EXPLORING DISSOCIATION IN PTSD

EXPLORING DISSOCIATION IN POST-TRAUMATIC STRESS DISORDER: IMPACT ON EMOTION, COGNITION, AND DAILY FUNCTIONING AMONG MILITARY MEMBERS, VETERANS, AND FIRST RESPONDERS IN CANADA

By ANNA H. PARK, B.Sc., M.Sc.

A Thesis Submitted to the School of Graduate Studies in Partial Fulfilment of the Requirements for the Degree Doctor of Philosophy

McMaster University DOCTOR OF PHILOSOPHY (2024) Hamilton, Ontario (Psychology)

TITLE: Exploring Dissociation in Post-Traumatic Stress Disorder: Impact on Emotion, Cognition, and Daily Functioning Among Military Members, Veterans, and First Responders in Canada AUTHOR: Anna H. Park, B.Sc. (McGill University), M.Sc. (University of St. Andrews) SUPERVISOR: Professor M. C. McKinnon NUMBER OF PAGES: xiii, 183

Lay Abstract

Military members, veterans, and first responders in Canada report more frequent and severe symptoms of post-traumatic stress disorder (PTSD) as compared to the general population. Up to a third of those with PTSD have chronic dissociation symptoms, including depersonalization (feeling detached from oneself) and derealization (feeling detached from the world), which contrast with classic PTSD symptoms (e.g., hypervigilance, bodily reactivity, reliving). Despite being recognized as a subtype of PTSD in 2013, there is a lack of research on the impact of dissociation in PTSD. In my dissertation, I address this gap by exploring the impact of trauma-related dissociation on emotion regulation, thinking, and daily functioning among samples of military members, veterans, first responders, and civilians seeking treatment for PTSD in Canada. I apply novel analytical methods, including machine learning, to explore the unique role of dissociation in worsening the burden of illness in PTSD.

Abstract

Military members, veterans, and public safety personnel in Canada experience more frequent and severe symptoms of post-traumatic stress disorder (PTSD) as compared to the general population. Up to a third of individuals with PTSD experience persistent trauma-related dissociation symptoms, including depersonalization (feeling detached from oneself) and derealization (feeling detached from the world). Dissociative presentations reflect hypoarousal (e.g., emotional numbing and blunted affect) and contrast with classic PTSD symptoms of hyperarousal (e.g., hypervigilance and physiological reactivity). Although dissociation is linked to severe trauma and PTSD, research focusing on classic PTSD symptoms has dominated the trauma literature. To address this gap in research, I explored the impact of dissociation on emotion regulation, cognition, and daily functioning among adults seeking treatment for PTSD in Canada. In Chapter 2, I characterized dissociation symptoms in a sample public safety personnel. Approximately 25% of individuals reported elevated dissociation, which was associated with greater PTSD severity, emotion dysregulation, and daily impairment. In Chapter 3, I examined whether dissociation and emotion dysregulation predict cognitive dysfunction in a sample of military members, veterans, and public safety personnel. Both dissociation and emotion dysregulation symptoms explained, in part, impairments in cognitive functioning, even after accounting for the effects of PTSD severity. In Chapter 4, I trained machine learning models to predict PTSD-related illness in a sample of military members, veterans, public safety personnel, and civilians. Machine learning models accurately predicted self-reported PTSD severity (43% of variance) and functional impairment (32% of variance) in unseen data from patients in a hold-out test set. Both dissociation and emotion dysregulation symptoms emerged as important contributors to predictions. Overall, my findings suggest that improved recognition of trauma-

related dissociative symptoms and tailored integration of evidence-based therapies may help address the complex needs of individuals experiencing PTSD.

Acknowledgements

This dissertation would not exist without the invaluable support of my supervisor, Dr. Margaret McKinnon. Thank you for your unwavering support and patience, for trusting me with this important data, and for believing in my potential from day one. To Drs. Geoff Hall and Heather McNeely – I feel lucky to have had such wonderful people on my committee. Thank you for being the reasons why I looked forward to our annual meetings. Thank you to the Trauma Lab, Michelle for your reliable help on the raw data and editing process, and especially the machine learning study team (Andrew N, James, and Herry) for helping to move a massive research project forward during a global pandemic.

Thank you to my clinical supervisors at St. Joe's and CAMH – you have not only helped shape the clinician I am but have made my research in trauma and mental health more meaningful. To all the individuals I was lucky enough to work with throughout my clinical training and residency – thank you for sharing and trusting your stories with me. You taught me more about trauma and life than I could have ever learned through reading any scientific paper.

Thank you to mom, dad, Benny, and sister Hilary for their constant support and belief in me, no matter what I do. Thank you to my friends for being my constant reminders of life outside of academia and keeping me balanced. Thank you to my friend and former labmate, Marta, for helping to make memories of my PhD journey a positive one. Finally, thank you to Andrew for your love, humour, and support that included wanting to be around me during comps and spending weekends with me in the library.

Table of Contents

List of Figures and Tables

Chapter 2

Chapter 3

Chapter 4

List of Abbreviations and Symbols

ACE	Adverse Childhood Experience
BPD	Borderline Personality Disorder
CAPS-5	Clinician-Administered PTSD Scale for DSM-5
CBT	Cognitive Behavioural Therapy
CFQ	Cognitive Failures Questionnaire
CI	Confidence Interval
COWAT	Controlled Oral Word Association Test
CPT	Cognitive Processing Therapy
CPT 3	Conners Continuous Performance Test, Third Edition
CTQ	Childhood Trauma Questionnaire
CVLT-II	California Verbal Learning Task, Second Edition
DASS-21	Depression Anxiety Stress Scales, 21-item
DBT	Dialectical Behaviour Therapy
DERS	Difficulties in Emotion Regulation Scale
DEX	Dysexecutive Questionnaire
D-KEFS	Delis-Kaplan Executive Function System
DSM-5	Diagnostic and Statistical Manual, Fifth Edition
FSIQ	Full-Scale Intelligence Quotient Subtest
HHC	Homewood Health Centre
HRI	Homewood Research Institute
MCAR	Missing Completely at Random
MDD	Major Depressive Disorder
MDI	Multiscale Dissociation Inventory
NRMSE	Normalized-Root Mean Squared Error
PCL-5	PTSD Checklist for DSM 5
PSP	Public Safety Personnel
PTSD	Post-Traumatic Stress Disorder
PTSR	Post-Traumatic Stress Recovery Programme
RCMP	Royal Canadian Mounted Police
RCT	Randomized Control Trial
RMSEA	Root Mean Square Error of Approximation
VIF	Variance Inflation Factor
WAIS-IV	Wechsler Adults Intelligence Scale, Fourth Edition
WASI-II	Wechsler Abbreviated Scale of Intelligence, Second Edition
WHO	World Health Organization
WHODAS 2.0	WHO Disability Assessment Schedule 2.0
WTAR	Weschler Test of Adult Reading

Declaration of Academic Achievement

This dissertation includes an introduction (Chapter 1), two empirical studies that have been published in peer-reviewed scientific journals (Chapters 2 and 4), one empirical study that is currently under review for publication (Chapter 3), and a general discussion (Chapter 5). As first author on all three studies, I declare that this dissertation presented for the degree of Doctor of Philosophy has been composed by myself and that the work contained herein is my own except where explicitly stated otherwise. My contribution and those of co-authors on studies are explicitly indicated below. All studies in Chapters 2-4 were conducted under the supervision of, and in collaboration with, Dr. Margaret C. McKinnon, who provided the resources to carry out the research and assisted in the review and editing of the final drafts.

Chapter 2 was previously published in *European Journal of Psychotraumatology* as *Dissociative symptoms predict severe illness presentation in Canadian public safety personnel with presumptive post-traumatic stress disorder (PTSD)* by *Anna H. Park, Alina Protopopescu, Michelle E. Pogue, Jenna E. Boyd, Charlene O'Connor, Ruth A. Lanius, and Margaret C. McKinnon*. This study was conceived by all the authors. I, AHP, served as lead for methodology, data curation, formal analysis, software, visualization, and writing-original draft, and served in a supporting role for conceptualization and writing-review and editing. MP served in a supporting role for data curation, methodology, writing-original draft and preparation, writing-reviewing and editing. RAL served in a supporting role for supervision and writing-reviewing and editing. MCM served as lead for conceptualization, funding acquisition, resources, project administration, supervision, and writing-reviewing and editing, and served in a supporting role for methodology. AP, JEB, and CO contributed equally to data acquisition and investigation.

Chapter 3 is currently under review in a peer-reviewed scientific journal for publication as *Dissociative symptoms and emotion dysregulation contribute to alterations in cognitive performance among military members, Veterans, and public safety personnel with a presumptive diagnosis of post-traumatic stress disorder* by *Anna H. Park, Alina Protopopescu, Michelle E. Pogue, Jenna E. Boyd, Charlene O'Connor, Ruth A. Lanius, and Margaret C. McKinnon*. This study was conceived by all the authors. I, AHP, served as lead for methodology, data curation, formal analysis, visualization, and writing-original draft and preparation, and served in a supporting role for writing-review and editing. MP served in a supporting role for data curation, methodology, writing-reviewing and editing. RAL served in a supporting role for funding acquisition, resources, and supervision. MCM served as lead for funding acquisition, resources, project administration, supervision, and writing-reviewing and editing, and served in a supporting role for methodology. AHP and MCM contributed equally to conceptualization. AP, JEB, and CO contributed equally to data acquisition and investigation.

Chapter 4 was previously published in *Psychological Trauma: Theory, Research, Practice, and Policy* by *Anna H. Park, Herry Patel, James Mirabelli, Stephanie J. Eder, David Steyrl, Brigitte Lueger-Schuster, Frank Scharnowski, Charlene O'Connor, Patrick Martin, Ruth A. Lanius, Margaret C. McKinnon, and Andrew A. Nicholson*. I, AHP, served as lead for conceptualization, methodology, visualization, and writing-original draft and served in a supporting role for data curation and writing-review and editing. HP served in a supporting role for conceptualization, data curation, methodology, visualization, writing-original draft, and writing-review and editing. JM served in a supporting role for conceptualization, methodology, visualization, writing-original draft, and writing-review and editing. SJE served in a supporting role for formal analysis, methodology, and visualization. DS served in a supporting role for

methodology and resources. BL served in a supporting role for writing-review and editing. FS served in a supporting role for formal analysis and methodology. CO served as lead for data curation. PM served in a supporting role for resources. RAL served in a supporting role for resources. MCM served as lead for resources and served in a supporting role for supervision. AAN served as lead for project administration, supervision, and writing-review and editing and served in a supporting role for conceptualization, methodology, resources, and writing-original draft. AHP, JM, DS contributed equally to formal analysis. JM, DS, FS, and PM contributed equally to software. PM, RAL, MCM, and AAN contributed equally to funding acquisition. PM, RAL, and MCM contributed equally to investigation.

Chapter 1:

General Introduction

Post-traumatic stress disorder (PTSD) is a debilitating psychiatric condition characterized by a diverse range of symptoms across affective, cognitive, behavioural, and physiological domains (American Psychiatric Association [APA], 2013). It is associated with poor quality of life and significant functional impairment including disability, reduced activity in the long-term, suicidality, and greater health care costs (Harper et al., 2022; Olatunji et al., 2007; Panagioti et al., 2015; Sareen et al., 2007). The heterogeneity of PTSD poses a serious challenge to understanding its effective recovery, given its potential to manifest in 636,120 different ways and co-occurrence with other medical and psychological conditions is the norm (Galatzer-Levy & Bryant, 2013). Since its introduction into the Diagnostic and Statistical Manual of Mental Disorders (DSM-III) in 1980, PTSD has been classically conceptualized as a disorder of *hyperarousal*, marked by intense fear, hypervigilance, and physiological reactivity. More recent advancements have led to the recognition of the dissociative subtype of PTSD in the 5th edition of the DSM in 2013 (APA), but the development of dissociation in the trauma literature is comparatively nascent (Brand, 2016), emphasizing the need for a comprehensive understanding that extends beyond classic conceptualizations of PTSD (APA, 2013).

To address this gap, I use empirical studies to explore the affective, cognitive, and functional impact of trauma-related dissociation among military members, veterans, public safety personnel, and civilians seeking treatment for PTSD in Canada. The purpose of my work is to better understand the clinical characteristics of dissociation and inform the development of tailored interventions to reduce the significant burden of PTSD on individuals and society. In this introduction (Chapter 1), I provide an overview of classic PTSD presentations, the role of dissociation in PTSD, and the existing challenges in PTSD research and treatment. In Chapter 2, I investigate the characteristics of elevated dissociation symptoms in a highly traumatized yet

understudied population of treatment-seeking public safety personnel in Canada. In Chapter 3, I aim to untangle the role of dissociation in cognitive dysfunction – a hallmark symptom of PTSD whose specific link with dissociation is unknown. Informed by findings from Chapters 2 and 3, I examine the relative importance of dissociation compared to related symptoms in trauma-related illness among treatment-seeking military members, veterans, public safety personnel, and civilians in Canada. Thus, in Chapter 4, I integrate a data-driven approach using machine learning algorithms to develop a predictive model that can forecast trauma-related illness severity in a novel subset of patients with unseen data (i.e., in a hold-out test dataset).

Background

Understanding PTSD: A Disorder of Hyperarousal

PTSD has its conceptual origins in the early 1900s, following the return of veterans from World War I (Kardiner, 1941) experiencing *traumatic neurosis* or *shell shock*. Symptoms of traumatic neurosis were characterized as being highly persistent and reactionary (i.e., shock, terror, and fright), accompanied by autonomic and somatic disturbances, and a fixation on the traumatic event(s). For example, Kardiner (1941) described a soldier who, after being gassed during the war, returned home with persistent fainting spells, confusion, and shortness of breath. He was bothered by re-experiencing symptoms, such as reliving the event through frequent dreams of being attacked, and sensations of falling and drowning. Being easily irritable and quick to temper, he reacted violently to annoyances or physical pain. Due to the irritating odor of gasoline, he was unable to sustain work at a taxicab company (Kardiner, 1941). These depictions have significantly shaped our contemporary understanding of PTSD as a disorder of hyperarousal.

