Traumatic brain injury and forensic mental health/criminality

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What is TBI?

Traumatic brain injury (TBI) occurs when a sudden trauma causes damage to the brain.

TBI can result when the head suddenly and violently hits an object, either

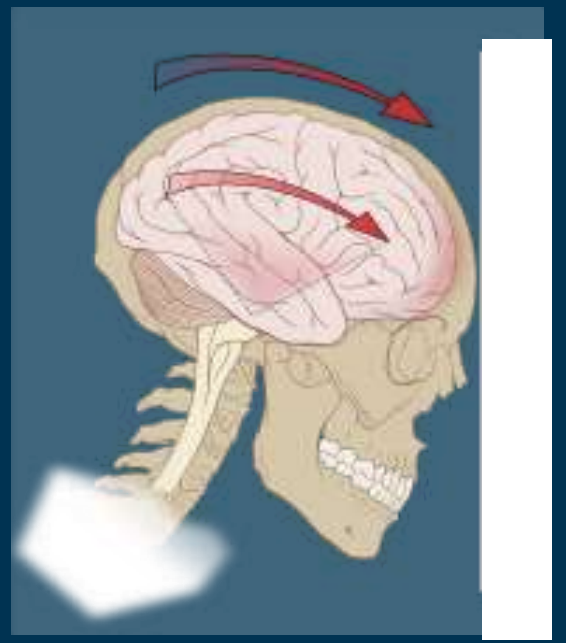
- penetrating to the brain
- causing impact between the skull and the brain.

What is TBI?

Traumatic brain injury (TBI) occurs when a sudden trauma causes damage to the brain.

TBI can also result from

- shockwaves from a blast
- rapid acceleration or deceleration, as in a motor vehicle accident



What is TBI? CDC definition

TBI is the result of an external force that is indicated by new onset or worsening of at least one of the following clinical signs, immediately following the event

- Any period of loss of or a decreased level of consciousness
- Any loss of memory for events immediately before or after the injury (posttraumatic amnesia)
- Any alteration in mental state at the time of the injury (confusion, disorientation, slowed thinking, etc.)
- Neurological deficits (weakness, loss of balance, change in vision, praxis, paresis/plegia, sensory loss, aphasia, etc.) that may or may not be transient
- Intracranial lesion

Mild TBI

A person with a **mild TBI** (mTBI) may remain conscious or may experience a loss of consciousness for a few seconds or minutes. Other symptoms of mild TBI include:

- Headache
- Confusion
- Lightheadedness
- Dizziness
- Blurred vision, tired eyes, or sensitivity to light
- Ringing in ears
- Trouble with memory, concentration, or attention
- Fatigue or lethargy
- Change in sleep pattern
- Mood or behavioral changes
- Bad taste in mouth

Moderate or Severe TBI

A person with a **moderate or severe TBI** may show symptoms of mTBI as well as:

- Worsening or persistent headache
- Nausea or vomiting
- Convulsions or seizures
- Inability to awaken from sleep
- Dilation of one or both pupils
- Slurred speech
- Weakness or numbness in the extremities
- Loss of coordination
- Increased confusion, restlessness, or agitation

Prognosis and Common Problems

Prognosis of a TBI depends on the

- severity of the injury
- location of the injury
- age and general health of the person

Problems with the following are common:

- cognition (thinking, memory, and reasoning)
- sensory processing (sight, hearing, touch, taste, and smell)
- communication (expression and understanding)
- behavior or mental health (depression, anxiety, personality changes, aggression, acting out, and social inappropriateness)

Prevalence of TBI

- At least 10 million TBIs serious enough to result in death or hospitalization occur annually (Langlois et al., 2006).
- An estimated 57 million people worldwide have been hospitalized with one or more TBIs, but the proportion living with TBI-related disability is not known (Murray et al., 1996; Langlois et al., 2006).
- In the United States, an average of 1.4 million TBIs occur each year, including 1.1 million emergency department visits, 235,000 hospitalizations, and 50,000 deaths (Finkelstein et al., 2006)
- These figures underestimate the true burden of TBI because they only include individuals treated in medical facilities.

TBI and Criminal Behavior

- As a result, TBI has been identified as a growing public health concern, not simply as an acute injury, but also for its potential long-term effects.
- One of the long-term effects of TBI involves possible increased risk of criminal and violent offenses (Williams, Chitsabesan, Fazel. McMillan, Hughes, Parsonage, & Tonks, 2018).
- Over the past two decades, TBI has been suggested to be a factor leading to antisocial behavior including violence (Filley et al., 2001; Kim, 2002; Miller, 1999a, 1999b; Schiltz, Witzel, & Bogerts, 2011) .

TBI and Criminal Behavior

- Criminal offending can lead to multiple adverse consequences including loss of social support, incarceration, and a criminal record, as well as increasing the risk to the surrounding community.
- Therefore, understanding the relationship between TBI and criminal behavior is crucial for ensuring the safety of caretakers and the community, informing appropriate practices in forensic psychiatry, legal and criminal justice, and providing effective rehabilitation to individuals with TBI.

Polling Question

What is the prevalence rate of TBI in criminal populations?

