concussion, emotional trauma, fatigue)

•DANA Standard

- for use by MO, BH, or allied healthcare professional to support diagnosis and disposition
- to assist in report writing and EMR

Output Screens

– Tailored for use by a range of provider types

Neuropsychologist
Neurologist

Medic

MO/BH

DANA Rapid (NO S)

Administered: 07/07/2011 at 19:20
by Examiner
Given to: John Doe

Overall Results

Details

Normative Results For Cognitive Tests

Test	Percentile
Reaction Time	
Procedural Reaction Time	
Go No Go	

Report Sections	
Test	Results
CES Survey	Functioning: Normal range. Overall Score: 0 Combat Exposure (CES) Light
PHQ Survey	Functioning: Normal range. Overall Score: 0
PSQI Survey	Functioning: Normal range. Overall Score: 0
PCLM Survey	Functioning: Abnormal range. Overall Score: 57 Score: 4 - Re-Experiencing Score: 22 - Avoidance Score: 20 - Hyper-Arousal

Report Sections			
<h3>Trial Sequence</h3>			
<h3>Key</h3>			
	Correct Trial		Incorrect Trial
	Lapsed Trial		Fast Trial
	Normalized Reaction Time		Skipped Trial
<h3>Details</h3>			
Trial	Response	Response Time	Inter-Trial Interval

DANA Standard

- ◉ *For follow-up from RAPID/BRIEF to support determination of cause and disposition (return to duty, continue to treat, triage to higher level of care)*

- ◉ 1. Simple Reaction Time
- ◉ **2. VLT Learning/Matching to Sample**
- ◉ 3. Code Sub
- ◉ **4. VLT Recall 1** (unless M2S was given above)
- ◉ 5. Procedural Reaction Time
- ◉ 6. Spatial Processing
- ◉ 7. Code Sub Recall
- ◉ **8. Choice Reaction (Go/No-Go)**
- ◉ **9. Sternberg Memory Search (letter set)**
- ◉ **10. VLT Recall II** (if not M2S above)
- ◉ 11. Simple Reaction Time
- ◉ **12. CES**
- ◉ 13. PHQ9
- ◉ **14. PSQI**
- ◉ **15. PCLM**
- ◉ **16. DSI – Neurobehavioral Symptom Inventory
plus Anger, Pain, Distress**

SIMPLE REACTION TIME (SRT)



PROCEDURAL REACTION TIME (PRT)



GO/NO-GO (GNG)

A figure will appear in a window of the building below.

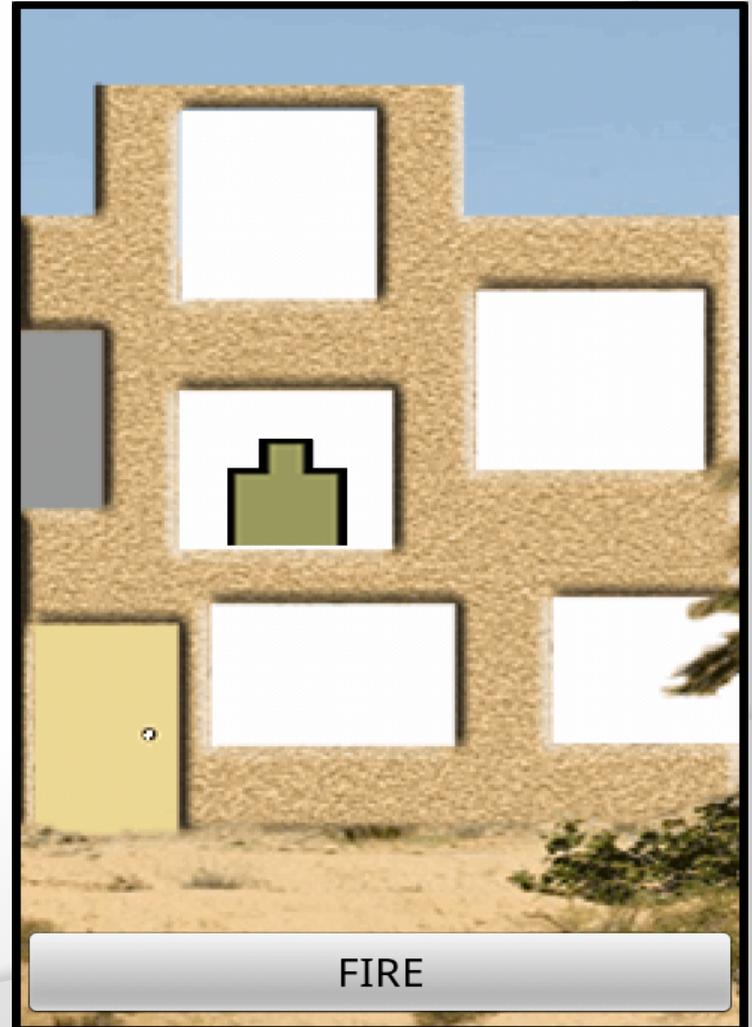


Foe Friend

Tap FIRE if the figure is a foe.
Do nothing if the figure is a friend.

Press FIRE to start.

FIRE



FIRE

CODE SUBSTITUTION

LEARNING (CLL)

DELAYED (CDD)

A screenshot of a mobile keypad interface for Learning (CLL) mode. The keypad is black with yellow text and symbols. It features a top row of function keys: a left arrow, a vertical bar with a cross, a square with a circle, the Greek letter delta, the Greek letter Omega, a double-headed vertical arrow, a horizontal line with three bars, the Yen symbol, and the Euro symbol. Below this is a row of numbers 1 through 9. In the center, the Yen symbol and the number 8 are highlighted with a yellow border. At the bottom, there are two buttons labeled 'Yes' and 'No'.

A screenshot of a mobile keypad interface for Delayed (CDD) mode. The keypad is black with yellow text and symbols. It features a single vertical column of two keys: a square with a circle and the number 2. At the bottom, there are two buttons labeled 'Yes' and 'No'.

MEMORY SEARCH (MS)

Memorize the list of letters below.

Z D T R W

When the section begins, single letters from the list will be shown.

Tap Yes if the letter shown was in the list.