Presently, PTSD is recognized as a mental health condition that can follow the experience of a traumatic event which threatens death or serious harm (APA, 2013). Potentially traumatic events include the direct experience (or witnessing or learning of a close other's experience) of physical assault, sexual abuse, war, natural disaster, or repeated exposure to aversive details of traumatic events (APA, 2013). According to the DSM-5, a diagnosis of PTSD requires the persistence of (1) at least one symptom each of (a) intrusions (e.g., nightmares), and (b) avoidance (e.g., avoiding places that are reminders of the event); and (2) at least 2 symptoms each of (a) negative alterations in cognition and mood (e.g., distorted self-blame for event) and (b) arousal/reactivity (e.g., hypervigilance; APA, 2013). In other words, PTSD typically involves intrusive memories, avoidance of trauma-related reminders, negative mood and cognitions, as well as heightened physiological arousal and reactivity (APA, 2013). These symptoms can present as affective (e.g., intense guilt, fear, horror, anger, and/or shame), cognitive (e.g., believing that one is broken or that no one in the world can be trusted), behavioural (e.g., avoiding people or places that remind them of the traumatic event) and/or physiological responses (e.g. hyperemotionality, hypervigilance in public), making PTSD a highly heterogeneous disorder. Thus, current conceptualizations of PTSD predominantly reflect a disorder of hyperarousal that is reminiscent of earlier depictions of traumatic neurosis.

Further complicating its presentation, individuals with PTSD frequently have co-occurring physical and medical conditions such as chronic pain, cardio-respiratory problems, and gastrointestinal issues (Fetzner et al., 2012; Pacella et al., 2013). Up to 70% of individuals with PTSD experience a concurrent mental disorder such as depression, anxiety, and substance use disorders, adding to the burden of PTSD (Greene et al., 2016; Hogg et al., 2023; Knowles et al., 2019). In fact, individuals with PTSD experience significant functional impairment, including

difficulties maintaining self-care, work, daily living, and relationships (Harper et al., 2022; Sareen, 2014; Scoglio et al., 2022). PTSD is associated with poor quality of life, disability, reduced activity in the long term, suicidality, and greater health care costs (Harper et al., 2022; Olatunji et al., 2007; Panagioti et al., 2015; Sareen et al., 2007). Notably, populations that are repeatedly exposed to severe or chronic traumatic events, such as military members, veterans and public safety personnel, experience elevated rates of PTSD, psychopathology, health problems, and impairment in life functioning (Alisic et al., 2014; Berger et al., 2012; da Silva et al., 2024; DeBellis & Zisk, 2014; Stein et al., 2013; Stewart et al., 2004).

Dissociation in PTSD: A Disorder of Hypoarousal

Across different disorders, dissociation is a disruption in the normal stream of consciousness and alterations in the perception of time, thoughts, and memories (Bernstein & Putnam, 1986; Janet, 1889). The general construct of dissociation was introduced into the DSM-III under the Dissociative Disorders in 1980 (APA), which included criteria for dissociative identity disorder (formerly multiple personality disorder). Symptoms of dissociation can also present in schizophrenia, eating disorders, anxiety disorders, problematic alcohol or substance use, and dissociative disorders (APA 1980, 2013). Transdiagnostically, dissociation can involve symptoms of depersonalization, derealization, disengagement, emotional numbing, memory disturbance, and identity dissociation (Brière et al., 2005). Although symptoms of dissociation can be pathological, they exist on a continuum of non-pathological dissociative experiences such as daydreaming or absorption (e.g., preoccupation to the point of distraction from one's immediate environment) to severe and impairing symptoms that are considered divisions of personality (Bernstein & Putnam, 1986; Dell, 2006; Frischholz et al., 1991; Wolf et al., 2017).

Up to a third of individuals with PTSD experience dissociation, marked by persistent symptoms of depersonalization and/or derealization (Armour et al., 2014; Bernstein & Putnam, 1986; Janet, 1889; McKinnon et al., 2016; Lanius, 2015; Stein et al., 2013; White et al., 2022; Wolf et al., 2012a, 2012b). *Depersonalization* involves feeling disconnected from one's body or self, whereas *derealization* can feel as though the world is distant, unreal, or dreamlike. As one patient illustrated, "It feels like I'm behind my eyes, or sometimes it feels like I'm beside myself. I can see my body, I can see what it's doing, but it's not me. It's not connected" (Frewen & Lanius, 2015, p. 53). Unlike classic hyperarousal symptoms of PTSD, marked by perceptible hyperemotionality, hypervigilance, and re-experiencing symptoms, dissociative PTSD presents as a disorder of *hypoarousal*, characterized by emotional constriction, blunted affect, and numbness (APA, 2013). Dissociation appears to be a defensive mechanism in the face of severe or chronic traumatic experiences by, for example, functioning as a psychological escape when physical escape is not possible. This mechanism may shield from overwhelming emotional or psychological distress and disrupt its integration into one's memory (Bernstein & Putnam, 1986; Janet, 1889). In this way, dissociation can be understood as a disorder of integration (Scalabrini et al., 2020) or perhaps – a disorder of sensory integration, involving a disconnect between the experience of one's external and internal environments.

Importantly, research suggests that trauma-related dissociation plays a critical role in worsening the burden of illness in PTSD. For instance, although dissociation is correlated with PTSD severity, dissociation symptoms have been found to mediate the relation between childhood trauma and trauma-related outcomes (Franzke et al., 2015; Lebois et al., 2022). In a sample of 1,464 recently trauma-exposed adults, persistent trauma-related derealization symptoms at 2 weeks post-trauma significantly predicted PTSD severity at 3 months post-trauma

(Lebois et al., 2022). Here, the effect was not explained by childhood trauma and current PTSD symptom severity (Lebois et al., 2022), suggesting that trauma-related dissociation may be a unique driver of PTSD severity. Similarly, Boyd et al. (2018) reported that trauma-related dissociation symptoms mediated the effect of PTSD symptoms on functional impairment in a Canadian sample of treatment-seeking military members, veterans, and public safety personnel. Franzke et al. (2015) also found that dissociation mediated the relationship between childhood maltreatment history and non-suicidal self-injury, suggesting that dissociation is uniquely contributing to PTSD-related illness. In a study of 1,484 veterans with PTSD, individuals with the dissociative subtype of PTSD were more likely than those with the non-dissociative subtype to experience severe anxiety, depression, and problematic alcohol use (Tsai et al., 2015). This effect was maintained after controlling for PTSD severity, emphasizing that there may be a distinct burden of illness due to symptoms of trauma-related dissociation (Tsai et al., 2015).

Despite their apparent clinical severity, dissociative symptoms are severely overlooked in clinical contexts, pointing to a critical gap in how we address dissociation in PTSD (Atchley & Bedford, 2021; Boyer et al., 2022; Brand, 2016). Individuals with dissociation symptoms report experiencing structural barriers to treatment due to a lack of trained providers (Nester et al., 2022), and many existing interventions for PTSD do not directly target dissociative symptoms (Atchley & Bedford, 2021). Notably, dissociation may be a barrier to engaging in or benefitting from existing evidence-based trauma-focused psychotherapies (Bae et al., 2015; Ebner-Priemer et al., 2009). This leaves an unmet need for the approximate 15-30% of individuals with PTSD who experience dissociative symptoms, highlighting the importance of innovating current treatment approaches (Bohus et al., 2013, 2020; McKinnon et al., 2016).

Interplay of Dissociation, Emotion, and Cognitive Functioning in PTSD

Emotion regulation involves the ability to be aware of, accept, and understand one's experience of emotions, as well as engage in goal-directed behaviours (Gratz & Roemer, 2004). Individuals with PTSD often report difficulties with emotional clarity and hold negative beliefs about their ability to regulate emotions (Hayes et al., 2012; Lanius et al., 2006, 2012; Powers et al., 2015; Seligowski et al., 2014). Emotion regulation is particularly impaired among those experiencing trauma-related dissociation (Bennett et al., 2015; Lanius et al., 2010; Powers et al., 2015; Wolf et al., 2012b). A recent study also found that emotion dysregulation was associated with greater dissociative symptoms and self-injurious behaviours among patients with dissociative disorders (Nester et al., 2022), suggesting its link to dissociation in worsening illness severity. Notably, emotion dysregulation may interfere with the ability to engage in or benefit from existing evidence-based trauma-focused psychotherapies. In a study of women with borderline personality disorder, Ebner-Priemer et al. (2009) found that women with high state dissociation did not experience a conditioned response to a conditioned stimulus (i.e., an aversive baby cry). However, those with low state dissociation acquired the conditioned response, which subsequently diminished over time during the extinction phase. This suggests that dissociation interferes with emotional learning, an essential element for trauma memory processing in existing trauma-focused psychotherapies (Ebner-Priemer et al., 2009). Thus, individuals experiencing dissociation symptoms may face additional barriers to PTSD treatment, given their increased problems with emotion dysregulation.

In addition to impairments in emotion regulation, cognitive difficulties are well-documented in PTSD (Qureshi et al., 2011; Schuitevoerder et al., 2013; Wrocklage et al., 2016). In general, individuals with PTSD report problems with memory, attention, planning, and

broader trauma-related beliefs that guide behavior (APA, 2013). One quantitative meta-analysis reported that PTSD is associated with impairments in attention (d = -.50), memory (d = -.46), processing speed (d = -.59), executive functioning (d = -.45), verbal learning (d = -.62), and language (d = -.43; Scott et al., 2015). Elevated dissociation is also associated with more cognitive complaints (Simeon, 2009), as well as greater impairment in tasks involving executive functioning, attention, and autobiographical memory (Rivera-Vélez et al., 2014; Roca et al., 2006). Dissociation is linked to neuropsychological impairment including greater traumatic memory fragmentation and incoherence (e.g., organization in time and space), impaired conceptual and self-referential processing, and poor integration of the trauma memory with other autobiographical memories (Ehlers & Clark, 2000; Halligan et al., 2003; Huntjens et al., 2013; Kleim et al., 2008; Lanius et al., 2012). Although these findings indicate that dissociative symptoms negatively impact cognitive functioning, existing research has failed to report on the specific link between cognitive functioning and trauma-related dissociative symptoms, making the specific role of dissociation symptoms in PTSD unclear (Scott et al., 2015). In fact, no study to date has examined the unique role of dissociation in cognitive functioning among individuals with PTSD, after accounting for the effects of PTSD severity.

Challenges in Current PTSD Research and Treatment

Empirical research demonstrates the efficacy of evidence-based psychological interventions for PTSD (i.e., cognitive processing therapy, prolonged exposure, and eye-movement desensitization and reprocessing), which outperform pharmacotherapies on a range of relevant outcome measures, even at 3-9 months follow-up (Foa et al., 2007; Lee et al., 2016; Merz et al., 2019; Resick et al., 2008). However, over one-third of individuals will continue to meet criteria for PTSD, despite completing trauma-focused therapy or pharmacotherapy (Berger

et al., 2009; Bradley et al., 2005), and 22-30% of individuals who begin psychotherapy for PTSD will drop out of treatment (Bryant et al., 2007; Eftekhari et al., 2020). Treatment non-responders also experience greater dissociation severity and comorbid mental health symptoms, even with currently available evidence-based trauma-focused psychotherapies (Bae et al., 2015). Drop out and poor treatment outcomes are associated with heightened trauma-related fear responses, excessive avoidance behaviours, greater PTSD severity, and greater pre-treatment social impairment (Bradley et al., 2005; Bryant et al., 2008; Najavits, 2015; Watts et al., 2013). Similarly, low help-seeking in PTSD correlates with symptoms associated with dissociation, including emotional numbing, interpersonal detachment, a lack of emotional readiness, and poor tolerability of existing exposure-based therapies (Blais et al., 2014; Ebner-Priemer et al., 2009; Smith et al., 2020; van der Kolk et al., 2016). Taken together, these findings indicate that high clinical symptom severity may pose a barrier to recovery, pointing to the need to explore the roles of dissociation and emotion regulation in PTSD.

Current research methodologies in PTSD predominantly employ model-driven, classical inferential approaches that are not optimized for the complex and heterogeneous symptom presentations of PTSD (see Chekroud et al., 2021 and Dwyer et al., 2018 for a more detailed discussion; Galatzer-Levy & Bryant, 2013). These approaches struggle with high degrees of intercorrelation among key variables, leading to problems in discerning the unique contributions of each factor on PTSD severity and related impairment. The sheer number of candidate factors often overwhelms these models, limiting their capacity to examine complex, non-linear relationships in PTSD. Moreover, these conventional approaches describe patterns in the data but cannot accurately predict outcomes in new datasets, limiting their applicability to clinical settings. As such, more innovative approaches to the study of PTSD are needed to identify key

targets for intervention and develop models that accurately forecast PTSD illness and impairment.

Dissertation Outline

The recognition of trauma-related dissociation symptoms in research and clinical settings is severely lacking. The following 3 chapters of my dissertation are empirical studies that aim to explore the unique role of dissociation in PTSD, with a focus on emotion regulation, cognitive functioning, and daily functioning.