A. <10%
B. 10-30%
C. 30-50%
D. 50-70%
E. 70-90%
F. >90%

TBI and Criminal Behavior - Studies Supporting a Link

- A meta-analysis found that 60% of adult criminals had sustained at least one TBI (Shiroma, Ferguson, & Pickelsimer, 2010) and another found a prevalence rate of 51% (Farrer & Hedges, 2011).
- Multiple studies find significant relationships between head injury and offending (Fazel, Grann, Langstrom, & Licchtenstein, 2011; Luukkainen, Riala, Laukkanen, Hakko, & Räsänen, 2012; Ommaya, Salazar, Dannenberg, Chervinsky, & Schwab, 1996; Williams, Cordan, Mewse, Tonks, & Burgess, 2010; Williams, Mewse, et al., 2010).

TBI and Criminal Behavior - Not Supporting Link

- On the other hand, similar studies of criminal populations have found no significant relationship between TBI and either incarceration (Perkes, 2011) or violent offending (Colantonio, Stamenova, Abramowitz, Clarke, & Christensen, 2007; Davies, 2012).
- Contradictory results have also been produced by studies examining criminality among brain-injured populations, finding no significant relationships between injury and offending (Virkkunen, Nuutila, & Huusko, 1977).

TBI and Criminal Behavior

- Link between TBI and criminality complicated by demographic and behavioral factors that predispose individuals to both injury and arrest.
- In TBI patients, criminality has been found to be associated with:
  - Previous arrests (Brooks, Campsie, Symington, Beattie, & McKinlay, 1986)
  - Male gender (Kolakowsky-Hayner & Kreutzer, 2001; Luiselli et al., 2000)
  - Lower educational achievement (Kolakowsky-Hayner & Kreutzer, 2001)
  - Receiving psychological treatment (Kreutzer, Marwitz, & Witol, 1995)
  - TBI as the result of an assault (Dagher, Habra, Lamoureux, de Guise, & Feyz, 2010)
  - Alcohol use (Kreutzer et al., 1995)

TBI and Criminal Behavior

- Among criminal offenders, TBI has been found to be statistically related to:
- younger age (Colantonio et al., 2007)
- male gender (Colantonio et al., 2007; Perron & Howard, 2008)
- substance use (Colantonio et al., 2007; Moore, Indig, & Haysom, 2013; Perron & Howard, 2008; Schofield, 2006; Williams, Cordan, et al., 2010)
- antisocial personality disorder (Colantonio et al., 2007; Schofield, 2006)
- major depression (Moore et al., 2013; Schofield, 2006)
- earlier onset of criminal activity (Perron & Howard, 2008; Williams, Mewse, et al., 2010)

Method

- In the current study, we examined data from the Traumatic Brain Injury Model System (TBIMS) National Database (Dijkers et al., 2010) .
- The TBIMS is a multicenter, longitudinal study of TBI funded by the National Institute on Disability and Rehabilitation Research.
- All TBIMS enrollees are age 16 or older, receive medical care in a TBIMS-affiliated trauma center within 72 hours of injury, and are transferred directly from acute care to an affiliated inpatient TBI rehabilitation program.
- TBIMS is representative of documented cases of TBI in the United States but may not reflect the mild TBIs that are undocumented and may not receive medical attention (Corrigan, 2012).

Method

- After obtaining institutional review board (IRB) approval to conduct secondary data analysis of the TBIMS, we followed procedures to obtain a database of relevant variables.
- For the current analysis, three study samples were created based on participants with complete data on all relevant measures: (a) the first year after injury, (b) the first and second years after injury, and (c) the first, second, and fifth years after injury.