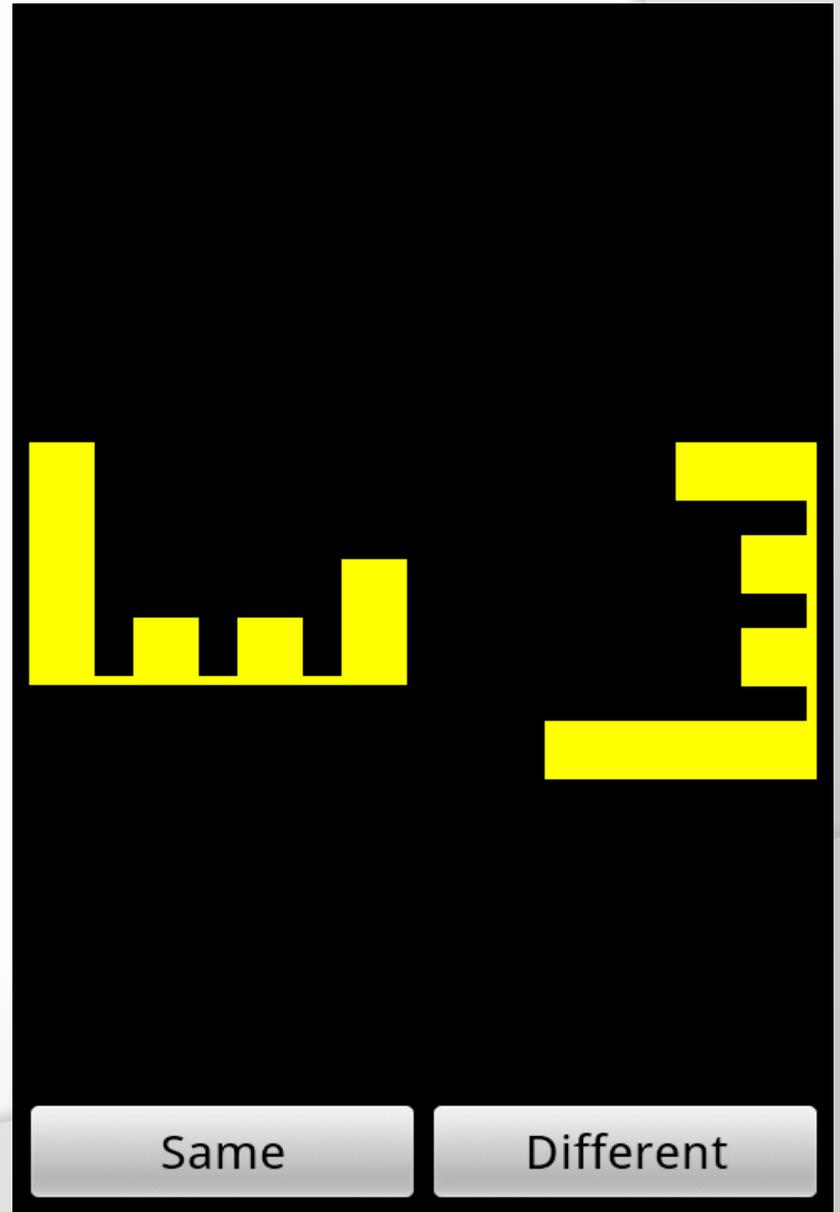
Tap No if the letter shown was not in the list.

Press a button to start.

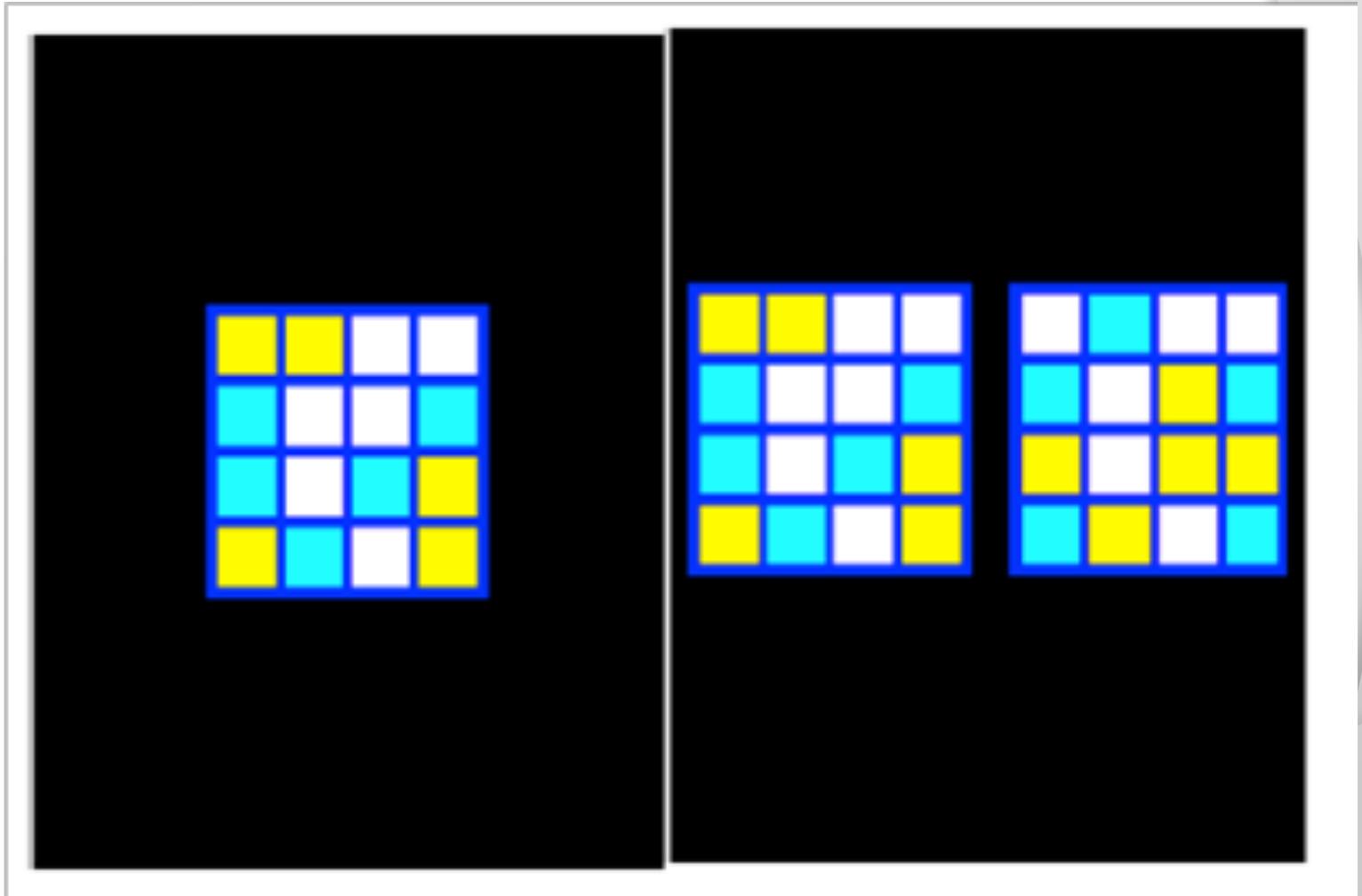
Yes

No

SPATIAL ROTATION (SPRT)