In Chapter 2, I characterize dissociation and related clinical symptoms in a sample of current or former public safety personnel seeking treatment for PTSD in Canada. I analyze self-reported demographic and baseline clinical symptom data drawn from a sample of patients with presumptive PTSD who had enrolled, but had not yet participated, in a psychological intervention for PTSD. In addition to descriptive analyses, I use multiple linear regressions to examine whether dissociation symptoms (i.e., depersonalization and derealization) predict PTSD symptom severity, emotion dysregulation, and functional impairment, controlling for biological sex and inpatient or outpatient status. I report that individuals with elevated levels of dissociation had more severe symptoms of PTSD, greater problems regulating their emotions, and more daily impairment. This indicates that experiencing higher levels of trauma-related dissociation symptoms are associated with a heightened burden of illness, in line with previous research linking dissociation with illness severity.

In Chapter 3, I investigate the unique contribution of trauma-related dissociation in cognitive dysfunction, after accounting for the effects of PTSD symptom severity and control variables. My sample consists of current or former military members, veterans, and public safety personnel seeking treatment for PTSD in Canada, who self-reported clinical symptoms and

completed a neuropsychological assessment battery. Hierarchical multiple linear regressions are conducted to assess the distinct contributions of dissociation and emotion dysregulation in predicting various domains of cognitive functioning (i.e., executive functioning, processing speed, attention, declarative memory, intellectual functioning, and subjective report of cognitive functioning). All regression models account for PTSD severity and control for biological sex, patient status, and premorbid intelligence. I find that deficits in executive functioning, intellectual functioning, and processing speed are exacerbated by increasing symptoms of dissociation, after accounting for PTSD symptom severity. Additionally, processing speed and subjective cognitive impairment worsened with greater emotion dysregulation, after accounting for PTSD severity and dissociation. Taken together, findings from Chapters 2 and 3 suggest that trauma-related dissociation uniquely contribute to severe clinical presentations by disrupting affective, cognitive, and daily functioning, in ways distinct from PTSD severity alone.

In Chapter 4, I attempt to disentangle the specific role of dissociation from other relevant correlates by training machine learning models to predict PTSD-related illness in a real-world sample (i.e., current or former military members, veterans, public safety personnel, and civilians seeking treatment for PTSD in Canada). The machine learning models accurately predict PTSD-related illness in a novel subset of patients with unseen data, accounting for 43% of the variance in PTSD symptom severity scores and 32% of the variance in functional impairment. Self-reported symptoms of anxiety, dissociation, negative trauma-related cognitions, depression, and emotion dysregulation emerged as the most important predictors of PTSD symptom severity. When predicting functional impairment, the most important predictors include self-reported symptoms of anxiety, PTSD severity, cognitive dysfunction, dissociation, and depression. Findings from my dissertation studies demonstrate that dissociation is central to trauma-related

illness and may help to inform innovative treatment approaches for PTSD. This underscores the need to integrate dissociation into our prevailing understanding of PTSD, which has traditionally focused on classic PTSD presentations.

References

Alisic, E., Zalta, A. K., Van Wesel, F., Larsen, S. E., Hafstad, G. S., Hassanpour, K., & Smid, G. E. (2014). Rates of post-traumatic stress disorder in trauma-exposed children and adolescents: meta-analysis. *The British Journal of Psychiatry*, *204*(5), 335-340. http://dx.doi.org/10.1192/bjp.bp.113.131227

American Psychiatric Association. (1980) Diagnostic and statistical manual of mental disorders (3rd Edition) (DSM-III). American Psychiatric Association, Washington DC.

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders. (5th ed.). https://doi.org/10.1176/appi.books.9780890425596

Armour, C., Karstoft, K. I., & Richardson, J. D. (2014). The co-occurrence of PTSD and dissociation: Differentiating severe PTSD from dissociative-PTSD. *Social Psychiatry and Psychiatric Epidemiology*, *49*(8), 1297–1306. https://doi.org/10.1007/s00127-014-0819-y

Atchley, R., & Bedford, C. (2021). Dissociative symptoms in posttraumatic stress disorder: A systematic review. *Journal of Trauma & Dissociation*, *22*(1), 69-88. http://dx.doi.org/10.1080/15299732.2020.1760410

Bae, H., Kim, D., & Park, Y. C. (2016). Dissociation predicts treatment response in eye-movement desensitization and reprocessing for posttraumatic stress disorder. *Journal of Trauma & Dissociation*, *17*(1), 112-130. http://dx.doi.org/10.1080/15299732.2015.1037039

Bennett, D. C., Modrowski, C. A., Kerig, P. K., & Chaplo, S. D. (2015). Investigating the Dissociative Subtype of Posttraumatic Stress Disorder in a Sample of Traumatized Detained Youth. *Psychological Trauma: Theory, Research, Practice, and Policy*, *7*(4), 465. https://doi.org/http://dx.doi.org/10.1037/tra0000057

Berger, W., Figueira, I., Sá, S. De, Janeiro, R. De, Marques-portella, C., Sá, S. De, … Janeiro, R. De. (2012). Rescuers at risk: a systematic review and meta-regression analysis of the worldwide current prevalence and correlates of PTSD in rescue workers. *Soc Psychiatry Psychiatr Epidemiol*, *47*(6), 1001–1011. https://doi.org/10.1007/s00127-011-0408-2.

Berger, W., Mendlowicz, M. V., Marques-Portella, C., Kinrys, G., Fontenelle, L. F., Marmar, C. R., & Figueira, I. (2009). Pharmacologic alternatives to antidepressants in posttraumatic stress disorder: a systematic review. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, *33*(2), 169-180. http://dx.doi.org/10.1016/j.pnpbp.2008.12.004

Bernstein, E.M., & Putnam, F.W. (1986). Development, reliability, and validity of a dissociation scale. *Journal of Nervous and Mental Disease, 174*(12),727-734. http://dx.doi.org/10.1097/00005053-198612000-00004

Chekroud, A. M., Bondar, J., Delgadillo, J., Doherty, G., Wasil, A., Fokkema, M., ... & Choi, K. (2021). The promise of machine learning in predicting treatment outcomes in psychiatry. *World Psychiatry*, *20*(2), 154-170. http://dx.doi.org/10.1002/wps.20882

Blais, R. K., Hoerster, K. D., Malte, C., Hunt, S., & Jakupcak, M. (2014). Unique PTSD clusters predict intention to seek mental health care and subsequent utilization in US veterans with PTSD symptoms. *Journal of Traumatic Stress*, *27*(2), 168-174. http://dx.doi.org/10.1002/jts.21898

Bohus, M., Dyer, A. S., Priebe, K., Krüger, A., Kleindienst, N., Schmahl, C., ... & Steil, R. (2013). Dialectical behaviour therapy for post-traumatic stress disorder after childhood sexual abuse in patients with and without borderline personality disorder: A randomised controlled trial. *Psychotherapy and psychosomatics*, *82*(4), 221-233. http://dx.doi.org/10.1159/000348451

Bohus, M., Kleindienst, N., Hahn, C., Müller-Engelmann, M., Ludäscher, P., Steil, R., ... & Priebe, K. (2020). Dialectical Behavior Therapy for Posttraumatic Stress Disorder (DBT-PTSD) Compared With Cognitive Processing Therapy (CPT) in Complex Presentations of PTSD in Women Survivors of Childhood Abuse: A Randomized Clinical Trial. *JAMA Psychiatry*, *77*(12), 1235-1245. http://dx.doi.org/10.1001/jamapsychiatry.2020.2148

Boyd, J. E., Protopopescu, A., O'Connor, C., Neufeld, R. W., Jetly, R., Hood, H. K., ... & McKinnon, M. C. (2018). Dissociative symptoms mediate the relation between PTSD symptoms and functional impairment in a sample of military members, veterans, and first responders with PTSD. *European Journal of Psychotraumatology*, *9*(1), 1463794. http://dx.doi.org/10.1080/20008198.2018.1463794

Boyer, S. M., Caplan, J. E., & Edwards, L. K. (2022). Trauma-Related Dissociation and the Dissociative Disorders: Neglected Symptoms with Severe Public Health Consequences. *Delaware Journal of Public Health*, *8*(2), 78.

Brand, B. L. (2016). The necessity of clinical training in trauma and dissociation. *Journal of Anxiety and Depression*, *5*(4), 2167-1044. http://dx.doi.org/10.4172/2167-1044.1000251

Bradley, R., Greene, J., Russ, E., Dutra, L., & Westen, D. (2005). A multidimensional meta-analysis of psychotherapy for PTSD. *American Journal of Psychiatry*, *162*(2), 214-227. http://dx.doi.org/10.1176/appi.ajp.162.2.214

Briere, J., Weathers, F. W., & Runtz, M. (2005). Is dissociation a multidimensional construct? Data from the Multiscale Dissociation Inventory. *Journal of Traumatic Stress: Official Publication of the International Society for Traumatic Stress Studies*, *18*(3), 221-231. http://dx.doi.org/10.1002/jts.20024

da Silva, H. C., Vilete, L., Coutinho, E. S. F., Luz, M. P., Mendlowicz, M., Portela, C. M., ... & Berger, W. (2024). The role of childhood cumulative trauma in the risk of lifetime PTSD: an epidemiological study. *Psychiatry Research*, *336*, 115887.

De Bellis, M. D., & Zisk, A. (2014). The biological effects of childhood trauma. *Child and Adolescent Psychiatric Clinics*, *23*(2), 185-222. http://dx.doi.org/10.1016/j.chc.2014.01.002

Dell, P. F. (2006). The Multidimensional Inventory of Dissociation (MID): A comprehensive measure of pathological dissociation. *Journal of Trauma & Dissociation*, *7*(2), 77-106. http://dx.doi.org/10.1300/J229v07n02_06

Dwyer, D. B., Falkai, P., & Koutsouleris, N. (2018). Machine Learning Approaches for Clinical Psychology and Psychiatry. *Annual Review of Clinical Psychology, 14*, 91-118. https://doi.org/10.1146/annurev-clinpsy-032816-045037

Ebner-Priemer, U. W., Mauchnik, J., Kleindienst, N., Schmahl, C., Peper, M., Rosenthal, M. Z., ... & Bohus, M. (2009). Emotional learning during dissociative states in borderline personality disorder. *Journal of Psychiatry and Neuroscience*, *34*(3), 214-222.

Ehlers, A., & Clark, D. M. (2000). A cognitive model of posttraumatic stress disorder. *Behaviour Research and Therapy*, *38*(4). https://doi.org/10.1016/S0005-7967(99)00123-0

Fetzner, M. G., McMillan, K. A., & Asmundson, G. J. (2012). Similarities in specific physical health disorder prevalence among formerly deployed Canadian forces veterans with full and subsyndromal PTSD. *Depression and Anxiety*, *29*(11), 958-965.

Foa, E. B., Chrestman, K. R., & Gilboa-Schechtman, E. (2007). *Prolonged Exposure Therapy for Adolescents with PTSD Emotional Processing of Traumatic Experiences*. Oxford University Press.

Franzke, I., Wabnitz, P., & Catani, C. (2015). Dissociation as a mediator of the relationship between childhood trauma and nonsuicidal self-injury in females: A path analytic approach. *Journal of Trauma & Dissociation*, *16*(3), 286-302. http://dx.doi.org/10.1080/15299732.2015.989646

Frischholz, E., Braun, B. G., Sachs, R. G., Schwartz, D. R., Lewis, J., Shaeffer, D., ... & Pasquotto, J. (1991). Construct validity of the Dissociative experiences scale (DES): I. The relationship between the DES and other self-report measures of DES. *Dissociation: Progress in the Dissociative Disorders*, *4*(4), 185-188.

Galatzer-Levy, I. R., & Bryant, R. A. (2013). 636,120 ways to have posttraumatic stress disorder. *Perspectives on Psychological Science*, *8*(6), 651-662. https://doi.org/10.1177/1745691613504115

Gratz, K. L.,&Roemer, L. (2004).Multidimensional assessment of emotion regulation and dysregulation: Development, factor structure, and initial validation of the difficulties in emotion regulation scale. *Journal of Psychopathology and Behavioral Assessment, 26*(1), 41–54. https://doi.org/10.1023/B:JOBA.00000 07455.08539.94

Greene, T., Neria, Y., & Gross, R. (2016). Prevalence, detection and correlates of PTSD in the primary care setting: A systematic review. *Journal of Clinical Psychology in Medical Settings*, *23*(2), 160-180. http://dx.doi.org/10.1007/s10880-016-9449-8

Halligan, S. L., Michael, T., Clark, D. M., & Ehlers, A. (2003). Posttraumatic stress disorder following assault: The role of cognitive processing, trauma memory, and appraisals. *Journal of Consulting and Clinical Psychology, 71*(3). https://doi.org/10.1037/0022-006X.71.3.419

Harper, K. L., Moshier, S., Ellickson-Larew, S., Andersen, M. S., Wisco, B. E., Mahoney, C. T., Keane, T. M., Marx, B. P. (2022). A prospective examination of health care costs associated with posttraumatic stress disorder diagnostic status and symptom severity among veterans. *Journal of Traumatic Stress, 35,* 671-681. https://dx.doi.org/10.1002/jts.22785

Hayes, J. P., VanElzakker, M. B., & Shin, L. M. (2012). Emotion and cognition interactions in PTSD: a review of neurocognitive and neuroimaging studies. *Frontiers in Integrative Neuroscience*, *6*, 89. http://dx.doi.org/10.3389/fnint.2012.00089

Hogg, B., Gardoki-Souto, I., Valiente-Gómez, A., Rosa, A. R., Fortea, L., Radua, J., ... & Moreno-Alcázar, A. (2023). Psychological trauma as a transdiagnostic risk factor for mental disorder: an umbrella meta-analysis. *European Archives of Psychiatry and Clinical Neuroscience*, *273*(2), 397-410.

Huntjens, R. J. C., Dorahy, M. J., & van Wees-Cieraad, R. (2013). Dissociation and memory fragmentation. In F. Kennedy, H. Kennerley, & D. Pearson (Eds.), *Cognitive Behavioural Approaches to Understanding the Treatment of Dissociation* (pp. 92–103). Routledge.