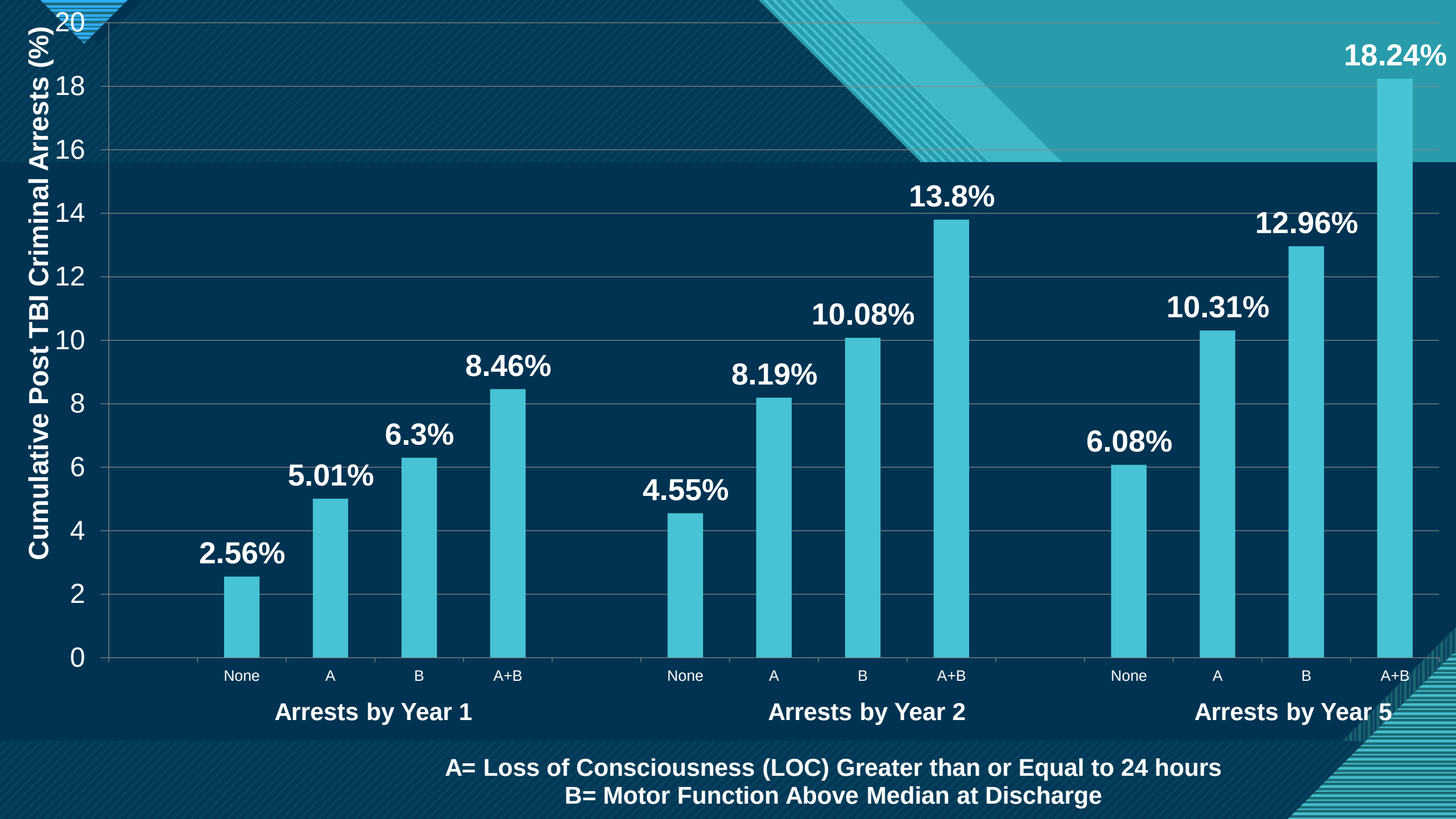
		Criminal Arrests (1 Year Post-TBI)			
		Arrested n / N	Arrested %	Chi-Square	p
Male	Yes	315 / 4553	6.92	45.02	<.0001
	No	45 / 1762	2.55		
Married	Yes	58 / 2195	2.64	58.54	<.0001
	No	302 / 4120	7.33		
Young Age	< 25 yrs	162 / 1805	8.98	50.41	<.0001
	≥ 25 yrs	198 / 4510	4.39		
White	Yes	247 / 4489	5.50	1.14	0.2864
	No	113 / 1826	6.19		
High School Education	Yes	223 / 4742	4.70	35.28	<.0001
	No	137 / 1573	8.71		

		Criminal Arrests (1 Year Post-TBI)			
		Arrested n / N	Arrested %	Chi-Square	p
Pre-TBI Felony	Yes	78 / 554	14.08	79.31	<.0001
	No	282 / 5761	4.89		
Pre-TBI Drugs	Yes	162 / 1238	13.09	156.22	<.0001
	No	198 / 5077	3.90		
Pre-TBI Alcoholic	Yes	106 / 1050	10.10	45.24	<.0001
	No	254 / 5265	4.82		
Pre-TBI SpEd	Yes	46 / 468	9.83	16.03	0.0001
	No	314 / 5847	5.37		
Pre-TBI Work	Yes	243 / 4478	5.43	2.15	0.1423
	No	117 / 1837	6.37		

		Criminal Arrests (1 Year Post-TBI)			
		Arrested n / N	Arrested %	Chi-Square	p
Frontal	Yes	181 / 3287	5.51	0.48	0.4881
	No	179 / 3028	5.91		
Temporal	Yes	132 / 2398	5.50	0.28	0.5989
	No	228 / 3917	5.82		
Parietal	Yes	73 / 1157	6.31	0.98	0.3231
	No	287 / 5158	5.56		
Occipital	Yes	19 / 406	4.68	0.84	0.3590
	No	341 / 5909	5.77		

		Criminal Arrests (1 Year Post-TBI)			
		Arrested n / N	Arrested %	Chi-Square	p
Fragments	Yes	27 / 413	6.54	0.58	0.4480
	No	333 / 5902	5.64		
Violent Cause of TBI	Yes	60 / 618	9.71	20.47	<.0001
	No	300 / 5697	5.27		
LOC ≥ 24 hrs	Yes	279 / 4444	6.28	9.30	0.0023
	No	81 / 1871	4.33		
Motor Function	Below Median	129 / 3130	4.12	28.79	<.0001
	Above Median	231 / 3185	7.25		

Multivariable Analysis	Criminal Arrests (1 Year Post-TBI)		
	OR	CI	p
Demographic Data			
Male	2.37	1.71-3.30	<.0001
Married	.60	.43-.82	.0015
Young	1.64	1.27-2.11	0.0001
High School Education	.69	.54-.87	.0020
Pre-TBI Felony	1.94	1.44-2.62	<.0001
Pre-TBI Drugs	2.13	1.67-2.72	<.0001
Pre-TBI Alcoholic	1.55	1.20-2.00	.0009
Pre-TBI Work	.73	.57-.94	.0136
Motor<median + LOC ≥ 24 hours	1.73	1.02-2.94	.0434
Motor>median + LOC < 24 hours	2.32	1.33-4.05	.0032
Motor>median + LOC ≥ 24 hours	2.80	1.65-4.73	0.0001