Matching to Sample (M2S)



RESPONSE VALIDITY:

- Trial responses considered too fast or too slow are noted, but eliminated from primary analysis.
- Administrations < 66% correct responses are invalid

Executive Function and Delayed Memory

- with test of effort

- VERBAL LEARNING TEST
 - Semantic word recognition memory
 - Easy/difficult trials
- MATCHING TO SAMPLE MEMORY TEST
 - visual strategy short-term memory
 - Easy/difficult trials

Psychological Screening Instruments

- ISI (Insomnia Screening Index)
- PC-PTSD (4 item screener)

Psychological Clinical Measures:

- PCL-m (PTSD)
- PHQ-8/9 (depression)
- PSQI (insomnia).
- Deployment Stress Inventory (DSI)
(NBSI + anger/pain/distress)

Combat Exposure Scale (CES)

MACE (assessment of concussion exam)

Veteran Version:

- Sheehan Disability
- Brief IFP

In the past month, how much have you been bothered by

Repeated, disturbing memories, thoughts, or images of a stressful military experience?

- Not at all
- A little bit
- Moderately
- Quite a bit
- Extremely

Phase 1: Feasibility and Reliability

- ◉ **DANA Batteries administered in 5 extreme training settings for durability and technical validation (n=240, >40/site)**
 - Arctic (Greenland, winter)
 - Desert (29 Palms, summer: MDWTC)
 - Mountainous (Bridgeport: MMWTC/Peru)
 - Jungle (Okinawa Humid Summer: MJWTC)
 - Shipboard (Yokosuka, heavy seas)

Phase II Data

Determining Validity in a Cross-sectional sample of US Marines (N=646, 2MEF)

- **Deployment:**
 - Never; Prior (>1yr); Recent (<3mo)
- **Concussions (self-report):**
 - Recency (<6 mo); Lifetime number
- **Psychological Factors (self-report measures of):**
 - PTSD; Depression; Insomnia; PsychoPhysical Sx
 - CES
- **Cognitive Measures**
 - DANA Standard (435); DANA Rapid (646)

Effects of emotional and somatic distress on cognitive functioning

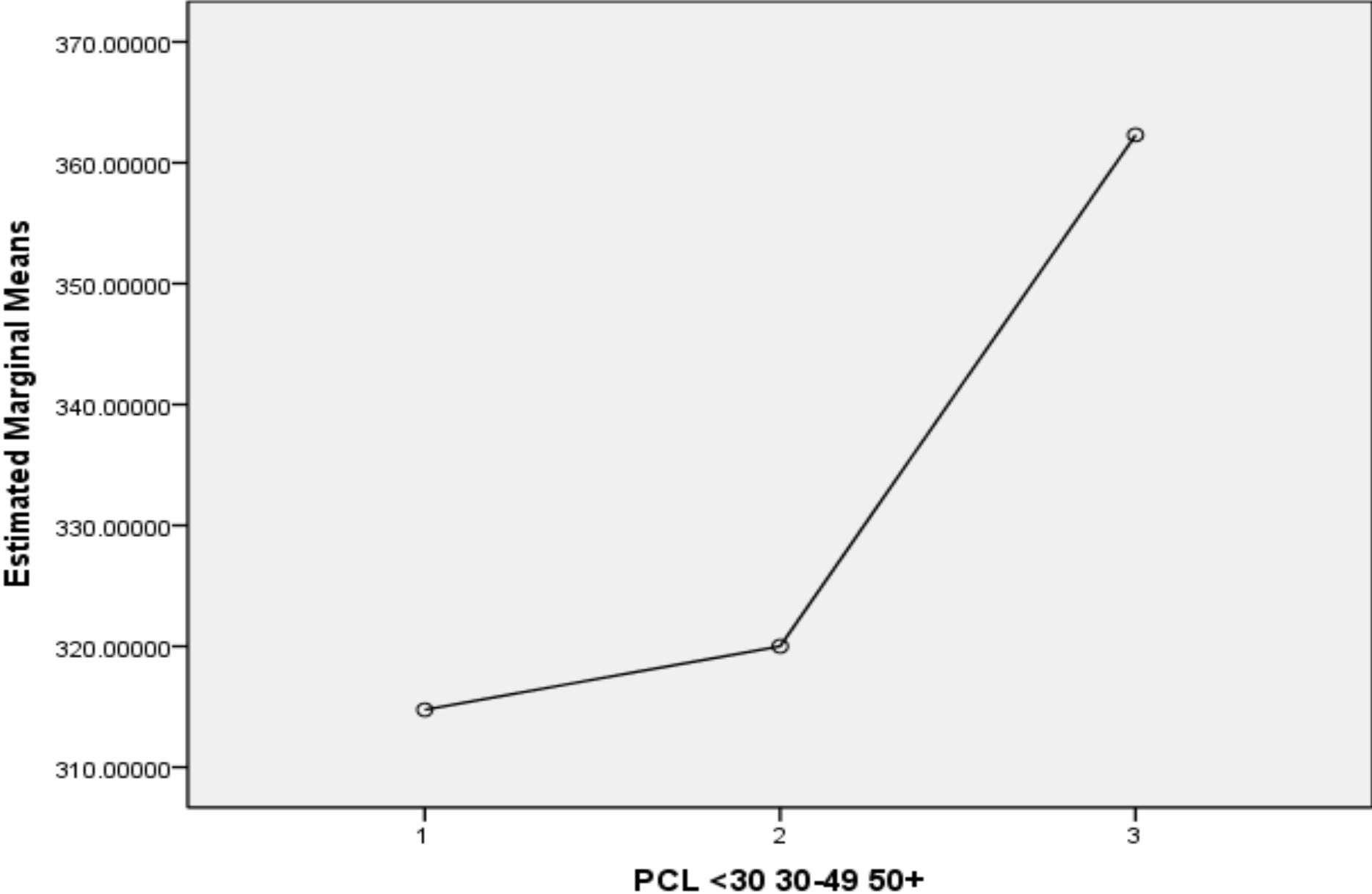
PTSD Cut-off Score

Group Statistics

	PCL-0- SCORE	N	Mean	Std. Deviation	Sig
SRT_AVG_MEDIAN_CORR _RT	>= 50	40	378.42	107.29	p<.000
	< 50	317	325.45	47.41	
MS_AVG_THRUPUT	>= 50	29	67.11	15.87	n.s
	< 50	252	68.17	16.18	
CSL_AVG_THRUPUT	>= 50	38	43.81	8.44	p<.024
	< 50	317	47.20	8.76	
GNG_AVG_THRUPUT	>= 50	39	106.92	24.38	p<.004
	< 50	314	115.36	18.27	
CSR_AVG_THRUPUT	>= 50	37	50.84	10.39	p<.009
	< 50	303	55.22	10.09	
SPRT_AVG_THRUPUT	>= 50	40	30.37	7.06	p<.001
	< 50	316	34.30	6.78	