Janet, P. (1889). *L'automatisme psychologique: essai de psychologie expérimentale sur les formes inférieures de l'activité humaine*. Alcan.

Kardiner, A. (1942). The Traumatic Neuroses of War. *Science and Society*, *6*(1).

Kleim, B., Wallott, F., & Ehlers, A. (2008). Are Trauma Memories Disjointed from other Autobiographical Memories in Posttraumatic Stress Disorder? An Experimental Investigation. *Behavioural and Cognitive Psychotherapy*, *36*(2), 221-234. http://dx.doi.org/10.1017/S1352465807004080.

Knowles, K. A., Sripada, R. K., Defever, M., & Rauch, S. A. (2019). Comorbid mood and anxiety disorders and severity of posttraumatic stress disorder symptoms in treatment-seeking veterans. *Psychological Trauma: Theory, Research, Practice, and Policy*, *11*(4), 451. http://dx.doi.org/10.1037/tra0000383

Lanius, R. A. (2015). Trauma-related dissociation and altered states of consciousness: a call for clinical, treatment, and neuroscience research. *European Journal of Psychotraumatology*, *6*(1), 27905. http://dx.doi.org/10.3402/ejpt.v6.27905

Lanius, R. A., Bluhm, R., Lanius, U., & Pain, C. (2006). A review of neuroimaging studies in PTSD: Heterogeneity of response to symptom provocation. *Journal of Psychiatric Research*, *40*(8), 709–729. https://doi.org/10.1016/j.jpsychires.2005.07.007

Lanius, R. A, Brand, B., Vermetten, E., Frewen, P. A., & Spiegel, D. (2012). The dissociative subtype of posttraumatic stress disorder: Rationale, clinical and neurobiological evidence, and implications. *Depression and Anxiety*, *29*(8), 701–708. https://doi.org/10.1002/da.21889

Lanius, R. A., Vermetten, E., Loewenstein, R. J., Brand, B., Schmahl, C., Bremner, J. D., & Spiegel, D. (2010). Emotion modulation in PTSD: Clinical and neurobiological evidence for a dissociative subtype. *American journal of psychiatry*, *167*(6), 640-647. http://dx.doi.org/10.1176/appi.ajp.2009.09081168

Lebois, L. A., Harnett, N. G., van Rooij, S. J., Ely, T. D., Jovanovic, T., Bruce, S. E., ... & Ressler, K. J. (2022). Persistent dissociation and its neural correlates in predicting outcomes after trauma exposure. *American Journal of Psychiatry*, *179*(9), 661-672.

Lee, D. J., Schnitzlein, C. W., Wolf, J. P., Vythilingam, M., Rasmusson, A. M., & Hoge, C. W. (2016). Psychotherapy versus pharmacotherapy for posttraumatic stress disorder:

Systemic review and meta-analyses to determine first-line treatments. *Depression and Anxiety*, *33*(9), 792-806. http://dx.doi.org/10.1002/da.22511

McKinnon, M. C., Boyd, J. E., Frewen, P. A., Lanius, U. F., Jetly, R., Richardson, J. D., & Lanius, R. A. (2016). A review of the relation between dissociation, memory, executive functioning and social cognition in military members and civilians with neuropsychiatric conditions. *Neuropsychologia*, *90*, 210–234. doi:10.1016/j.neuropsychologia.2016.07.017

Merz, J., Schwarzer, G., & Gerger, H. (2019). Comparative efficacy and acceptability of pharmacological, psychotherapeutic, and combination treatments in adults with posttraumatic stress disorder: a network meta-analysis. *JAMA Psychiatry, 76*(9), 904-913. https://doi.org/10.1001/jamapsychiatry.2019.0951

Najavits, L. M. (2015). The problem of dropout from" gold standard" PTSD therapies. *F1000prime Reports*, *7*, 43. http://dx.doi.org/10.12703/P7-43

Nester, M. S., Hawkins, S. L., & Brand, B. L. (2022). Barriers to accessing and continuing mental health treatment among individuals with dissociative symptoms. *European Journal of Psychotraumatology*, *13*(1). http://dx.doi.org/10.1080/20008198.2022.2031594

Olatunji, B. O., Cisler, J. M., & Tolin, D. F. (2007). Quality of life in the anxiety disorders: a meta-analytic review. *Clinical Psychology Review*, *27*(5), 572-581. http://dx.doi.org/10.1016/j.cpr.2007.01.015

Pacella, M. L., Hruska, B., & Delahanty, D. L. (2013). The physical health consequences of PTSD and PTSD symptoms: a meta-analytic review. *Journal of Anxiety Disorders*, *27*(1), 33-46. http://dx.doi.org/10.1016/j.janxdis.2012.08.004

Panagioti, M., Gooding, P. A., Triantafyllou, K., & Tarrier, N. (2015). Suicidality and posttraumatic stress disorder (PTSD) in adolescents: a systematic review and meta-analysis. *Social Psychiatry and Psychiatric Epidemiology, 50*(4), 525-537. http://dx.doi.org/10.1007/s00127-014-0978-x

Powers, A., Cross, D., Fani, N., & Bradley, B. (2015). PTSD, emotion dysregulation, and dissociative symptoms in a highly traumatized sample. *Journal of Psychiatric Research, 61*. https://doi.org/10.1016/j.jpsychires.2014.12.011

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?. *The Journal of Neuropsychiatry and Clinical Neurosciences*, *23*(1), 16-28. http://dx.doi.org/10.1176/appi.neuropsych.23.1.16

Resick, P. A., Galovski, T. E., Uhlmansiek, M. O. B., Scher, C. D., Clum, G. A., & Young-Xu, Y. (2008). A Randomized Clinical Trial to Dismantle Components of Cognitive Processing Therapy for Posttraumatic Stress Disorder in Female Victims of Interpersonal Violence. *Journal of Consulting and Clinical Psychology*, 76(2). https://doi.org/10.1037/0022-006X.76.2.243

Rivera-Vélez, G. M., González-Viruet, M., Martínez-Taboas, A., & Pérez-Mojica, D. (2014). Post-traumatic stress disorder, dissociation, and neuropsychological performance in latina victims of childhood sexual abuse. *Journal of Child Sexual Abuse, 23*(1), 55–73. https://doi.org/10.1080/10538712.2014.864746

Roca, V., Hart, J., Kimbrell, T., & Freeman, T. (2006). Cognitive function and dissociative disorder status among veteran subjects with chronic posttraumatic stress disorder: A

preliminary study. *The Journal of Neuropsychiatry and Clinical Neurosciences*, *18*(2), 226-230. http://dx.doi.org/10.1176/jnp.2006.18.2.226

Sareen, J. (2014). Posttraumatic stress disorder in adults: impact, comorbidity, risk factors, and treatment. *The Canadian Journal of Psychiatry*, *59*(9), 460-467. http://dx.doi.org/10.1177/070674371405900902

Sareen, J., Cox, B. J., Stein, M. B., Afifi, T. O., Fleet, C., & Asmundson, G. J. (2007). Physical and mental comorbidity, disability, and suicidal behavior associated with posttraumatic stress disorder in a large community sample. *Psychosomatic Medicine*, *69*(3), 242-248.

Scalabrini, A., Mucci, C., Esposito, R., Damiani, S., & Northoff, G. (2020). Dissociation as a disorder of integration–On the footsteps of Pierre Janet. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, *101*, 109928. https://doi.org/10.1016/j.pnpbp.2020.109928

Schuitevoerder, S., Rosen, J. W., Twamley, E. W., Ayers, C. R., Sones, H., Lohr, J. B., ... & Thorp, S. R. (2013). A meta-analysis of cognitive functioning in older adults with PTSD. *Journal of Anxiety Disorders*, *27*(6), 550-558. http://dx.doi.org/10.1016/j.janxdis.2013.01.001

Scoglio, A. A., Reilly, E. D., Girouard, C., Quigley, K. S., Carnes, S., & Kelly, M. M. (2022). Social functioning in individuals with post-traumatic stress disorder: A systematic review. *Trauma, Violence, & Abuse*, *23*(2), 356-371. http://dx.doi.org/10.1177/1524838020946800

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. http://dx.doi.org/10.1037/a0038039

Seligowski, A. V., Lee, D. J., Bardeen, J. R., & Orcutt, H. K. (2014). Emotion regulation and posttraumatic stress symptoms: A meta-analysis. *Cognitive Behaviour Therapy*, *44*(2), 87-102.

Simeon, D., Giesbrecht, T., Knutelska, M., Smith, R. J., & Smith, L. M. (2009). Alexithymia, absorption, and cognitive failures in depersonalization disorder: a comparison to posttraumatic stress disorder and healthy volunteers. *The Journal of Nervous and Nental Disease*, *197*(7), 492-498. http://dx.doi.org/10.1097/NMD.0b013e3181aaef6b

Smith, J. R., Workneh, A., & Yaya, S. (2020). Barriers and facilitators to help-seeking for individuals with posttraumatic stress disorder: A systematic review. *Journal of Traumatic Stress*, *33*(2), 137-150. http://dx.doi.org/10.1002/jts.22456

Stewart, S. H., Mitchell, T. L., Wright, K. D., & Loba, P. (2004). The relations of PTSD symptoms to alcohol use and coping drinking in volunteers who responded to the Swissair Flight 111 airline disaster. *Journal of Anxiety Disorders*, *18*(1), 51–68. https://doi.org/10.1016/j.janxdis.2003.07.006

Stein, D. J., Koenen, K. C., Friedman, M. J., Hill, E., McLaughlin, K. A., Petukhova, M., ... & Kessler, R. C. (2013). Dissociation in posttraumatic stress disorder: evidence from the world mental health surveys. *Biological Psychiatry*, *73*(4), 302-312. http://dx.doi.org/10.1016/j.biopsych.2012.08.022

Tsai, J., Armour, C., Southwick, S. M., & Pietrzak, R. H. (2015). Dissociative subtype of DSM-5 posttraumatic stress disorder in U.S. veterans. *Journal of Psychiatric Research*, *66–67*, 67–74. https://doi.org/10.1016/j.jpsychires.2015.04.017

van der Kolk, B. A., Hodgdon, H., Gapen, M., Musicaro, R., Suvak, M. K., Hamlin, E., & Spinazzola, J. (2016). A randomized controlled study of neurofeedback for chronic PTSD. *PloS one, 11*(12), e0166752. http://dx.doi.org/10.1371/journal.pone.0166752

Watts, B. V., Schnurr, P. P., Mayo, L., Young-Xu, Y., Weeks, W. B., & Friedman, M. J. (2013). Meta-analysis of the efficacy of treatments for posttraumatic stress disorder. *The Journal of Clinical Psychiatry, 74*(6), 541-550. http://dx.doi.org/10.4088/JCP.12r08225

White, W. F., Burgess, A., Dalgleish, T., Halligan, S., Hiller, R., Oxley, A., ... & Meiser-Stedman, R. (2022). Prevalence of the dissociative subtype of post-traumatic stress disorder: a systematic review and meta-analysis. *Psychological Medicine,* 1-16. http://dx.doi.org/10.1017/S0033291722001647

Wolf, E. J., Lunney, C. A., Miller, M. W., Resick, P. A., Friedman, M. J., & Schnurr, P. P. (2012a). The dissociative subtype of PTSD: A replication and extension. *Depression and Anxiety, 29*(8), 679–688. doi:10.1002/ da.21946

Wolf, E. J., Miller, M., Reardon, A., Ryabchenko, K. A., Castillo, D., & Freund, R. (2012b). A latent class analysis of dissociation and posttraumatic stress disorder. *Archives of General Psychiatry, 69* (7), 698–705. doi:10.1001/archgenpsychiatry.2011.1574

Wolf, E. J., Mitchell, K. S., Sadeh, N., Hein, C., Fuhrman, I., Pietrzak, R. H., & Miller, M. W. (2017). The dissociative subtype of PTSD scale: Initial evaluation in a national sample of trauma-exposed veterans. *Assessment*, *24*(4), 503-516. http://dx.doi.org/10.1177/1073191115615212

Chapter 2:

Dissociative symptoms predict severe illness presentation in Canadian public safety personnel with presumptive post-traumatic stress disorder (PTSD)

Park, A. H., Protopopescu, A., Pogue, M. E., Boyd, J. E., O'Connor, C., Lanius, R. A., & McKinnon, M. C. (2021). Dissociative symptoms predict severe illness presentation in Canadian public safety personnel with presumptive post-traumatic stress disorder (PTSD). *European Journal of Psychotraumatology*, *12*(1), 1953789. https://doi.org/10.1080/20008198.2021.1953789

Abstract

Background

Post-traumatic stress disorder affects 9% of individuals across their lifetime and increases nearly fourfold to 35% in Canadian public safety personnel (PSP). On-the-job experiences of PSP frequently meet criteria for traumatic events, making these individuals highly vulnerable to exposures of trauma and the negative consequences of PTSD. Few studies have reported on the clinical characteristics of Canadian samples of PSP and even fewer have examined the dissociative subtype of PTSD, which is associated with more severe, chronic traumatic experiences, and worse outcomes.

Objective

This study aimed to characterize dissociative symptoms, PTSD symptom severity, and other clinical variables among Canadian PSP with presumptive PTSD.

Methods

We sampled current and past PSP in Canada from both inpatient and outpatient populations (N = 50) that were enrolled in a psychological intervention. Only baseline testing data (prior to any intervention) were analysed in this study, such as PTSD symptom severity, dissociative symptoms, emotion dysregulation, and functional impairment.

Results

In our sample, 24.4% self-reported elevated levels of dissociation, specifically symptoms of depersonalization and derealization. Depersonalization and derealization symptoms were associated with more severe PTSD symptoms, greater emotion dysregulation, and functional impairment.