Cumulative Post TBI Criminal Arrests (%)
20
18
16
14
12
10
8
6
4
2
0
2.56%
5.01%
6.3%
8.46%
4.55%
8.19%
10.08%
13.8%
6.08%
10.31%
12.96%
18.24%
None
A
B
A+B
Arrests by Year 1
Arrests by Year 2
Arrests by Year 5
A= Loss of Consciousness (LOC) Greater than or Equal to 24 hours
B= Motor Function Above Median at Discharge

Discussion

- Demographic variables (young, single, less educated, male) were related to criminal arrest after a TBI, just as in the general population. This finding is consistent with other research (Colantonio et al., 2007; Kolakowsky-Hayner & Kreutzer, 2001; Perron & Howard, 2008)
- Regardless of type of TBI, basic demographics should be included in gauging risk of criminal or antisocial behavior in the context of forensic assessment and rehabilitation efforts.

Discussion

- As opposed to global functional impairment, retention of specific brain functions such as motor function needs to be considered in understanding this link.
- Loss of consciousness in the absence of motor impairment appeared related to increased risk of criminal arrest, showing that TBI can affect an individual's behavior and subsequent risk of criminal justice involvement.

Discussion

- The data also indicate that premorbid variables, including history of criminal offending, had robust associations with post-TBI arrests.
- Most research, with a few exceptions (Perron & Howard, 2008; Williams, Mewse, et al., 2010), has not examined premorbid criminal behavior.
- However, as this variable was highly related to post-TBI arrests, it seems an especially important variable for future studies to address.
- Such individuals may at higher risk of criminal justice involvement even before their head injuries.

Discussion

- Similarly, other premorbid variables also need to be examined, such as substance abuse.(Colantonio et al., 2007; Moore et al., 2013; Perron & Howard, 2008; Schofield, 2006; Williams, Cordan, et al., 2010)
- The rates of substance abuse in the TBIMS sample are instructive, as they were higher than in the general population (Dijkers et al., 2010)
- This suggests that individuals with premorbid correlates of antisocial behavior, such as drug and alcohol misuse, may be more likely to get into situations leading to TBIs in the first place.

Discussion

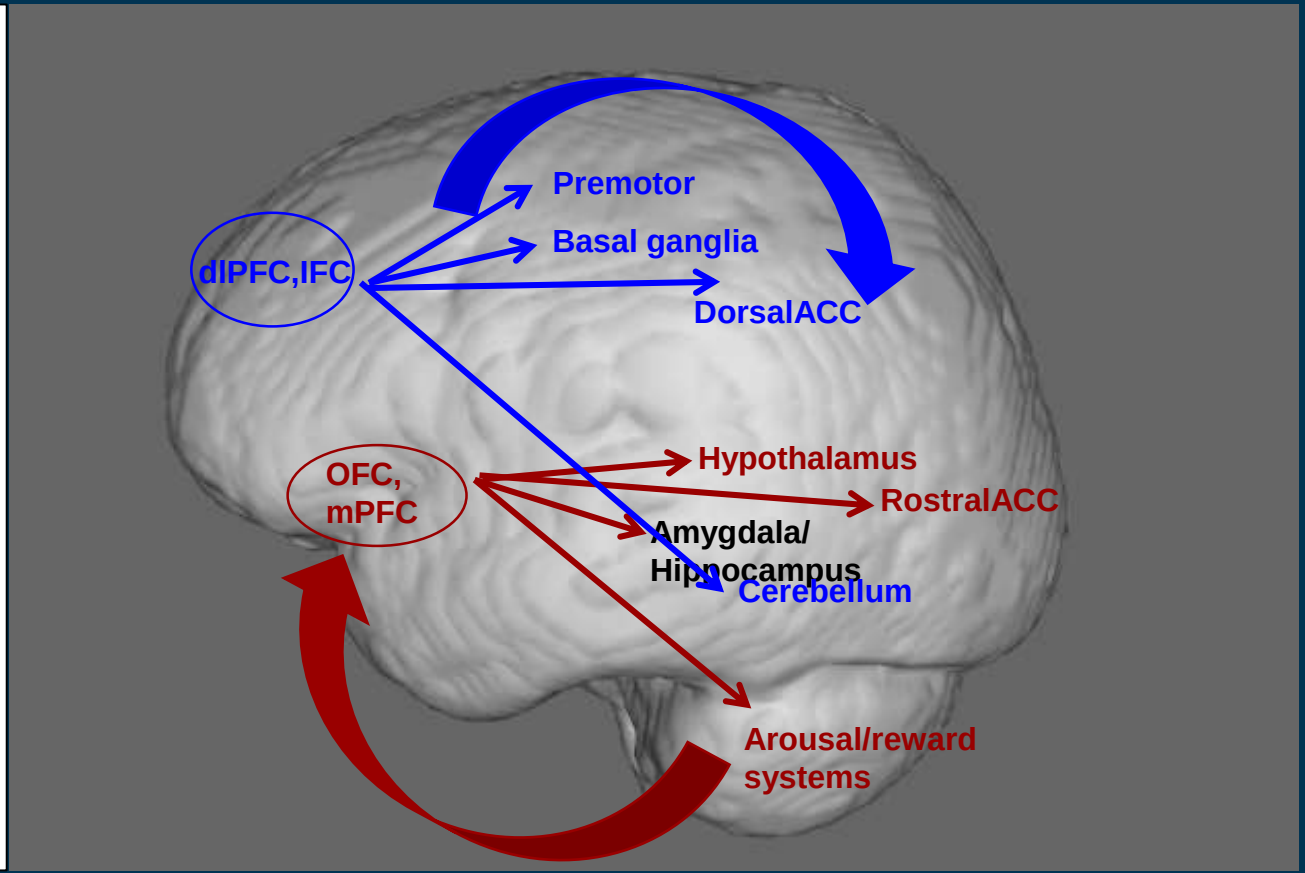
- These findings are consistent with recent study from Mosti & Coccaro (2018) which showed that individuals with intermittent explosive disorder were significantly more likely to have a history of mild TBI (with or without history of a brief loss of consciousness) compared with both healthy controls and individuals with psychiatric disorders.
- The authors write, “the data are consistent with the hypothesis that lifelong presence of an impulsive aggressive temperament places impulsive aggressive individuals in circumstances that put them at greater risk for mTBI compared with other individuals with and without nonimpulsive aggressive psychopathology.”