With PTSD, speed is impaired

Estimated Marginal Means of SRT_AVG_MEDIAN_CORR_RT



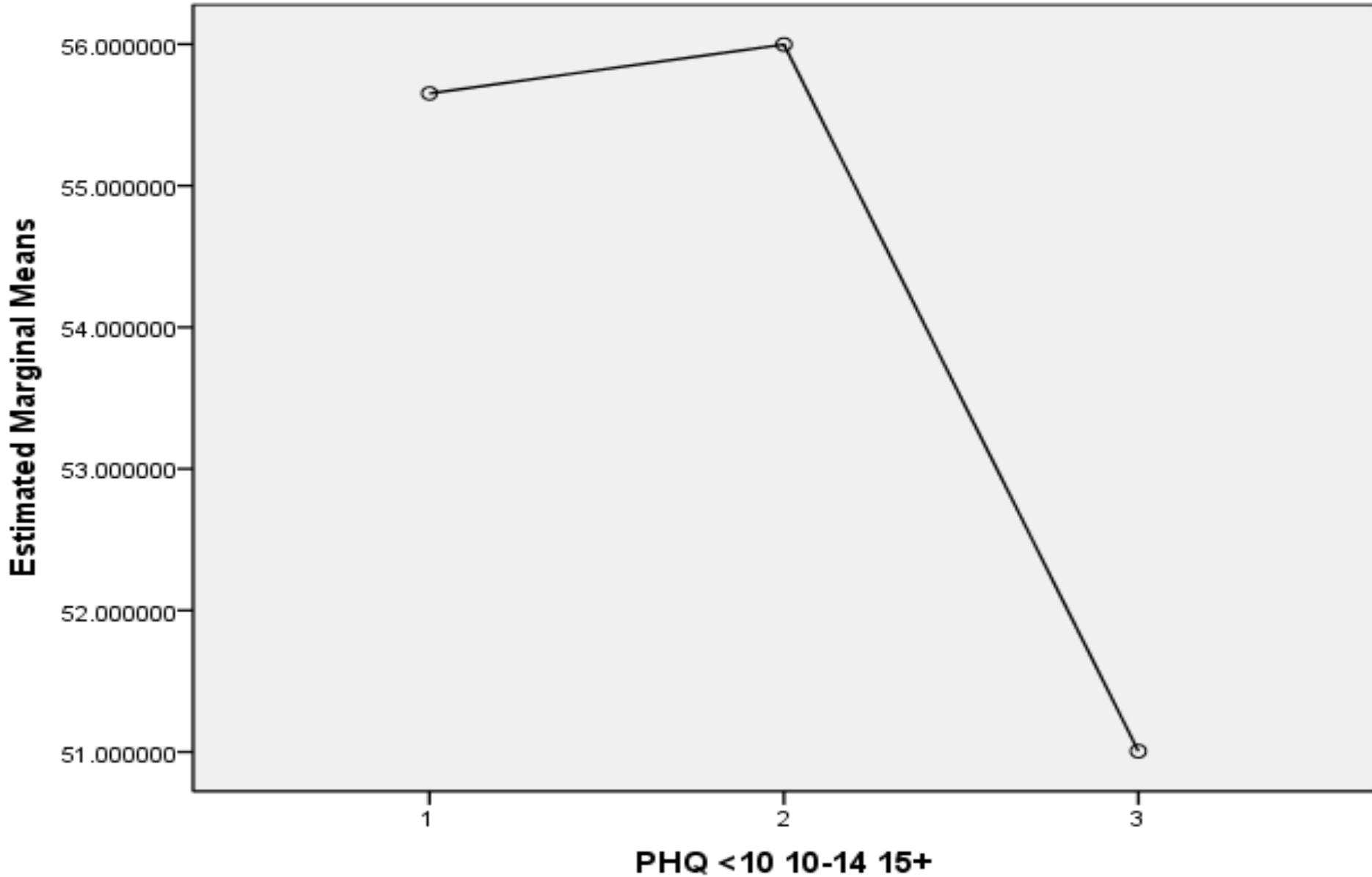
Moderate Depression Cut-off Score

Group Statistics

	PHQ-0- SCORE	N	Mean	Std. Deviation	Sig. p<
SRT_AVG_MEDIAN_C ORR_RT	>= 15	26	359.27	77.73	.013
	< 15	333	329.26	57.28	
MS_AVG_THRUPUT	>= 15	18	67.77	15.08	n.s.
	< 15	263	68.08	16.22	
CSL_AVG_THRUPUT	>= 15	25	41.13	9.11	.001
	< 15	332	47.23	8.60	
GNG_AVG_THRUPUT	>= 15	24	102.17	23.95	.001
	< 15	331	115.22	18.62	
CSR_AVG_THRUPUT	>= 15	22	50.58	8.59	.047
	< 15	320	55.05	10.23	
SPRT_AVG_THRUPUT	>= 15	26	29.35	6.46	.001
	< 15	332	34.18	6.83	

With depression, visual scanning and memory is impaired

Estimated Marginal Means of CSR_AVG_THRUPUT



Moderate DSI Cut-off Score (range: 0-56)
(Somatic Symptoms: associated with PPCSx)

Group Statistics

	DSI-0- SCORE	N	Mean	Std. Deviation	Sig p<
SRT_AVG_MEDI	>= 30	29	390.25	123.08	.000
AN_CORR_RT	< 30	328	326.18	47.10	
MS_AVG_THRUP	>= 30	20	66.59	14.61	ns
UT	< 30	261	68.17	16.26	
CSL_AVG_THRU	>= 30	27	42.95	8.34	.017
PUT	< 30	328	47.15	8.75	
GNG_AVG_THR	>= 30	28	102.58	26.71	.001
UPUT	< 30	325	115.45	18.09	
CSR_AVG_THRU	>= 30	26	49.95	11.33	.012
PUT	< 30	314	55.14	10.02	
SPRT_AVG_THR	>= 30	29	30.49	7.21	.006
UPUT	< 30	327	34.15	6.82	