Conclusions

Nearly a quarter of this sample of Canadian PSP reported experiencing elevated levels of PTSD-related dissociation (depersonalization and derealization). These high levels of depersonalization and derealization were consistently positively associated with greater illness severity across clinical measures. It is imperative that dissociative symptoms be better recognized in patient populations that are exposed to chronic traumatic events such as PSP, so that treatment interventions can be designed to target a more severe illness presentation.

Highlights

24.4% of traumatized Canadian public safety personnel reported elevated levels of depersonalization and derealization, which was associated with a severe illness profile characterized by greater trauma symptoms, emotional dysregulation, and difficulty with life tasks.

Introduction

Public safety personnel (PSP), which include firefighters, police officers, paramedics, search and rescue personnel, emergency service workers, and ambulance personnel have a higher prevalence of post-traumatic stress disorder (PTSD) than civilian populations (Berger et al., 2012; Petrie et al., 2018). In Canada, PSP also include correctional employees, dispatch personnel, operational and intelligence personnel, Indigenous emergency managers, and the Royal Canadian Mounted Police (RCMP). The pervasiveness of PTSD in PSP is not surprising given many of the events experienced on-the-job, such as witnessing multiple casualties and human violence, meet the DSM-5 criteria for traumatic events (American Psychiatric Association, 2013; Berger et al., 2012; Carleton et al., 2019; Neuner et al., 2004). A systematic review comprising 20,424 rescue workers from 40 samples found that their pooled prevalence rate of PTSD worldwide is 10%, with rates reaching 46% in some studies (Berger et al., 2012; Stewart, Mitchell, Wright, & Loba, 2004). In a large Canadian sample, 44.5% of PSP screened positively for a mental disorder, including PTSD, anxiety, panic disorder, and persistent depressive disorder, with 23.2% specifically meeting criteria for PTSD (Carleton, Afifi, Turner, Duranceau, et al., 2018a). It is estimated that 10–35% of PSP in Canada will meet criteria for PTSD, with the Standing committee on Public Safety and National Security (2016) having declared PTSD in PSP as a foremost public safety issue.

Direct and repeated exposure to highly traumatic events is a risk factor for greater PTSD symptom severity and for *dissociation*, which is present in 15–30% of individuals with PTSD (Armour, Karstoft, & Richardson, 2014; Lanius, Bluhm, Lanius, & Pain, 2006; Lanius et al., 2001; McKinnon et al., 2016; Tsai, Armour, Southwick, & Pietrzak, 2015; Wolf et al., 2012a, 2012b). Dissociation is thought to be a psychological response to cope with or escape from extremely severe or chronic traumatic experiences. The dissociative subtype of PTSD, characterized by a

sense of *depersonalization* and *derealization*, involves feeling detached from one's own body or feeling as if the outside world is not real (American Psychiatric Association, 2013). Among the 1484 U.S. military veterans, those with the dissociative subtype of PTSD had experienced significantly more potentially traumatic events compared to those without the subtype and trauma-exposed controls (Tsai et al., 2015). Dissociation experienced during the occurrence of or immediately after the traumatic event (peritraumatic dissociation) is also predictive of the development of PTSD, particularly among treatment-seeking samples (Ozer, Best, Lipsey, & Weiss, 2003). In a sample of 223 junior police officers and 132 Canadian police officers, respectively, peritraumatic dissociation has been identified as the most significant risk factor for developing post-traumatic stress symptoms (Hodgins, Creamer, & Bell, 2001), as well as both full and sub-syndromal PTSD (Martin, Marchand, Boyer, & Martin, 2009). Moreover, in a Canadian sample of 432 treatment seeking military veterans, greater dissociation severity was associated with greater PTSD severity (Armour et al., 2014).

Dissociation and PTSD symptom severity are also significantly higher among individuals who have experienced childhood sexual abuse than those without this history (Carlson, Yates, & Sroufe, 2009; Frewen, Zhu, Lanius, & Frewen, 2019; Rivera-Vélez, González-Viruet, Martínez-Taboas, & Pérez-Mojica, 2014; Steuwe, Lanius, & Frewen, 2012). Findings that early childhood adversity positively correlates with dissociation in adulthood (Wolf et al., 2012b) suggest that the early onset of trauma in vulnerable youth populations may be associated with the development of psychopathological patterns of coping and emotion regulation (D'Andrea, Ford, Stolbach, Spinazzola, & van der Kolk, 2012). Emotion regulation is particularly impaired in those with dissociative symptoms (Bennett, Modrowski, Kerig, & Chaplo, 2015; Lanius et al., 2010; Powers, Cross, Fani, & Bradley, 2015) and compelling neuroimaging research demonstrates that

dissociative symptoms may arise from emotion overmodulation due to prefrontal inhibition of limbic regions (Lanius et al., 2018, 2010). Abnormally high activation in the prefrontal regions that modulate arousal and regulate emotion are specifically thought to be a response mechanism to deal with the overwhelming experience of trauma.

The above findings linking greater trauma severity in PTSD with high dissociation to a more severe illness course are consistent with evidence from the World Mental Health Surveys (Stein et al., 2013), demonstrating that dissociation is associated with increased PTSD symptoms and functional impairment, as well as self-harm and suicidality (Foote, Smolin, Neft, & Lipschitz, 2008). Recently, Boyd et al. (2018) identified dissociative symptoms as mediating the relation between PTSD symptom severity and functional impairment, underlining the importance of addressing dissociative symptoms for successful recovery and resumption of functional roles. Moreover, differences in symptom profiles between individuals with and without elevated levels of dissociative symptoms suggest that treatment efficacy and response may differ across subtypes (Cloitre, Petkova, Wang, & Lu, 2012; Lanius, Brand, Vermetten, Frewen, & Spiegel, 2012). Further complicating treatment is the finding that PTSD characterized by dissociative symptoms may be accompanied by psychiatric comorbidities. In fact, individuals diagnosed as having PTSD with dissociation are more likely than those without dissociation to meet criteria for depression, anxiety, and alcohol use problems, even when PTSD symptoms are controlled for (Tsai et al., 2015). Although in treatment-seeking samples, rates of psychiatric comorbidities are expected to be higher, little is known about rates of dissociation in Canadian PSP seeking treatment for PTSD.

Currently, there are only a few studies that have investigated PTSD and trauma-related mental health in a Canadian PSP sample (Carleton, Afifi, Turner, Duranceau, et al., 2018a; Carleton et al., 2019, 2018), and only one study to date has reported on dissociation and related

clinical characteristics of treatment-seeking Canadian PSP with PTSD (Boyd et al., 2018). We found that total dissociative symptoms and derealization significantly mediated the relation between PTSD symptoms and functional impairment in a sample of Canadian PSP, military members, and veterans (Boyd et al., 2018). We identified dissociative symptoms as the strongest correlate of functional impairment across our sample. However, only 27 participants were PSP, highlighting the importance of conducting this research among Canadian PSP who may be experiencing significantly reduced functional roles. Even within North America, Canada differs from the USA in the organizational structure of public safety, law enforcement, and use of emergency powers (Hebdon & Jalette, 2008; Scheppele, 2006), making it crucial to explore how post-traumatic stress affects Canadian front-line personnel. As a result, there is an urgent need to assess the relations between dissociative symptoms, PTSD severity, and other clinical characteristics among highly traumatized populations like Canadian PSP to better understand how individuals present and respond to PTSD treatment. The current study is designed to address such characteristics in a sample of Canadian PSP with a presumptive diagnosis of PTSD with the prediction that dissociation will be associated with a severe illness presentation. Specifically, it was hypothesized that PSP with higher levels of depersonalization and derealization would demonstrate more severe PTSD symptoms, elevated levels of emotion dysregulation, and reduced functional roles.

Method

Participants

This study investigated 50 patients who self-identified as current or former PSP (e.g. police, firefighters, paramedics) seeking treatment related to trauma exposure. The data were combined from a feasibility study in an inpatient unit, and a randomized control trial (RCT) within an

outpatient programme, both at the Post-Traumatic Stress Recovery programme at Homewood Health Centre, examining the efficacy of the same psychological intervention (i.e. Goal Management Training; Levine et al., 2011). Both studies were approved by the Homewood Health Centre Research Ethics board (REB #17-03 and REB #15-29, respectively). All individuals gave written consent to participate and those data discussed here were obtained from the baseline testing session prior to group commencement and group assignment. Individuals were eligible for the study if they were between the age of 18–65, could provide written informed consent, were fluent in written and spoken English, and had a presumptive diagnosis of PTSD as indicated by a score of 33 or higher on the PTSD Checklist for DSM-5 (PCL-5; Wortmann et al., 2016). Participants were ineligible if they had a medical disorder within the past 12 months known to adversely affect cognition. In the first dataset, inpatients were also ineligible if they were receiving treatment with anti-cholinergic or anti-psychotic medication, or have had electroconvulsive therapy within the past year (n = 24). In the second dataset, outpatients were ineligible if they indicated alcohol and/or substance abuse within the past 3 months (n = 64). These participants were recruited from multiple sites across Ontario including: The Post-Traumatic Stress Recovery (PTSR) programme at Homewood Health Centre, Homewood Health's outpatient clinics (e.g. Mississauga Clinic), PTSR programme's external referral agencies that also serve clients via outpatient services/programmes (e.g. Military Family Resource Centres), external community agencies and support groups (e.g. KW Counselling Services, Military Casualty Support Foundation, Project Trauma Support, etc.), and social media (e.g. Facebook groups, Twitter, etc.). From these two studies, 16 of the 24 inpatients and 34 of the 64 outpatients identified as being current and former PSP and denied they were a current or former military member or veteran. Therefore, a total of 50 individuals were eligible for and included in the current study.

Design

The baseline testing session lasted approximately four to six hours where a clinician obtained demographic information (age, sex, race, and years of education), and an estimate of premorbid intelligence using the Wechsler Test of Adult Reading (WTAR; Wechsler, 2001). An extensive battery of functional and clinical symptom measures was also administered.

Functional measures included the World Health Organization Disability Assessment Schedule 2.0 (WHODAS 2.0; World Health Organization, 2000). The WHODAS 2.0 is a 12-item self-report questionnaire on a 5-point Likert scale (1 = *none*, 5 = *extreme/cannot do*) that assesses difficulties in six functional domains including (1) cognition, (2) mobility, (3) self-care, (4) getting along with others, (5) life activities, and (6) participation in the community. Domain 1 assesses difficulties understanding and communicating with others, such as finding solutions to problems, understanding what people say, and starting and maintaining conversations. Domain 2 probes how difficult it is to stand up, sit down, move around inside the home, as well as get out of the home. Domain 3 asks about challenges in eating and being alone for a few days. Domain 4 assesses difficulties getting along with people, making new friends, and sexual activities. Domain 5 examines difficulties related to completing household tasks, including doing such tasks well and as quickly as needed. Finally, domain 6 probes problems related to barriers in their world, living with dignity, time spent on their health condition, financial drain, and family problems related to their health condition.

Other symptom-based measures included the PCL-5 (Weathers et al., 2013), a 20-item self-report questionnaire assessing the severity of DSM-5 PTSD symptom clusters. Intrusive symptoms included items related to memories, dreams, flashbacks, cued distress, and cued physical reactions. Avoidance symptoms referred to avoidance of internal and external reminders. Negative

alterations in mood and cognitions held items related to dissociative amnesia, negative beliefs, blame, negative feelings, loss of interest, detachment or estrangement, and numbing. Alterations of arousal and reactivity contained items related to irritability or aggressive behaviour, reckless behaviour, hypervigilance, startle, concentration, and sleep. The PCL-5 has been found to be a reliable and valid tool for detecting a PTSD diagnosis using a cut-off score of 33 (Wortmann et al., 2016). Among military veteran samples, the gold standard Clinician-Administered PTSD Scale for DSM-5 (CAPS-5) has shown good convergent validity with the PCL-5 (r = 0.66) for total PTSD severity scores, and signal detection analyses demonstrated that PCL-5 scores between 31 and 33 were optimally efficient in predicting a CAPS-5 diagnosis according to DSM-5 PTSD Criteria A-G (Bovin et al., 2016; Weathers et al., 2018).

The Multiscale Dissociation Inventory (MDI; Brière, 2002), a 30-item self-report inventory on a 5-point Likert scale (1 = *never*, 5 = *very often*), was used to measure dissociation. The MDI measures six domains of dissociation including disengagement (e.g. staring into space without thinking), depersonalization (e.g. feeling like you don't belong in your body), derealization (e.g. feeling like you were in a dream), emotional constriction (e.g. not being able to feel emotions), memory disturbance (e.g. having blank spells), and identity dissociation (e.g. different people taking charge inside of your mind). Because the MDI assesses dissociation symptoms more broadly, our study focused on the two subscales of depersonalization and derealization symptoms, which are specifically indicated in the diagnostic criteria for the dissociative subtype of PTSD (American Psychiatric Association, 2013; Dorahy & van der Hart, 2015; Lanius et al., 2012). Notably, the combined items of the depersonalization and derealization subscales of the MDI have been found to represent a single underlying dimension (Briere, Weathers, & Runtz, 2005).

Finally, the Difficulties in Emotion Regulation Scale (DERS; Roemer & Gratz, 2004) is a 36-item multidimensional measure on a 5-point Likert scale (1 = *almost never*, 5 = *almost always*) of difficulties in emotion regulation including nonacceptance of emotional responses, difficulty engaging in goal-directed behaviour, impulse control difficulties, lack of emotional awareness, limited access to emotion regulation strategies, and lack of emotional clarity.