Violence and TBI

- The prevalence of violent behavior following mild to severe TBI has ranged from 11% to 35% (Baguley, Cooper, & Felmingham, 2006; Rao et al., 2009; Tateno, Jorge, & Robinson, 2003).
- According to frameworks for sudden-onset aggression following TBI, impulsive aggression may result from loss of inhibitory control (Wood & Thomas, 2013) or an imbalance between inhibitory pathways in the prefrontal and limbic structures that influences mood (Starkstein & Robinson, 1997).

Possible Neural Mechanisms underlying Aggressive Behavior

- **Fronto-limbic: Regulate emotion/ motivation processing**
- **Amygdala, Hippocampus – Memory/Fear response to Stress in Environment**
- **Fronto-striate: working memory, attention**



Violence and TBI

- Damage to the prefrontal cortex has been implicated in increased hostility, impulsivity, aggression, and violence (Bufkin & Luttrel, 2005; Grafman, Schwab, Warden, Pridgen, Brown, & Salazar, 1996; Tateno et al., 2003).
- Structural injury to this area is associated with lasting executive function (EF) impairment (Christ, White, Brunstrom, & Abrams, 2003; Xiao et al., 2013).
- Theoretically, then, we would expect to find a significant relationship between EF ability, impulsivity, and aggression.
- Poor performances on both the Stroop and Trail Making Test significantly predict antisocial behavior (Ogilvie, Stewart, Chan, & Shum, 2011).

Violence and TBI

- Kim (2002) writes “[D]eficits in executive cognitive functioning have been reported in non-brain-injured children with aggressive behaviors and young men without neurological or behavioral problems.
- These data suggest that impulsive aggression, both in brain-injured and non-brain-injured patients, represents a form of cognitive deficit that may be detected by neuropsychological testing.”
- Neuropsychological measures (i.e., Stroop Color Word Test) have explained significant variance in aggression scores in non-TBI forensic patients (Foster, Hillbrand, Silverstein & 1993)

Cognitive Task

PINK	BLUE	GREEN
GREEN	PINK	BLUE
PINK	GREEN	PINK
BLUE	PINK	BLUE
GREEN	BLUE	GREEN
BLUE	PINK	BLUE
PINK	GREEN	GREEN

Cognitive Task

BLUE	PINK	BLUE
PINK	GREEN	PINK
GREEN	PINK	GREEN
PINK	BLUE	PINK
BLUE	GREEN	BLUE
GREEN	BLUE	GREEN
BLUE	PINK	PINK

Attention vs. Executive Functioning

- The first task involves straight attentional abilities and taps into focus and processing speed.
- The second task is harder because it involves the ability to inhibit the overlearned response (reading the word).

This second exercise measures disinhibition because it involves higher-order ability to

- keep in mind a rule
- inhibit initial overlearned responses
- execute the new rule instead.

Method

- We administered the Delis-Kaplan Executive Function System (D-KEFS) (Delis et al., 2001) to 116 Operations Enduring Freedom/Iraqi Freedom/New Dawn (OEF/OIF/OND) veterans with TBI and PTSD.
- The Barratt Impulsiveness Scale (BIS) (Patton, Stanford, & Barratt, 1995) is a 30-item, self-report scale used to measure motor, attentional, and non-planning impulsivity.
- Family members completed the Head Injury Behaviour Scale (HIBS) which measures maladapative behaviors (e.g., aggression, impulsivity) of individuals with TBI.

Measure	BIS-II		HIBS	
	r	p	r	p
D-KEFS (executive function)				
Stroop– color	-0.33	< 0.001*	-0.17	0.08
Stroop– word	-0.34	< 0.001*	-0.20	0.03
Stroop– inhibition	-0.26	< 0.01	-0.17	0.07
Trails – visual search	-0.18	0.05	-0.22	0.02
Trails – number sequencing	-0.27	<0.01	-0.24	0.01
Trails – letter sequencing	-0.42	< 0.001*	-0.31	< 0.001*
Trails – number-letter switching	-0.27	< 0.01	-0.27	< 0.01
Trails – motor speed	-0.29	0.002*	-0.11	0.26

Discussion

- Our findings indicate individuals with TBI who perform poorly on attention and processing speed tasks were at increased risk for impulsive behaviour.
- Consistent with previous work, we found poorer Stroop task performance, specifically the separate colour and word tasks, was associated with increased self-reported impulsivity.
- The connection between these functional impairments and self-reported impulsivity suggests impaired attentional and motor control on neurocognitive testing translates to behavioural impulsivity more generally, at least in our sample.