The Effects of Comorbid Conditions on Cognitive Functioning

PCL>50; PHQ>15; PSQI>12; DSI>30

SRT_AVG_MEDIAN_CORR_RT

COMORBID		Mean	Std Dev	N
0	SRT_AVG_MEDIAN_CORR_RT316	59.8	558	
1	SRT_AVG_MEDIAN_CORR_RT328	60.6	51	
2	SRT_AVG_MEDIAN_CORR_RT352	62.4	12	
3	SRT_AVG_MEDIAN_CORR_RT347	89.0	14	
4	SRT_AVG_MEDIAN_CORR_RT438	162.1	9	

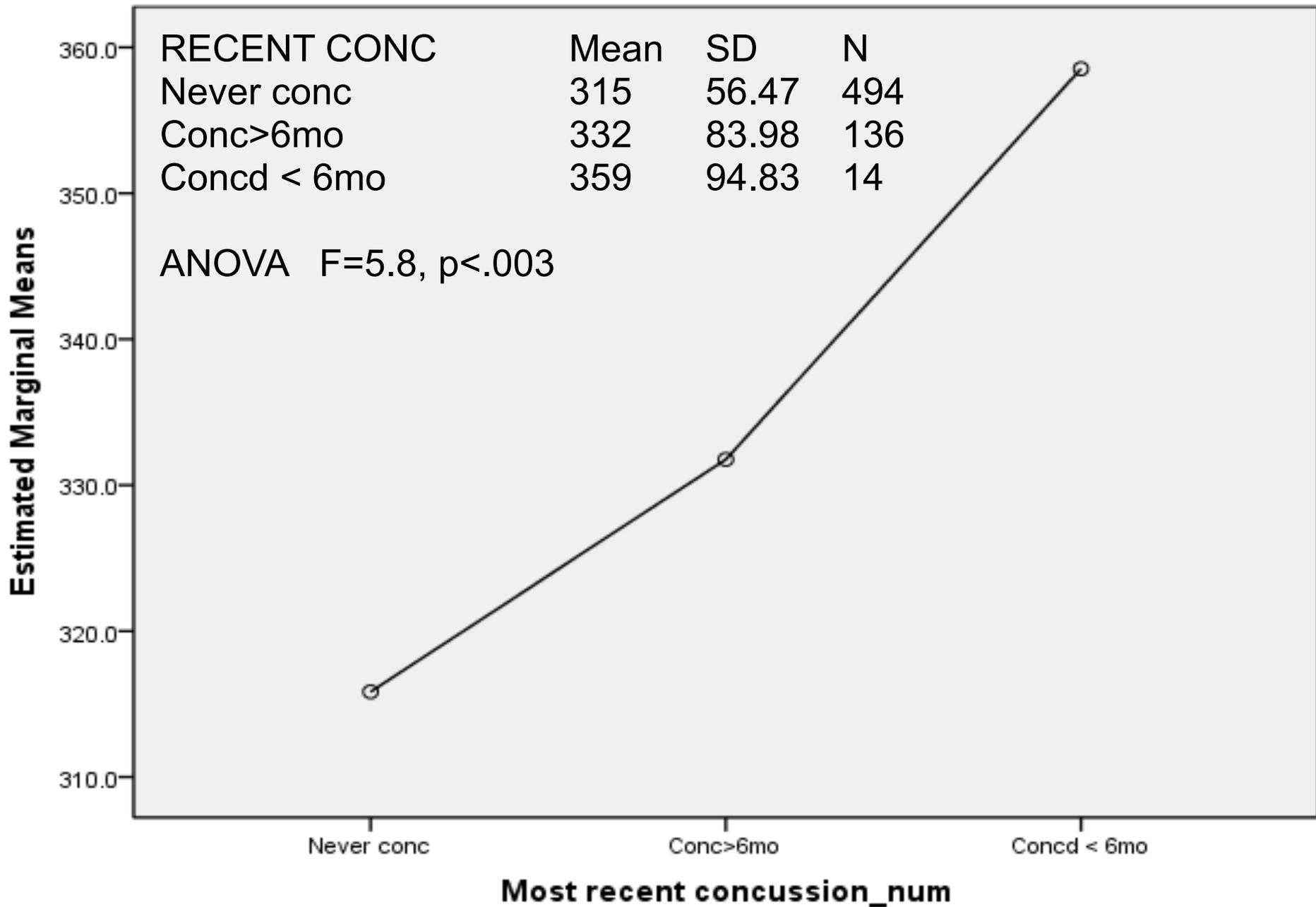
ANOVA: F=10.2, p<.000

The effects of concussion on emotional distress,
cognitive functioning, and postconcussive Sx

Most recent concussion		DSI-SCORE	PCLm SCORE	PHQ8 SCORE	PSQI SCORE	SRT TP
Never conc	Mean	11.22	29.15	5.15	5.53	188
	SD	9.918	11.902	4.836	3.233	32
	N	224	222	224	222	228
Conc >6mo	Mean	16.47	36.23	6.44	7.67	180
	SD	12.443	15.098	5.217	4.106	42
	N	74	73	73	73	73
Conc <6mo	Mean	26.00	43.00	10.43	9.07	175
	SD	14.681	17.854	5.388	3.772	44
	N	14	14	14	14	13
ANOVA significance		17.0 p<.000	13.9 p<.000	8.6 p<.000	15.4 p<.000	2.1 p<.04