Statistical Analyses

Statistical analyses were conducted using R version 4.0.0 (R Core Team, 2019). Missing values in the data were considered to be missing at random, with a total of 11.1% missing data. There were 21 out of 50 patients (42%) with incomplete data, of which patients were missing 2.3–72.1% of the values. The percentage of missing values across all variables ranged from 0.0% to 0.22%. Missing data were multiply imputed using multivariate imputation by chained equations using the 'mice' package (van Buuren & Groothuis-Oudshoorn, 2011). Multiple imputation replaces each missing value by a set of $m > 1$ plausible values and generates m complete datasets. Superior to a single imputation, multiple imputation with $m = 20$ has been reviewed as a highly effective way to estimate missing data points while accounting for uncertainty due to missing values (Graham, Olchowski, & Gilreath, 2007; Schafer & Graham, 2002). The following results were obtained from pooling the results of each of the 20 imputed datasets and combined using Rubin's rules (Rubin, 1987). Continuous variables in all regression models were scaled (mean set to 0) to allow for easier interpretation of the magnitude of effects, and all R^2 values were adjusted to account for multiple predictors. Due to the nature of multiple imputation, some patients for whom values were imputed may have been classified as having elevated levels of dissociation in some imputed datasets while not in others. As a result, the n referring to a subset of the sample was not always a whole number. Hence, percentages of the sample were additionally reported.

To examine levels of PTSD-related dissociation in the sample, we identified individuals as having elevated levels of dissociation if they had a depersonalization or derealization score that was 1 *SD* above the mean. Multiple linear regressions were conducted to test whether dissociation scores (derealization and depersonalization) significantly predict numerous clinical variables, while controlling for sex and patient status. Therefore, multiple linear regression models included dissociation score, sex (0 = *female*, 1 = *male*), and patient status (0 = *inpatient*, 1 = *outpatient*) as predictors, and the dependent variables tested are listed in Table 3. All the statistical tests were 2-tailed at $\alpha = 0.05$, 95% CI, $p < .05$, while the significance level for subscales were set at $p < .01$ to reduce Type I error.

Results

Demographic Characteristics

Age ranged from 34 to 60 years ($M = 44.9 \pm 6.7$), total years of education from 12 to 24 years ($M = 16.8 \pm 2.5$), and females made up 38.2% ($n = 19.1$) of the sample (Table 1). In this sample, 24.4% ($n = 12.2$) of individuals were identified as having elevated levels of dissociation, such that their depersonalization or derealization scores were at least 1 *SD* above their respective means (Table 2). Elevated levels of dissociation were present in 28.3% ($n = 14.2$) of females and in 22.0% ($n = 11$) of males. Inpatients accounted for 32.0% ($n = 16$) of the sample, within which 38.8% ($n = 6.2$) were classified as having elevated dissociation. Outpatients made up 68.0% ($n = 34$) of the sample, of which 17.6% ($n = 6$) had elevated dissociation. Age, years of education, and estimated premorbid intelligence (WTAR) did not significantly differ between the those with and without elevated dissociation ($p > .40$). Mean values are reported in Table 1 broken down by dissociation score, sex, and patient status.

Table 1

Demographic characteristics of the study sample

Characteristics	Mean (*SD*)			% of sample (*n*)
	Age	Education	WTAR	
Dissociation				
≥*M*+1*SD*	44.9 (6.4)	16.6 (2.1)	108.9 (10.8)	24.4 (12.2)
<*M*+1*SD*	44.9 (6.7)	16.9 (2.6)	111.1 (7.9)	75.6 (37.8)
Sex				
Female	44.1 (6.3)	17.1 (3.0)	110.8 (7.8)	38.2 (19.1)
Male	45.3 (7.0)	16.6 (2.2)	110.4 (9.4)	61.8 (30.9)
Patient status				
Inpatient	46.7 (6.2)	15.8 (2.3)	103.1 (9.8)	32.0 (16)
Outpatient	44.0 (6.8)	17.3 (2.5)	114.1 (5.4)	68.0 (34)

Table 1

Mean depersonalization and derealization scores of individuals with and without elevated levels of dissociation

	Mean (*SD*)		
Dissociation	≥*M*+1*SD*	<*M*+1*SD*	Total
Depersonalization	13.1 (3.8)	6.4 (1.7)	8.0 (3.8)
Derealization	14.5 (3.8)	6.9 (2.0)	8.7 (4.1)

Clinical Characteristics

Multiple regression results revealed that the dissociation score (depersonalization and derealization) significantly predicted total PCL-5 score (β= .43, p = .003) and explained 28.7% of the variance, controlling for sex and patient status (Table 3). Dissociation scores did not significantly predict PCL-5 subscales assessing reactivity/arousal, negative mood and cognition, intrusion, or avoidance symptoms ($p \geq .029$).

Table 2

Regression analyses summary for dissociation (depersonalization and derealization) predicting PTSD symptom severity (PCL-5), controlling for sex and patient status, N = *50*

PTSD symptom severity	Adj R^2	Predictor	β	*SE*	CI	*t (p)*
PCL-5 total	0.287	Dissociation	.43	.14	0.16 – 0.71	3.18 (.003)**
		Sex	-.21	.26	-0.74 – 0.32	-0.81 (.424)
		Patient status	-.69	.29	-1.28 – -0.11	-2.41 (.022)*
PCL-5 reactivity/arousal	0.216	Dissociation	.36	.16	0.04 – 0.69	2.32 (.029)*
		Sex	-.11	.32	-0.77 – 0.56	-0.33 (.741)
		Patient status	-.65	.32	-1.31 – 0.01	-2.02 (.053)
PCL-5 mood/cognitions	0.189	Dissociation	.31	.17	-0.05 – 0.68	1.81 (.086)
		Sex	-.15	.29	-0.74 – 0.44	-0.51 (.614)
		Patient status	-.68	.35	-1.40 – 0.03	-1.97 (.061)
PCL-5 intrusions	0.158	Dissociation	.36	.18	-0.02 – 0.73	1.98 (.062)
		Sex	-.27	.31	-0.90 – 0.35	-0.89 (.378)
		Patient status	-.40	.34	-1.10 – 0.31	-1.16 (.256)
PCL-5 avoidance	0.112	Dissociation	.28	.19	-0.11 – 0.68	1.49 (.153)
		Sex	-.23	.31	-0.86 – 0.40	-0.75 (.460)
		Patient status	-.44	.33	-1.11 – 0.23	-1.34 (.189)

*$p < .05$. **$p < .01$. ***$p < .001$

Total and subscale scores on the DERS were entered into multiple regression models, again controlling for sex and patient status (Table 4). Dissociation (depersonalization and derealization) significantly predicted the total DERS score (β= .44, p = .002) accounting for 21.3% of the variance. Depersonalization and derealization also significantly predicted DERS strategies subscale score (β= .39, p = .008), accounting for 18.2% of the variance. DERS subscales assessing

impulse control, clarity, nonacceptance, awareness, and goals were not significantly predicted by dissociation score ($p \geq .022$).

Table 3

Regression analyses summary for dissociation (depersonalization and derealization) predicting emotion dysregulation (DERS), controlling for sex and patient status, N = *50*

Emotion dysregulation	Adj R^2	Predictor	β	*SE*	CI	*t (p)*
DERS total	0.213	Dissociation	.44	.14	0.17 – 0.72	3.26 (.002)**
		Sex	.20	.28	-0.37 – 0.77	0.71 (.482)
		Patient status	-.45	.29	-1.04 – 0.15	-1.52 (.136)
DERS strategies	0.182	Dissociation	.39	.14	0.11 – 0.67	2.82 (.008)**
		Sex	.22	.30	-0.39 – 0.84	0.74 (.464)
		Patient status	-.47	.32	-1.12 – 0.18	-1.48 (.150)
DERS impulse control	0.149	Dissociation	.32	.15	0.01 – 0.63	2.14 (.040)*
		Sex	.40	.31	-0.22 – 1.02	1.32 (.196)
		Patient status	-.45	.34	-1.15 – 0.26	-1.30 (.206)
DERS clarity	0.129	Dissociation	.36	.15	0.06 – 0.66	2.41 (.022)*
		Sex	.20	.31	-0.42 – 0.82	0.64 (.525)
		Patient status	-.36	.34	-1.07 – 0.35	-1.05 (.303)
DERS nonacceptance	0.077	Dissociation	.33	.16	0.00 – 0.66	2.05 (.050)*
		Sex	-.20	.31	-0.84 – 0.43	-0.65 (.520)
		Patient status	-.05	.33	-0.72 – 0.62	-0.15 (.879)
DERS awareness	0.013	Dissociation	.24	.16	-0.08 – 0.55	1.52 (.138)
		Sex	-.02	.32	-0.67 – 0.63	-0.06 (.955)
		Patient status	-.08	.39	-0.89 – 0.73	-0.20 (.844)
DERS goals	0.069	Dissociation	.16	.16	-0.17 – 0.49	1.01 (.323)
		Sex	.29	.30	-0.32 – 0.89	0.96 (.342)
		Patient status	-.53	.34	-1.22 – 0.16	-1.57 (.126)

*$p < .05$. **$p < .01$. ***$p < .001$

On measures of functional impairment usingthe WHODAS 2.0, dissociation (depersonalization and derealization) significantly predicted total impairment score (β = .48, p = .001; Table 5) and accounted for 22.3% of the variance. WHODAS 2.0 subscales measuring getting along with people, understanding and communicating, life/household activities, participation in society, interference of difficulties on life, overall health, experiencing difficulty in the past 30 days, self-care, getting around were not significantly predicted by dissociation score ($p \geq .011$).

Table 4

Regression analyses summary for dissociation (depersonalization and derealization) predicting functional impairment (WHODAS 2.0), controlling for sex and patient status, N = *50*

Functional impairment	Adj R^2	Predictor	β	*SE*	CI	*t (p)*
WHODAS 2.0 total	0.223	Dissociation	.48	.13	0.21 – 0.74	3.63 (.001)***
		Sex	-.20	.28	-0.77 – 0.38	-0.70 (.491)
		Patient status	-.26	.29	-0.86 – 0.34	-0.88 (.384)
WHODAS 2.0 getting along	0.164	Dissociation	.40	.15	0.10 – 0.71	2.70 (.011)*
		Sex	.26	.30	-0.36 – 0.88	0.86 (.398)
		Patient status	-.32	.33	-1.01 – 0.36	-0.96 (.343)
WHODAS 2.0 understanding	0.143	Dissociation	.38	.16	0.04 – 0.72	2.31 (.029)*
		Sex	-.32	.30	-0.92 – 0.28	-1.07 (.290)
		Patient status	.12	.37	-0.65 – 0.88	0.31 (.757)
WHODAS 2.0 life activities	0.119	Dissociation	.28	.15	-0.03 – 0.59	1.84 (.075)
		Sex	-.40	.30	-1.01 – 0.21	-1.33 (.193)
		Patient status	-.40	.35	-1.12 – 0.32	-1.15 (.259)
WHODAS 2.0 society participation	0.108	Dissociation	.38	.15	0.07 – 0.70	2.48 (.019)*
		Sex	-.01	.31	-0.63 – 0.61	-0.03 (.978)
		Patient status	-.07	.34	-0.77 – 0.63	-0.20 (.841)
WHODAS 2.0 interference	0.107	Dissociation	.26	.16	-0.08 – 0.59	1.58 (.127)
		Sex	.04	.30	-0.57 – 0.65	0.14 (.888)
		Patient status	-.56	.39	-1.38 – 0.26	-1.42 (.171)
WHODAS 2.0 difficulty 30 days	0.052	Dissociation	.17	.18	-0.19 – 0.54	0.99 (.333)
		Sex	-.42	.32	-1.08 – 0.24	-1.29 (.206)
		Patient status	-.19	.39	-1.00 – 0.62	-0.49 (.630)
WHODAS 2.0 self-care	0.007	Dissociation	.23	.16	-0.10 – 0.55	1.43 (.161)
		Sex	-.05	.32	-0.70 – 0.61	-0.14 (.889)
		Patient status	-.10	.35	-0.81 – 0.61	-0.29 (.772)
WHODAS 2.0 getting around	0.005	Dissociation	.17	.15	-0.15 – 0.48	1.09 (.284)
		Sex	-.29	.31	-0.92 – 0.35	-0.92 (.365)
		Patient status	-.14	.36	-0.89 – 0.60	-0.40 (.694)
WHODAS 2.0 overall health	0.000	Dissociation	.07	.17	-0.28 – 0.42	0.43 (.672)
		Sex	-.02	.32	-0.68 – 0.64	-0.05 (.958)
		Patient status	.05	.40	-0.78 – 0.87	0.12 (.905)

*$p < .05$. **$p < .01$. ***$p < .001$

Discussion

In line with previous research that estimates 15–30% of individuals with PTSD experience the dissociative subtype, we found that 24.4% of individuals in our sample were characterized as having elevated levels of dissociation (Armour et al., 2014; Lanius et al., 2006, 2010, 2001;

McKinnon et al., 2016; Stein et al., 2013; Tsai et al., 2015; Wolf et al., 2012a, 2012b). The prevalence of dissociative symptoms in our sample suggests that PSP may, like military samples, experience a high burden of PTSD-related illness. Moreover, we found that more severe symptoms of depersonalization and derealization were associated with a heightened burden of illness, including greater PTSD symptom severity, emotion dysregulation, and functional impairment, a finding that was maintained after controlling for sex.