Background

- Empirical literature supports the use of cognitive rehabilitation for enhancing executive function and emotion regulation, most commonly in TBI (Gordon et al., 2006).
- Research shows “top-down” or “metacognitive” strategies increase self-monitoring and self-control (e.g., Goal Management Training with cueing shown to improve psychosocial function in TBI) (Levine et al., 2011; Tornas et al., 2016; Hart et al., 2017).
- Also, “bottom-up” approaches can directly train attention and working memory (e.g., n-back) (Owen et al., 2005).

Current Study

- In randomized clinical trial, we tested effects of Cognitive Apps for Life Management (CALM) on executive function and emotion regulation in veterans with TBI+PTSD.
- CALM combines *top down* and *bottom up* approaches, delivers these via a mobile device, and involves the support of a family member or friend.

Design and Methodology

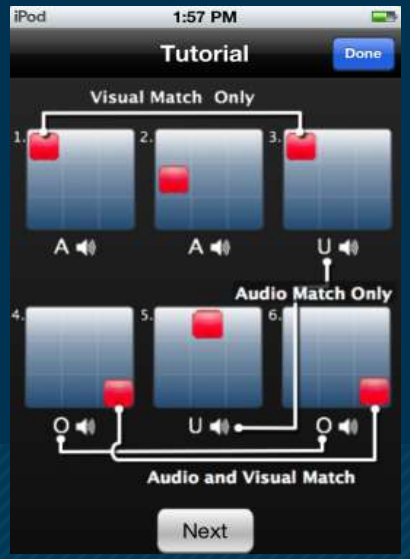
- Clinical trial of cognitive rehabilitation of N=112 dyads of post-9/11 veterans with TBI+PTSD and a family member or friend.
- Veterans randomized to “Cognitive Apps for Life Management” (CALM) or active control group for six month intervention.

Cognitive Applications for Life Management (CALM)

Goal Management Training (GMT)

Step 1	STOP
Step 2	FOCUS
Step 3	CHECK

n-back app



Content-Free Cueing

Personal Project:
An everyday activity that vets are having trouble with, broken into manageable steps, apply GMT strategies.

Polling Question

- How many times a day does the average consumer check his or her smartphone?
  a) 0-10
  b) 10-20
  c) 20-30
  d) 30-40
  e) 40-50
  f) 50+

Polling Question

- How many times a day does average consumer touch or swipe his or her smartphone screen?
  a) 0-500
  b) 500-1000
  c) 1000-2000
  d) 2000-3000
  e) 3000-4000
  f) 4000+