No other cognitive measures significant for recent concussion

Estimated Marginal Means of SRT_0_MedianCorrRT



Independent Effects of Concussion on Functioning

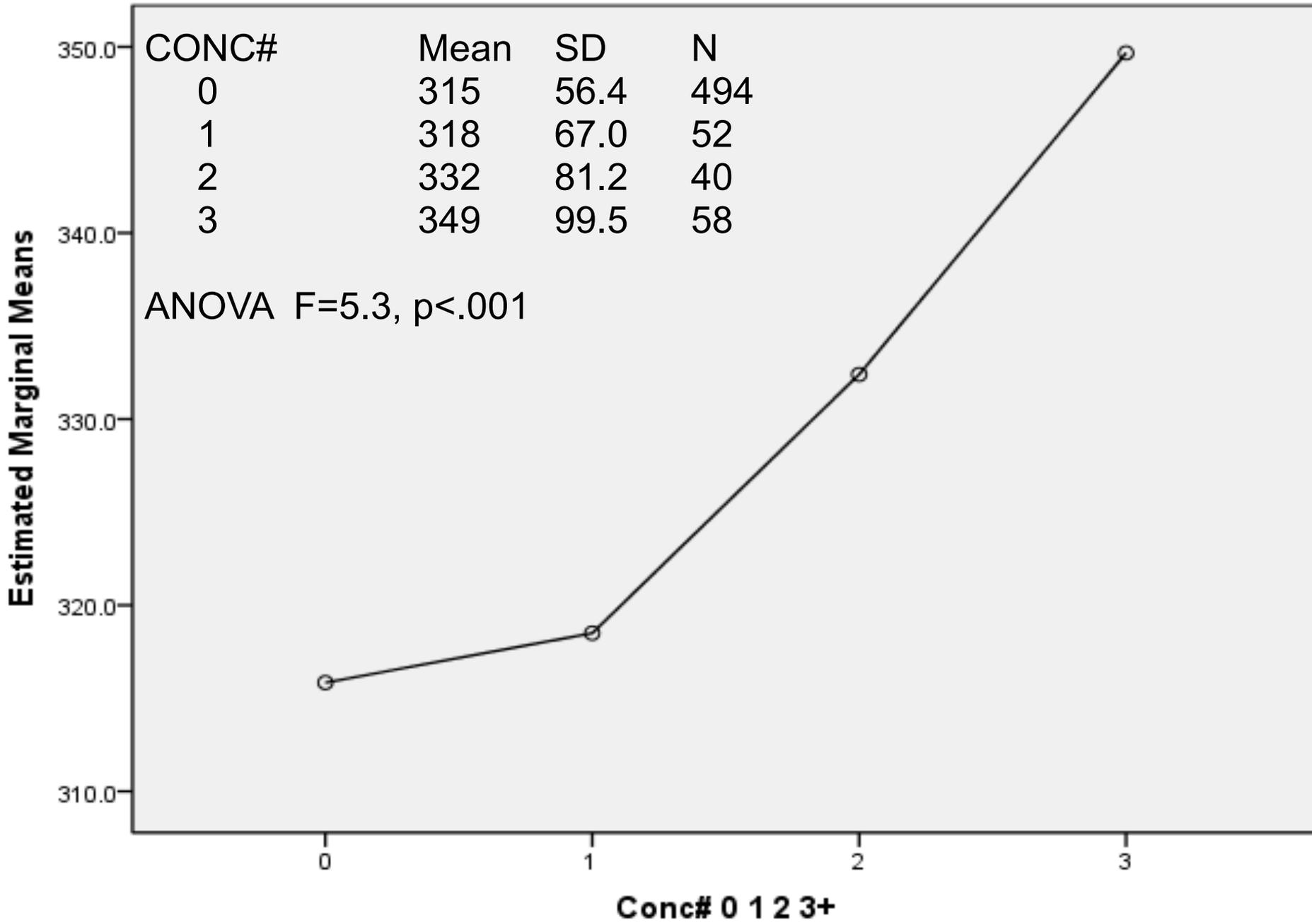
Are persistent postconcussive symptoms caused by concussion or by emotional factors alone?

- i.e. independent of Deployment, CES, PTSD, or depression

Test associated with:	N	Mean (SD)	p value	η ² p
Any prior concussion				
Time since last concussion				
#concussions (continuous)				
#concussions (3 or more)				
(with all covariates included)				
<u>PCL-m</u>				
Any Past Concussion:	N 300	27.7 (11.8)		
	Y 117	34.2 (15.4)	.000	(m)
Never Concussed	305	27.5 (11.7)		
>6 months	98	33.6 (14.8)		
<6months	15	42.1 (17.6)	.000	(m)
#0	305	27.5 (11.7)		
1	36	32.2 (13.4)		
2	33	31.2 (14.6)		
3+	43	39.4 (16.9)	.000	(m)
0-1 vs 3+ on PCL-m > 50	387		.000	OR=2.48

Effects of Postconcussive Sx on Cognitive Functioning

Estimated Marginal Means of SRT_0_MedianCorrRT



Lifetime Concussion is related to slower RT:

- Treating Concussion (0-1 v 3+) and SRT (<1SD normal) as nominal variables produces stronger positive effects, **independent of PCL and PHQ.**

- Continuous scores

Parameter Estimates

Multinomial Logistic Regression

Z SRT Mean TP <-1 ^a		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp (B)	
								Lower Bound	Upper Bound
1.00	Intercept	1.791	.600	8.904	1	.003			
	PCL_ScoreCode	-.448	.276	2.640	1	.104	.639	.372	1.097
	PHQ0_ScoreCode	-.197	.301	.427	1	.514	.821	.455	1.483
	[Conc_Count_01_v_3plus=1]	.859	.412	4.356	1	.037	2.361	1.054	5.289
	[Conc_Count_01_v_3plus=3]	0 ^b	.	.	0

a. The reference category is: .00.

b. This parameter is set to zero because it is redundant.

Lifetime Concussion is related to slower RT:

- Treating Concussion (0-1 v 3+) and SRT (<1SD normal) as nominal variables produces stronger positive effects, independent of PCL and PHQ.