Importantly, PSP who experienced elevated depersonalization and derealization symptoms appeared to experience greater difficulty regulating their emotions, suggesting that dissociative symptoms may impact upon emotional regulation in this population. Our results suggest that those who experience depersonalization and derealization symptoms may be less able to regulate their emotions (DERS strategies). Interestingly, Powers et al. (2015) found that both strategies and clarity were the only DERS subscales significantly predicting dissociative symptoms in a sample of 154 trauma-exposed individuals. These findings are in line with the common symptom profile of the dissociative subtype of PTSD, which is marked by emotional detachment, numbness, and blunted arousal. Such notions would also be consistent with dissociation being strongly negatively correlated with self-concept clarity (Evans, Reid, Preston, Palmier-Claus, & Sellwood, 2015), as well as cognitive reappraisal gains being partially dependent on having increased emotional clarity (Boden, Bonn-Miller, Kashdan, Alvarez, & Gross, 2012). This appears to be supported by an RCT evaluating changes in PTSD symptoms and diagnosis among 121 chronic PTSD patients randomly assigned to cognitive therapy, waitlist, or emotion-focused supportive therapy, which targeted clarifying the patient's emotions without cognitive restructuring or elaboration of the trauma memories (Ehlers et al., 2014). They found that 43% of the patients that received 12-week emotion-focused supportive therapy no longer met criteria for PTSD post-treatment, and 40% did not meet

criteria for PTSD at week 40. Individuals with elevated levels of trauma-related dissociation may therefore benefit from treatment building strategies that facilitate emotional awareness (e.g. through the use of body scans; Frewen & Lanius, 2015) and regulation of emotions.

One such treatment targeting emotion regulation is dialectical behaviour therapy (DBT) which was developed, and remains the gold standard treatment, for individuals with borderline personality disorder (BPD; Lynch, Trost, Salsman, & Linehan, 2007). Individuals with BPD who receive DBT have demonstrated significantly steeper declines in both emotional dysregulation and self-harm incidents compared to those receiving treatment focused on mentalizing (mentalization-based therapy) the states of self and of others (Barnicot & Crawford, 2019). This treatment has also been adapted for individuals suffering from PTSD (Bohus et al., 2013, 2020) and has been shown to be effective in reducing emotion dysregulation. Here, Bohus et al. (2013) evaluated the efficacy of a 12-week residential programme of DBT for PTSD in a sample of treatment-resistant female patients with an index trauma of childhood sexual abuse. Although approximately half of these patients had comorbid BPD, their PTSD symptoms improved substantially after treatment completion as compared to a treatment-as-usual waitlist control group. More recently, Bohus et al. (2020) conducted a multicentre RCT comparing the efficacy of DBT for PTSD to Cognitive Processing Therapy (CPT), a leading evidence-based treatment for PTSD targeting unhelpful trauma-related cognitions (Resick et al., 2008; Watts et al., 2013). Researchers randomized a sample of 193 treatment-seeking women with childhood abuse-related PTSD, BPD symptoms, and affective instability, to either DBT-PTSD or CPT, and found that both groups showed significant improvements in PTSD symptoms. Interestingly, DBT-PTSD outperformed CPT on several other measures, with more pronounced improvements in PTSD symptoms, significantly steeper decreases in the intensity of dissociative symptoms, and greater rates of symptom remission

(Bohus et al., 2020). Taken together, these findings highlight the potential efficacy of therapies facilitating emotion regulation, such as DBT, in reducing dissociative symptoms in severe PTSD, even in the presence of other complex clinical conditions.

In the present study, functional impairment (WHODAS 2.0) was also strongly associated with depersonalization and derealization symptoms, accounting for nearly a quarter of the variance in functional outcomes in this sample. Here, a number of specific functional subdomains approached significance ($.011 \leq p \leq .029$), including getting along with other people, understanding and communicating, and participation in society, all of which concern social life (e.g. the ability to deal with people they did not know, maintaining friendships, finding solutions to problems, understanding what people say, starting and maintaining conversations, joining in community activities). Given these findings, it appears probable that individuals with severe dissociative symptoms may experience difficulties, in particular, with social functioning. Studies by Nazarov et al. (2014, 2015) found impaired performance on tests of social cognition among those with PTSD experiencing dissociative symptoms. Specifically, identity dissociation, amnesia, and disengagement symptoms were associated with reduced accuracy in identifying positive and neutral mental states from facial expressions, poor performance in accurately identifying kinship relationships using verbal and non-verbal cues from a social scene (Nazarov et al., 2014). Identity dissociation and depersonalization (and derealization, marginally) were also associated with reduced accuracy in identifying emotions based on prosody (Nazarov et al., 2015). Interestingly, the odds of screening positively for social anxiety disorder has been associated with increased frequency of exposure to traumatic events among Canadian PSP (Carleton et al., 2019). Accordingly, it will be important to carefully assess levels of social resources and social functioning among individuals with PTSD who present clinically, particularly when dissociative

symptoms are prominent. This is particularly concerning as social support and seeking support coping have been found to contribute to posttraumatic growth (Prati & Pietrantoni, 2009) as well as recovery from PTSD (Dai et al., 2016).

Despite careful design of the study, it comes with its limitations. We did not employ a clinician-administered interview to diagnose PTSD and instead relied on a self-report PCL-5 for a provisional PTSD diagnosis. Although the PCL-5 is considered a reliable and valid method of detecting PTSD, our study may have been strengthened by a clinician-confirmed diagnosis of PTSD using a more structured interview (Wortmann et al., 2016). Due to the small sample size, this study collapsed all PSP into one group (including firefighters, police officers, and ambulance personnel). As a result, the effect of subgroups could not be further explored, thus limiting our ability to determine whether some occupations may be at greater risk of developing dissociative symptoms than others. A recent study suggestive of differential rates of mental disorders among Canadian PSP where RCMP, paramedics, and correctional workers were at greater risk of developing most mental disorders than firefighters and police officers (Carleton, Afifi, Turner, Duranceau, et al., 2018a). Systematic reviews of the literature also indicate that PTSD prevalence rates may vary slightly by occupational group: 7–19% in law enforcement, 17–22% in firefighters, 13.34–15.56% in dispatchers (Klimley, Van Hasselt, & Stripling, 2018), and 20% in ambulance service populations (Sterud, Ekeberg, & Hem, 2006). A larger sample size may also have enhanced our ability to detect the dissociative subtype using the conservative T-score cut-off greater than or equal to 80 on subscales of the MDI (Brière, 2002; Herzog, DePierro, & D'Andrea, 2018). This would have created an expectedly greater variance in dissociative symptom presentations that may have allowed for a greater range of MDI scores.

In addition, we were unable to study histories of childhood trauma because the two inpatient and outpatient samples employed different measures which could not be reliably compared. Childhood emotional, physical, and sexual abuse are considered to play important roles in dissociative symptoms and PTSD severity and would have been highly relevant to our study (Bennett et al., 2015; Herzog et al., 2018; Powers et al., 2015). Nonetheless, we investigated other variables that have been indirectly associated with childhood trauma such as emotion regulation, which was found to be significantly dysregulated among those who experience elevated levels of dissociation.

Despite these limitations, our data point towards a severe clinical symptom presentation among traumatized PSP who experience dissociative symptoms, with consistent patterns observed across clinical measures assessing PTSD symptom severity, emotion regulation skills, and impairment in important life domains. Our findings are in line with existing literature where we report comparable proportions of individuals diagnosed with and without the dissociative subtype of PTSD, as have been observed in past samples. The complexity of treating and managing a severe illness presentation such as highly dissociative PTSD is compounded by the high comorbidity rates of psychiatric disorders. Rates of comorbidity in PTSD range from 62% to 92%, and commonly include major depressive disorder, panic disorder, generalized anxiety disorder, social anxiety disorder, specific phobias, and alcohol and substance use disorders (Brown, Campbell, Lehman, Grisham, & Mancill, 2001). Certain dual diagnoses like social anxiety disorder with dissociative PTSD may pose a serious risk if they make social support less accessible or relationships more difficult to manage, especially if dissociative symptoms are already associated with significantly reduced functional roles and severe emotion dysregulation as found in our study. Our findings capture an important population in Canada that is understudied yet experience persistent traumatic

events that have severe implications for individual well-being and the healthcare system. Improving our understanding of how dissociative symptoms impact emotional adjustment, functioning in daily life, and vulnerability to other mental illnesses will have important implications for identifying specific treatment needs when PTSD presents with dissociation.

Disclosure statement

The authors do not have any conflicts of interest to report.

Funding

This work was supported by the Homewood Chair in Mental Health and Trauma at McMaster University, the Harris-Woodman Chair in Psyche and Soma, and Mitacs. We are grateful to the Homewood Research Institute for their generous infrastructure support of this research and to Homewood Health Centre for allowing us access to their inpatient treatment setting.

Data Availability Statement

Due to the ethical concerns of publicly sharing private patient data, supporting data from this study is not available.

References

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders. *Arlington* (5th Edition: DSM-5). doi:10.1176/appi.books.9780890425596.893619

Armour, C., Karstoft, K.-I., & Richardson, J. D. (2014). The co-occurrence of PTSD and dissociation: Differentiating severe PTSD from dissociative-PTSD. *Social Psychiatry and Psychiatric Epidemiology*, *49*(8), 1297–1306. doi:10.1007/s00127-014-0819-y

Barnicot, K., & Crawford, M. (2019). Dialectical behaviour therapy v. mentalisation-based therapy for borderline personality disorder. *Psychological Medicine*, *49*(12), 2060–2068. doi:10.1017/S0033291718002878

Bennett, D. C., Modrowski, C. A., Kerig, P. K., & Chaplo, S. D. (2015). Investigating the dissociative subtype of posttraumatic stress disorder in a sample of traumatized detained youth. *Psychological Trauma: Theory, Research, Practice, and Policy*, *7*(5), 465. doi:10.1037/ tra0000057

Berger, W., Coutinho, E. S. F., Figueira, I., Marques-Portella, C., Luz, M. P., Neylan, T. C., . . . Mendlowicz, M. V. (2012). Rescuers at risk: A systematic review and meta-regression analysis of the worldwide current prevalence and correlates of PTSD in rescue workers. *Social Psychiatry and Psychiatric Epidemiology*, *47*(6), 1001–1011. doi:10.1007/ s00127-011-0408-2

Boden, M. T., Bonn-Miller, M. O., Kashdan, T. B., Alvarez, J., & Gross, J. J. (2012). The interactive effects of emotional clarity and cognitive reappraisal in posttraumatic stress disorder. *Journal of Anxiety Disorders*, *26*(1), 233–238. doi:10.1016/j.janxdis.2011.11.007

Bohus, M., Dyer, A. S., Priebe, K., Krüger, A., Kleindienst, N., Schmahl, C., . . . Steil, R. (2013). Dialectical behaviour therapy for post-traumatic stress disorder after childhood sexual abuse in patients with and without borderline personality disorder: A randomised controlled trial. *Psychotherapy and Psychosomatics*, *82*(4), 221–233. doi:10.1159/000348451

Bohus, M., Kleindienst, N., Hahn, C., Müller-Engelmann, M., Ludäscher, P., Steil, R., . . . Schmahl, C. (2020). Dialectical Behavior Therapy for Posttraumatic Stress Disorder (DBT-PTSD) Compared With Cognitive Processing Therapy (CPT) in Complex Presentations of PTSD in women survivors of childhood abuse: a randomized clinical trial. *JAMA Psychiatry*, *77*(12), 1235–1245. doi:10.1001/jamapsychiatry.2020.2148

Bovin, M. J., Marx, B. P., Weathers, F. W., Gallagher, M. W., Rodriguez, P., Schnurr, P. P., & Keane, T. M. (2016). Psychometric properties of the PTSD checklist for diagnostic and statistical manual of mental disorders–fifth edition (PCL-5) in veterans. *Psychological Assessment*, *28*(11), 1379–1391. doi:10.1037/pas0000254

Boyd, J. E., Protopopescu, A., O'Connor, C., Neufeld, R. W., Jetly, R., Hood, H. K., . . . McKinnon, M. C. (2018). Dissociative symptoms mediate the relation between PTSD symptoms and functional impairment in a sample of military members, veterans, and first responders with PTSD. *European Journal of Psychotraumatology*, *9*(1), 1463794. doi:10.1080/20008198.2018.1463794

Brière, J. (2002). *MDI, Multiscale dissociation inventory: Professional manual*. Odessa, Florida: Psychological Assessment Resources, Incorporated.