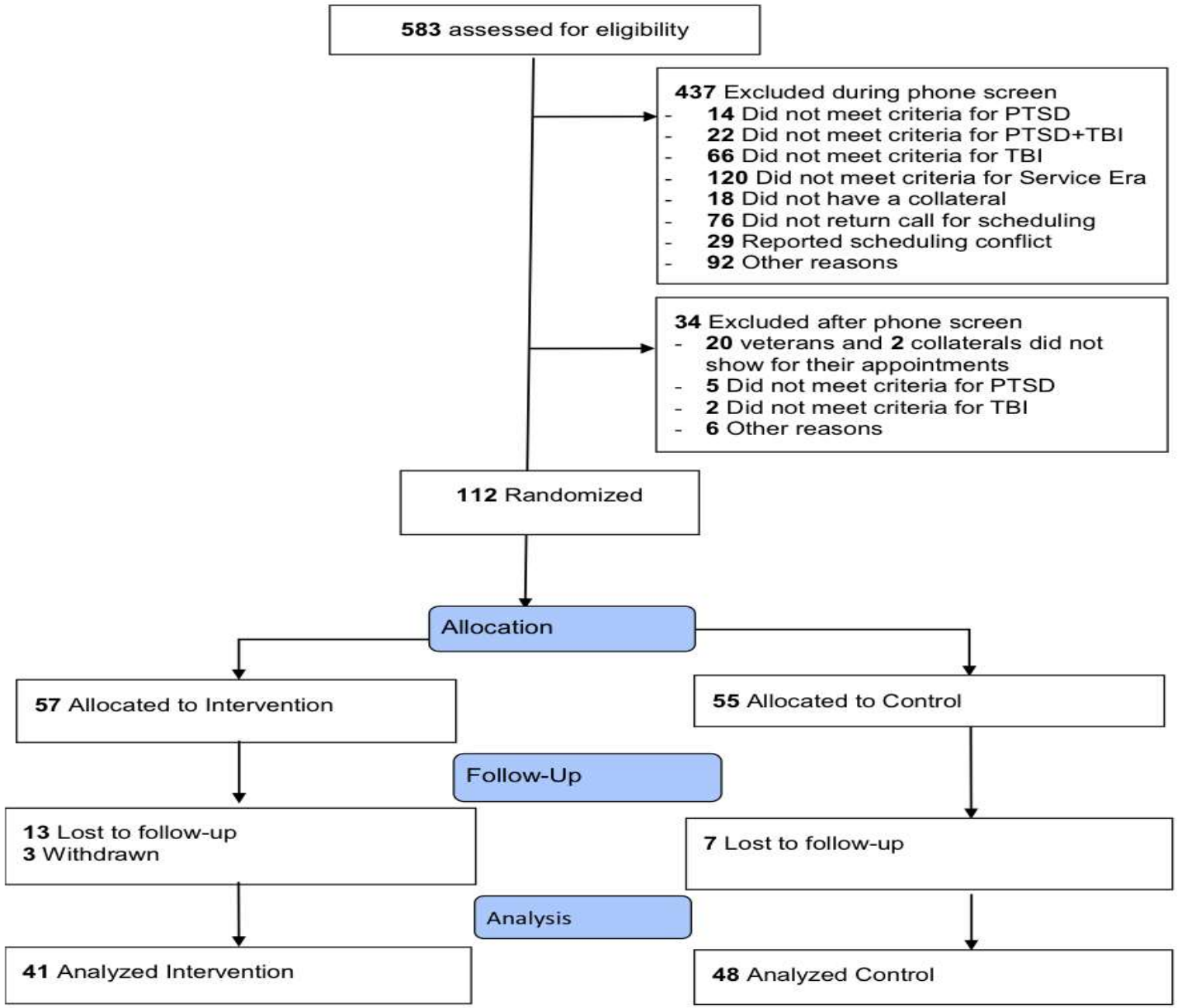
Facts about Technology Use

- How many times a day does the average consumer check his or her smartphone?
  - 47 (that's 17,155 times a year)
- How many times a day does average consumer touch or swipe his or her smartphone screen?
  - 2617 (that's almost a million times a year)

Design and Methodology

- Family members trained as coaches and mentors to reinforce veterans' daily use of iPod applications.
- Facilitators go to veterans' homes, facilitate applying skills in home environments, troubleshoot iPod problems, and review family mentoring processes.