- Cut-off scores

Parameter Estimates

Multinomial Logistic Regression

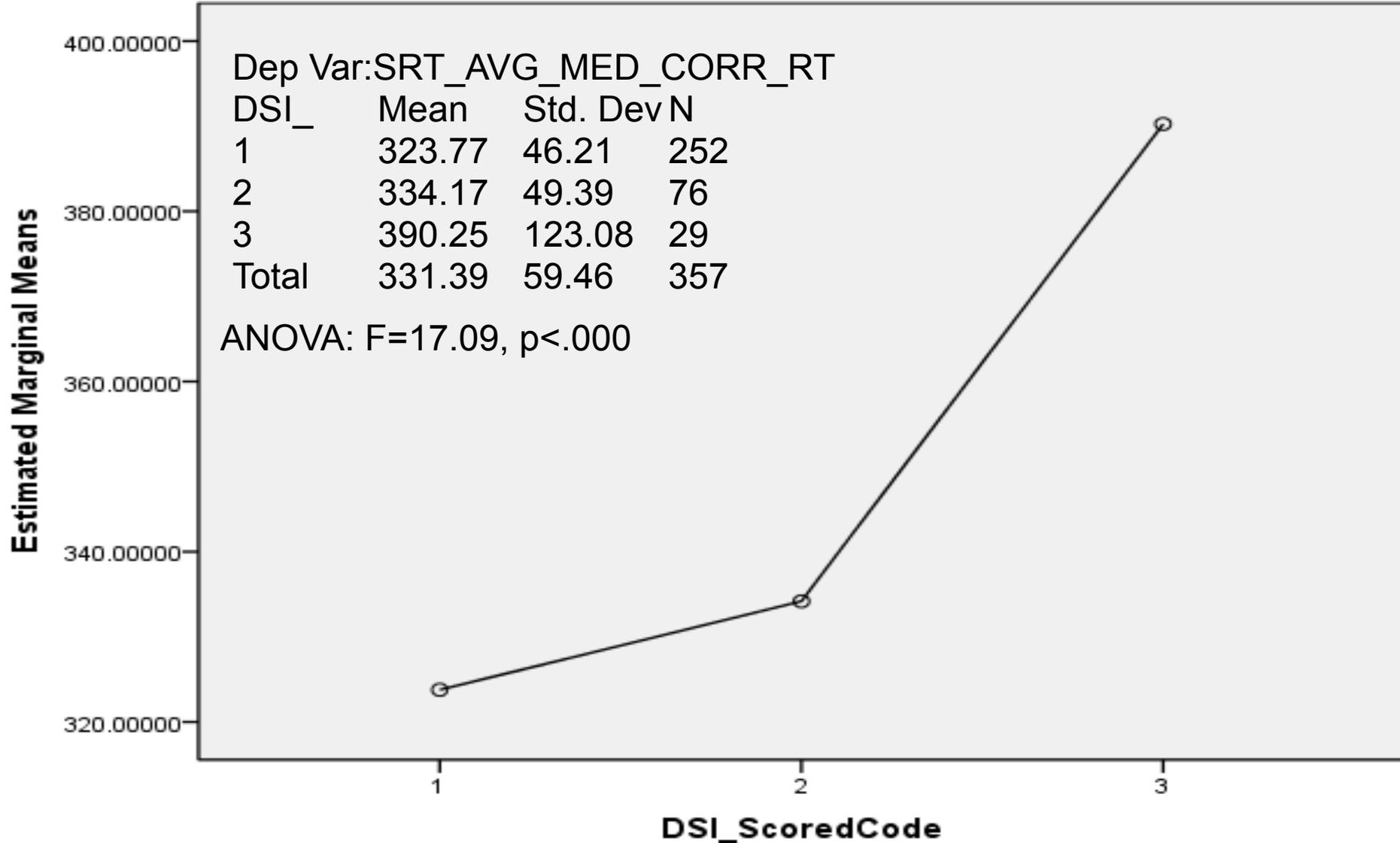
		B	Std. Error	Wald	df	Sig.	Exp(B)	95% Confidence Interval for Exp (B)	
								Lower Bound	Upper Bound
Z SRT Mean TP <-1 ^a									
1.00	Intercept	.866	.394	4.824	1	.028			
	PCL_Cutoff_50	-.323	.498	.419	1	.517	.724	.273	1.924
	PHQ_Cutoff_10plus	-.482	.388	1.543	1	.214	.617	.289	1.321
	[Conc_Count_01_v_3plus=1]	.974	.410	5.650	1	.017	2.648	1.186	5.910
	[Conc_Count_01_v_3plus=3]	0 ^b	.	.	0

a. The reference category is: .00.

b. This parameter is set to zero because it is redundant.

DSI – Complaints of Postconcussive Symptoms

Estimated Marginal Means of SRT_AVG_MEDIAN_CORR_RT



Outcomes - Concussion

- **Concussion** was associated with worse psychological scores and some cognitive scores:
 - Recent Concussion:
 - **Post-concussive Sx** ($p < .000$); **PTSD Sx** ($p < .000$), **depressive Sx** ($p < .000$), **SRT** ($p < .04$), but no other cognitive measures.
 - However, this finding was *not upheld when PTSD and Depression were included as covariates* (possibly due to the low cell size).
 - Lifetime Concussions:
 - Number of lifetime concussions associated with **worse SRT/PRT/GNG**, *independent of PTSD or Depressive symptoms*.
 - **3+ concussions had a 2.6 likelihood (OR) of SRT being >20% above the mean**, *independent of PTSD or Depressive Sx* ($p < .01$).

Summary - Concussion

- Multiple lifetime and more recent concussion is associated with:
 - worse emotional distress
 - independent of deployment or CES
 - worse postconcussive symptom reporting
 - Independent of deployment, CES, PTSD, Dep
 - worse simple cognitive functioning
 - Independent of deployment, CES, PTSD, Dep

Overall Summary

- ◉ Recent Combat Deployment was associated with emotional distress, concussions, postconcussive symptoms, and neurocognitive functioning
- ◉ BUT - these results were almost entirely due to the degree of combat exposure experienced during deployment
- ◉ above and beyond baseline levels of distress in a cohort of demographically similar marines.

Overall Summary

- ◉ Multiple lifetime concussions is associated with increased emotional distress, worse postconcussive functioning, and poorer neurocognitive performance
 - independent of Recent Deployment, Combat Exposure (CES), Depressive (PHQ-8) and Posttraumatic Stress (PCL-m) symptoms
- ◉ However, having suffered a single concussion did not increase the risk of neurocognitive functioning independent of combat exposure, PTSD or depressive symptom reporting
 - The effects of single concussion on postconcussive symptoms disappeared or only resulted in a small effect size when CES, PCL-m, and PHQ-8 were entered as covariates.

Overall Summary

- ◉ These results support earlier research that failed to show the independent effects of having had a concussion on postconcussive functioning.
- ◉ However, the current findings go beyond earlier work in that multiple lifetime concussions do appear to exert an independent influence on emotional, postconcussive, and neurocognitive performance associated with simple attention-discrimination rather than tasks dependent upon memory.