CONSORT Diagram

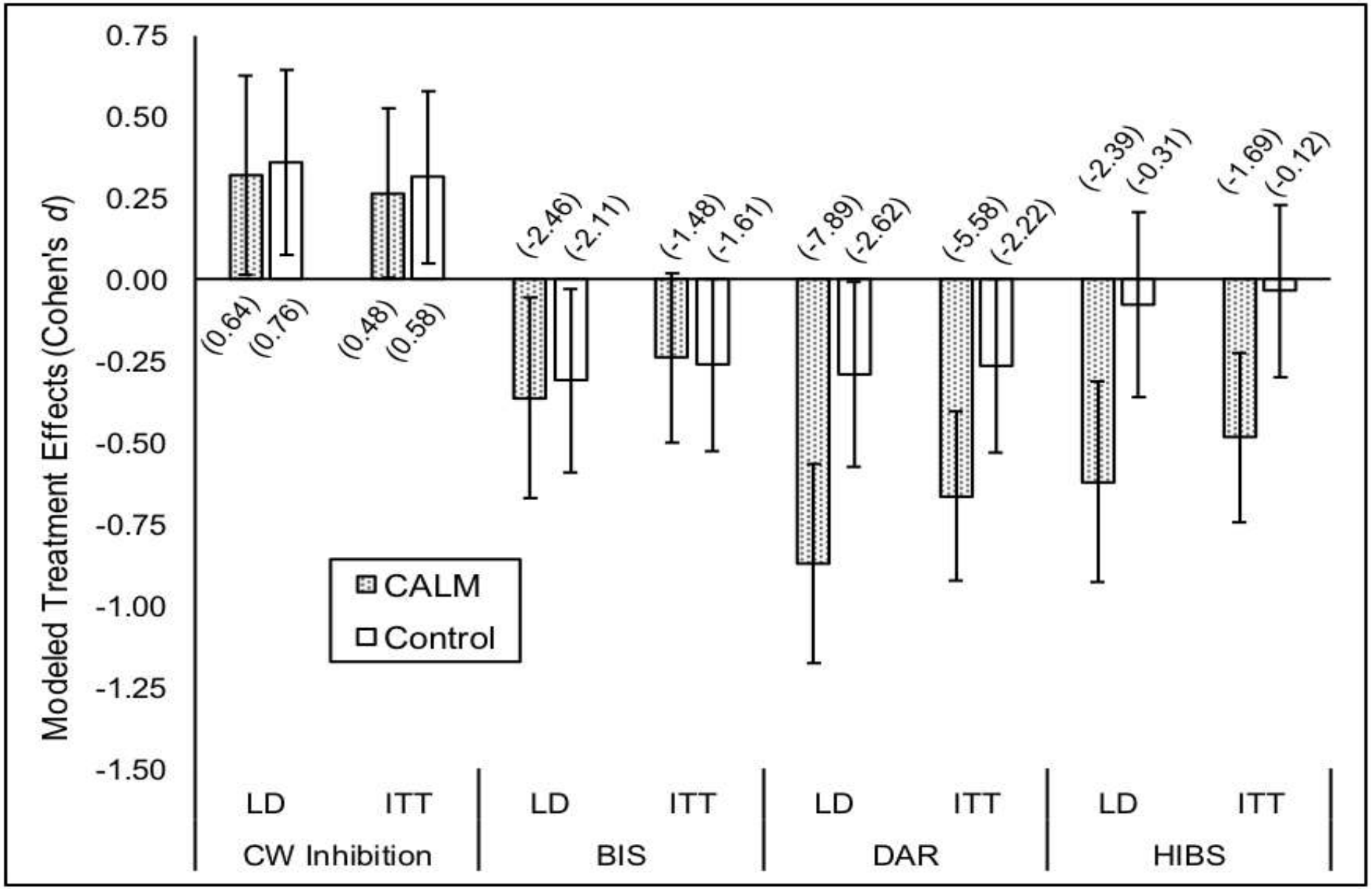


Design and Methodology

- 0 and 6 month outcomes:
  - Delis-Kaplan Executive Function System (DKEFS)
  - Barratt Impulsiveness Scale (BIS)
  - Dimensions of Anger Reactions (DAR)
  - Head Injury Behavior Scale (HIBS)
- Two sets of regression models were analyzed for each outcome.
  - Listwise deletion (LD) included participants with baseline and posttreatment data.
  - Intent-to-treat (ITT) use last observations carried forward for participants with missing post-treatment data.

		Treatment Effects				
		CALM		Control		Regression Coefficients (Standard Errors)
Outcome	Model	Pre	Post	Pre	Post	Treatment[a]
Executive Function/Impulsivity						
Disinhibition (DKEFS)	LD	9.80 (3.50)	10.25 (3.36)	8.69 (3.79)	9.91 (3.24)	**-0.12 (0.44) n.s.**
	ITT	9.79 (3.32)	10.18 (3.23)	8.85 (3.68)	9.53 (3.48)	**-0.10 (0.35) n.s.**
Impulsivity (BIS)	LD	69.34 (12.84)	67.29 (11.72)	71.04 (12.81)	68.98 (11.80)	**-0.35 (1.44) n.s.**
	ITT	71.26 (13.17)	69.79 (12.66)	71.31 (12.42)	69.69 (12.64)	**0.14 (1.17) n.s.**

		Treatment Effects				
		CALM		Control		Regression Coefficients (Standard Errors)
Outcome	Model	Pre	Post	Pre	Post	Treatment
Emotion/Behavior Regulation						
Anger (DAR)	LD	30.68 (15.57)	22.80 (16.53)	30.74 (16.15)	28.13 (15.39)	**-5.27** (1.93)**
	ITT	30.35 (15.77)	24.82 (16.53)	31.13 (16.15)	28.85 (15.56)	**-3.35* (1.60)**
Maladaptive Behaviors (HIBS)	LD	7.68 (4.88)	5.66 (4.67)	9.33 (5.21)	8.81 (5.23)	**-2.08* (0.84)**
	ITT	7.68 (4.89)	6.23 (4.83)	9.80 (5.56)	9.44 (5.77)	**-1.58* (0.67)**



Note. Negative scores reflect reductions from baseline, positive scores increases.

Discussion

- To our knowledge, study is the first to yield empirical support for an intervention to decrease anger, aggressive impulses, and maladaptive behavior in TBI.
- This mobile-technology based approach is also feasible, portable, low-cost, and showed relatively high level of engagement (72% completed six month CALM intervention).

Discussion

- No group differences in changes detected on the DKEFS task or BIS.
- 12% of the sample of impaired on DKEFS task and most participants below BIS cut-off for impulsiveness.
- TBI alone may be insufficient as inclusion criteria for future cognitive rehabilitation or other treatment studies, which should instead specify cognitive and/or behavioral criteria.

Discussion

- Regarding emotional and behavioral regulation, current findings are consistent with research in cognitive rehabilitation of TBI showing that metacognitive strategies targeting self-awareness of beliefs, self-monitoring, and self-control are effective at improving social functioning.
- Our results suggest integrating cognitive rehabilitation strategies into more targeted anger management programs for veterans may have potential for improving clinical and functional outcomes.

Recap: Predictors of Post-TBI Criminal Arrest

- Motor function and loss of consciousness were important to consider with respect to post-TBI criminal arrest.
- At the same time, demographics (e.g., young, single, less educated males), history (e.g., pre-TBI history of substance abuse and criminal arrest) predicted greater likelihood of getting arrested after a TBI, just as in the general population.
- The findings emphasize that for criminal behavior in TBI, many risk factors mirror those of the non-TBI population.
- Many of the same risk factors for non-TBI populations apply to TBI and need to be considered by forensic clinicians and policymakers.
- Findings also imply many individuals with TBI may have been at higher risk of criminal arrest even before their head injuries.

Recap: Predictors of Impulsivity and Aggression in TBI

- Individuals with TBI who perform poorly on attention and processing speed tasks were at increased risk for impulsive behaviour.
- Consistent with previous work, we found poorer Stroop task performance, specifically the separate color and word tasks, was associated with increased self-reported impulsivity.
- The connection between these functional impairments and self-reported impulsivity suggests impaired attentional and motor control on neurocognitive testing translates to behavioural impulsivity more generally, at least in our sample.
- Assessment of executive function and attention may enhance violence risk assessment in forensic cases involving TBI.

Recap: Reducing Anger and Aggression in TBI

- A mobile-technology based approach to cognitive rehabilitation of executive dysfunction following TBI is feasible, portable, low-cost, and showed relatively high level of engagement (72% completed six month CALM intervention).
- To our knowledge, CALM is the first intervention using mobile technology and social support to yield empirical support decrease anger, aggressive impulses, and maladaptive behavior in TBI.
- Our results suggest integrating cognitive rehabilitation strategies into more targeted anger management programs for individuals with TBI may have potential for effective risk management strategies in forensic and criminal populations.

Thank You