Implications for Commanders and Medical Corps / Mental Health

- If a SM has PCLm>50, PHQ>15, DSI>30, multiple concussion history or possibly recent concussion, they likely:
 - Have slower RT
 - scan the environment less rapidly and accurately
 - are less able to decide when to shoot vs not shoot
 - have worse memory for recently learned information
 - have worse spatial ability

Implications for Commanders and Medical Corps / Mental Health

- ◉ If they deny Sx, the cognitive scores could be used as an objective indication of readiness to return to duty
 - Especially when compared to their prior pre-incident scores
- ◉ Continued objective functioning could also be an indication for continued treatment and determining return to duty

Implications for Commanders and Medical Corps / Mental Health

- ◉ In the field or in the clinic:
 - Assess for number of lifetime concussions whenever you conduct an evaluation
 - Following a suspected trauma, assess for Concussion, PTSD, Depression, Anger, Insomnia

Implications for Commanders and Medical Corps / Mental Health

- ◉ Be aware that:
 - a single concussion may not be associated with lasting problems, independent of PTSD, depression, or combat exposure

Implications for Commanders and Medical Corps / Mental Health

- PTSD and depression account for many symptoms that look like postconcussive symptoms

Implications for Commanders and Medical Corps / Mental Health

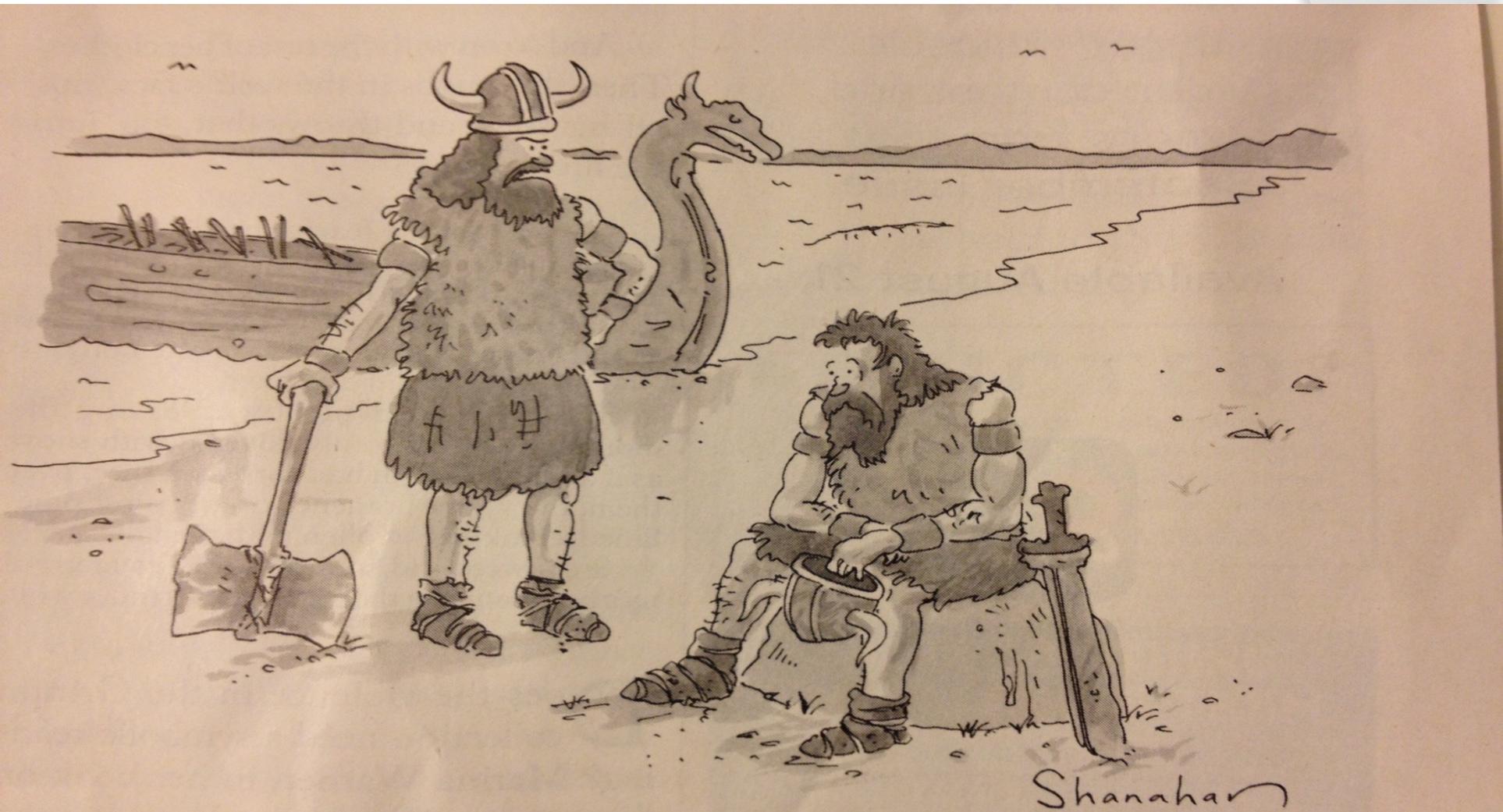
- Multiple concussion affects
 - emotional distress, persistent postconcussive symptom reporting, and neurocognitive functioning (speed and accuracy)
 - independent of PTSD or depression or CES

Implications for Commanders and Medical Corps / Mental Health

- ⦿ Treat Service Members as athletes:
 - They have to train to perform optimally and prevent injury
 - If they do become injured, they need to see the “trainer”, do “rehab”, and ease back into the game

Return to Duty Determination:

With regard to recent concussion – prevention is the best medicine



"It's a concussion, Sven—you're sitting out the next siege."

Implications for Commanders and Medical Corps / Mental Health

- In the field, regular assessments of neurocognitive functioning can indicate if there is impairment due to any cause (concussion, emotional distress, combat exhaustion)

Implications for Commanders and Medical Corps / Mental Health

- Collaborative assessments of concussion history, emotional distress and insomnia can help determine the cause for the lowered functioning

Implications for Commanders and Medical Corps / Mental Health

- Return to Duty Determination
 - Since deployment itself can impact neurocognitive functioning, it is best to assess in country rather than prior to deployment

Implications for Commanders and Medical Corps / Mental Health

- Regular neurocognitive and sleep assessments (q 1 or 3 mo) during deployment is optimal to establish a within-subject contextual baseline against which a post-trauma follow-up can be compared for significant change

Implications for Commanders and Medical Corps / Mental Health

- Treatment Considerations for Comorbidity:
 - early and regular assessments allows for earlier and more aggressive treatment
 - treating PTSD, depression, and insomnia can help reduce persistent postconcussive symptoms

Implications for Commanders and Medical Corps / Mental Health

- directly addressing persistent postconcussive symptoms may be of benefit:
 - Early and at their optimal threshold
 - Cognitive remediation: attention and effort, verbal, non-verbal, problem-solving
 - Somatic rehabilitation: exercise and attention to task at hand
 - Set expectations that they will recover

Questions?

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