Briere, J., Weathers, F. W., & Runtz, M. (2005). Is dissociation a multidimensional construct? Data from the multiscale dissociation inventory. *Journal of Traumatic Stress: Official*

Publication of the International Society for Traumatic Stress Studies, 18(3), 221–231. doi:10.1002/jts.20024

Brown, T. A., Campbell, L. A., Lehman, C. L., Grisham, J. R., & Mancill, R. B. (2001). Current and lifetime comorbidity of the DSM-IV anxiety and mood disorders in a large clinical sample. *Journal of Abnormal Psychology, 110*(4), 585. doi:10.1037/0021-843X.110.4.585

Carleton, R. N., Afifi, T. O., Taillieu, T., Turner, S., Krakauer, R., Anderson, G. S., . . . McCreary, D. R. (2019). Exposures to potentially traumatic events among public safety personnel in Canada. *Canadian Journal of Behavioural Science*, *51*(1), 37–52. doi:10.1037/ cbs0000115

Carleton, R. N., Afifi, T. O., Turner, S., Taillieu, T., Duranceau, S., LeBouthillier, D. M., . . . Hozempa, K. (2018a). Mental disorder symptoms among public safety personnel in Canada. *Canadian Journal of Psychiatry, 63* (1), 54–64. doi:10.1177/0706743717723825

Carleton, R. N., Afifi, T. O., Turner, S., Taillieu, T., LeBouthillier, D. M., Duranceau, S., . . . Hozempa, K. (2018b). Suicidal ideation, plans, and attempts among public safety personnel in Canada. *Canadian Psychology/Psychologie Canadienne*, *59*(3), 220. doi:10.1037/cap0000136

Carlson, E. A., Yates, T. M., & Sroufe, L. A. (2009). Development of dissociation and development of the self. *Dissociation and The Dissociative Disorders: DSM-V and Beyond*, (January 2008), 39–52. https://www.research gate.net/profile/Tuppett_Yates/publication/237457865_ Development_of_Dissociation_and_Development_of_

the_Self/links/574da36d08ae061b33035234/Development-of-Dissociation-and-Development-of-the-Self.pdf

Cloitre, M., Petkova, E., Wang, J., & Lu, F. (2012). An examination of the influence of a sequential treatment on the course and impact of dissociation among women with PTSD related to childhood abuse. *Depression and Anxiety, 29*(8), 709–717. doi:10.1002/da.21920

D'Andrea, W., Ford, J., Stolbach, B., Spinazzola, J., & van der Kolk, B. A. (2012). Understanding interpersonal trauma in children: Why we need a developmentally appropriate trauma diagnosis. *American Journal of Orthopsychiatry, 82*(2), 187–200. doi:10.1111/j.1939-0025.2012.01154.x

Dai, W., Chen, L., Tan, H., Wang, J., Lai, Z., Kaminga, C., . . . Liu, A. (2016). Association between social support and recovery from post-traumatic stress disorder after flood: A 13–14 year follow-up study in Hunan, China. *BMC Public Health*, *16*(1), 1–9. doi:10.1186/s12889-016-2871-x

Dorahy, M. J., & Van Der Hart, O. (2015). DSM–5's posttraumatic stress disorder with dissociative symptoms: Challenges and future directions. *Journal of Trauma & Dissociation*, *16*(1), 7–28. doi:10.1080/15299732.2014.908806

Ehlers, A., Hackmann, A., Grey, N., Wild, J., Liness, S., Albert, I., . . . Clark, D. M. (2014). A randomized controlled trial of 7-day intensive and standard weekly cognitive therapy for PTSD and emotion-focused supportive therapy. *American Journal of Psychiatry, 171*(3), 294–304. doi:10.1176/appi.ajp.2013.13040552

Evans, G. J., Reid, G., Preston, P., Palmier-Claus, J., & Sellwood, W. (2015). Trauma and psychosis: The mediating role of self-concept clarity and dissociation. *Psychiatry Research*, *228*(3), 626–632. doi:10.1016/j. psychres.2015.04.053

Foote, B., Smolin, Y., Neft, D. I., & Lipschitz, D. (2008). Dissociative disorders and suicidality in psychiatric outpatients. *Journal of Nervous and Mental Disease, 196* (1), 29–36. doi:10.1097/NMD.0b013e31815fa4e7

Frewen, P., & Lanius, R. (2015). *The Norton series on interpersonal neurobiology. Healing the traumatized self: Consciousness, neuroscience, treatment*. New York, NY: W. W. Norton & Company.

Frewen, P., Zhu, J., Lanius, R., & Frewen, P. (2019). Lifetime traumatic stressors and adverse childhood experiences uniquely predict concurrent PTSD, complex PTSD, and dissociative subtype of PTSD symptoms whereas recent adult non-traumatic stressors do not: Results from an online survey study an online survey study. *European Journal of Psychotraumatology, 10*(1). doi:10.1080/ 20008198.2019.1606625

Graham, J. W., Olchowski, A. E., & Gilreath, T. D. (2007). How many imputations are really needed? some practical clarifications of multiple imputation theory. *Prevention Science, 8*(3), 206–213. doi:10.1007/s11121-007-0070-9

Hebdon, R., & Jalette, P. (2008). The restructuring of municipal services: A Canada—USA comparison. *Environment and Planning. C, Government & Policy*, *26* (1), 144–158. doi:10.1068/c0634

Herzog, S., DePierro, J., & D'Andrea, W. (2018). Driven to distraction: Childhood trauma and dissociation, but not PTSD symptoms, are related to threat avoidance. *European Journal of Trauma & Dissociation*, *2*(4), 179–187. doi:10.1016/j.ejtd.2018.03.001

Hodgins, G. A., Creamer, M., & Bell, R. (2001). Risk factors for posttrauma reactions in police officers: A longitudinal study. *Journal of Nervous and Mental Disease, 189*(8), 541–547. doi:10.1097/00005053-200108000-00007

Klimley, K. E., Van Hasselt, V. B., & Stripling, A. M. (2018). Posttraumatic stress disorder in police, firefighters, and emergency dispatchers. *Aggression and Violent Behavior, 43,* 33–44. doi:10.1016/j.avb.2018.08.005

Lanius, R. A., Bluhm, R., Lanius, U., & Pain, C. (2006). A review of neuroimaging studies in PTSD: Heterogeneity of response to symptom provocation. *Journal of Psychiatric Research, 40*(8), 709–729. doi:10.1016/j.jpsychires.2005.07.007

Lanius, R. A., Boyd, J. E., McKinnon, M. C., Nicholson, A. A., Frewen, P., Vermetten, E., . . . Spiegel, D. (2018). A review of the neurobiological basis of trauma-related dissociation and its relation to cannabinoid- and opioid-mediated stress response: A transdiagnostic, translational approach. *Current Psychiatry Reports, 20*(12). doi:10.1007/s11920-018-0983-y

Lanius, R. A., Brand, B., Vermetten, E., Frewen, P. A., & Spiegel, D. (2012). The dissociative subtype of posttraumatic stress disorder: Rationale, clinical and neurobiological evidence, and implications. *Depression and Anxiety, 29*(8), 701–708. doi:10.1002/da.21889

Lanius, R. A., Vermetten, E., Loewenstein, R. J., Brand, B., Schmahl, C., Bremner, J. D., & Spiegel, D. (2010). Emotion modulation in PTSD: Clinical and neurobiological evidence for a dissociative subtype. *American Journal of Psychiatry, 167*(6), 640–647.

Lanius, R. A., Williamson, P. C., Densmore, M., Boksman, K., Gupta, M. A., Neufeld, R. W., . . . Menon, R. S. (2001). Neural correlates of traumatic memories in posttraumatic stress disorder: A functional MRI investigation. *American Journal of Psychiatry,*

158(11), 1920–1922. http://ovidsp.ovid.com/ovid web.cgi?T=JS&PAGE=reference&D=med4&NEWS=N&AN=11691703%5Cnhttp://ovidsp.ovid.com/ovidweb.cgi? T=JS&PAGE=reference&D=emed5&NEWS=N&AN=2001402453

Levine, B., Schweizer, T. A., O'Connor, C., Turner, G., Gillingham, S., Stuss, D. T., . . . Robertson, I. H. (2011). Rehabilitation of executive functioning in patients with frontal lobe brain damage with goal management training. *Frontiers Human Neuroscience, 5*, 9. doi:10.3389/fnhum.2011.00009

Lynch, T. R., Trost, W. T., Salsman, N., & Linehan, M. M. (2007). Dialectical Behavior therapy for borderline personality disorder. *Annual Review of Clinical Psychology*, *3*(1), 181–205. doi:10.1146/annurev.clinpsy.2.022305.095229

Martin, M., Marchand, A., Boyer, R., & Martin, N. (2009). Predictors of the development of posttraumatic stress disorder among police officers. *Journal of Trauma and Dissociation*, *10* (4), 451–468. doi:10.1080/15299730903143626

McKinnon, M. C., Boyd, J. E., Frewen, P. A., Lanius, U. F., Jetly, R., Richardson, J. D., & Lanius, R. A. (2016). A review of the relation between dissociation, memory, executive functioning and social cognition in military members and civilians with neuropsychiatric conditions. *Neuropsychologia*, *90*, 210–234. doi:10.1016/j.neuropsychologia.2016.07.017

Nazarov, A., Frewen, P., Oremus, C., Schellenberg, E. G., McKinnon, M. C., & Lanius, R. (2015). Comprehension of affective prosody in women with post-traumatic stress disorder related to childhood abuse. *Acta Psychiatrica Scandinavica*, *131*(5), 342–349. doi:10.1111/acps.12364

Nazarov, A., Frewen, P., Parlar, M., Oremus, C., MacQueen, G., McKinnon, M., & Lanius, R. (2014). Theory of mind performance in women with posttraumatic stress disorder related to childhood abuse. *Acta Psychiatrica Scandinavica*, *129*(3), 193–201. doi:10.1111/acps.12142

Neuner, F., Schauer, M., Karunakara, U., Klaschik, C., Robert, C., & Elbert, T. (2004). Psychological trauma and evidence for enhanced vulnerability for posttraumatic stress disorder through previous trauma among West Nile refugees. *BMC Psychiatry*, *4*(1), 1–7. doi:10.1186/1471-244X-4-34

Ozer, E. J., Best, S. R., Lipsey, T. L., & Weiss, D. S. (2003). Predictors of posttraumatic stress disorder and symptoms in adults: A meta-analysis. *Psychological Bulletin*, *129*(1), 52. doi:10.1037/0033-2909.129.1.52

Petrie, K., Milligan-Saville, J., Gayed, A., Deady, M., Phelps, A., Dell, L., . . . Harvey, S. B. (2018). Prevalence of PTSD and common mental disorders amongst ambulance personnel: A systematic review and meta-analysis. *Social Psychiatry and Psychiatric Epidemiology*, *53*(9), 897–909. doi:10.1007/s00127-018-1539-5

Powers, A., Cross, D., Fani, N., & Bradley, B. (2015). PTSD, emotion dysregulation, and dissociative symptoms in a highly traumatized sample. *Journal of Psychiatric Research*, *61*, 174–179. doi:10.1016/j.jpsychires.2014.12.011

Prati, G., & Pietrantoni, L. (2009). Optimism, social support, and coping strategies as factors contributing to posttraumatic growth: A meta-analysis. *Journal of Loss & Trauma*, *14*(5), 364–388. doi:10.1080/15325020902724271

R Core Team. (2019). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. https://www.R-project.org/

Resick, P. A., Galovski, T. E., Uhlmansiek, M. O. B., Scher, C. D., Clum, G. A., & Young-Xu, Y. (2008). A randomized clinical trial to dismantle components of cognitive processing therapy for posttraumatic stress disorder in female victims of interpersonal violence. *Journal of Consulting and Clinical Psychology*, *76*(2), 243. doi:10.1037/0022-006X.76.2.243

Rivera-Vélez, G. M., González-Viruet, M., Martínez-Taboas, A., & Pérez-Mojica, D. (2014). Post-traumatic stress disorder, dissociation, and neuropsychological performance in latina victims of childhood sexual abuse. *Journal of Child Sexual Abuse*, *23*(1), 55–73. doi:10.1080/10538712.2014.864746

Roemer, L., & Gratz, K. L. (2004). Multidimensional assessment of emotion regulation and dysregulation: Development, factor structure, and initial validation of the difficulties in emotion regulation scale. *Journal of Psychopathology and Behavioral Assessment*, *30*(4), 41–54. doi:10.1023/B

Rubin, D. B. (1987). *Multiple Imputation for nonresponse in surveys*. New York, NY: John Wiley & Sons. Vol. 81

Schafer, J. L., & Graham, J. W. (2002). Missing data: Our view of the state of the art. *Psychological Methods*, *7*(2), 147–177. doi:10.1037/1082-989X.7.2.147

Scheppele, K. L. (2006). North American emergencies: The use of emergency powers in Canada and the USA. *International Journal of Constitutional Law*, *4*(2), 213–243. doi:10.1093/icon/mol003

Standing committee on Public Safety and National Security. (2016). *Healthy minds, safe communities: Supporting our public safety officers through a national strategy for operational stress injuries. Committee Report No. 5 - SECU (42-1)*. (October), 1–39.

https://www.ourcommons.ca/ Content/Committee/421/SECU/Reports/RP8457704/ securp05/securp05-e.pdf

Stein, D. J., Koenen, K. C., Friedman, M. J., Hill, E., McLaughlin, K. A., Petukhova, M., . . . Bunting, B. (2013). Dissociation in posttraumatic stress disorder: Evidence from the world mental health surveys. *Biological Psychiatry, 73*(4), 302–312. doi:10.1016/j.biopsych.2012.08.022

Sterud, T., Ekeberg, Ø., & Hem, E. (2006). Health status in the ambulance services: A systematic review. *BMC Health Services Research*, *6*(1), 82. doi:10.1186/1472-6963-6-82

Steuwe, C., Lanius, R. A., & Frewen, P. A. (2012). Evidence for a dissociative subtype of PTSD by latent profile and confirmatory factor analyses in a civilian sample. *Depression and Anxiety*, *29*(8), 689–700. doi:10.1002/da.21944

Stewart, S. H., Mitchell, T. L., Wright, K. D., & Loba, P. (2004). The relations of PTSD symptoms to alcohol use and coping drinking in volunteers who responded to the Swissair Flight 111 airline disaster. *Journal of Anxiety Disorders*, *18*(1), 51–68. doi:10.1016/j. janxdis.2003.07.006

Tsai, J., Armour, C., Southwick, S. M., & Pietrzak, R. H. (2015). Dissociative subtype of DSM-5 posttraumatic stress disorder in U.S. veterans. *Journal of Psychiatric Research, 66-67*, 67–74. doi:10.1016/j.jpsychires.2015.04.017

van Buuren, S., & Groothuis-Oudshoorn, K. (2011). mice: Multivariate imputation by chained equations in R. *Journal of Statistical Software*, *45*(3), 1–67. doi:10.18637/jss.v045.i03

Watts, B. V., Schnurr, P. P., Mayo, L., Young-Xu, Y., Weeks, W. B., & Friedman, M. J. (2013). Meta-analysis of the efficacy of treatments for posttraumatic stress disorder. *The Journal of Clinical Psychiatry, 74*(6), 541–550. doi:10.4088/JCP.12r08225

Weathers, F. W., Bovin, M. J., Lee, D. J., Sloan, D. M., Schnurr, P. P., Kaloupek, D. G., . . . Marx, B. P. (2018). The Clinician-Administered PTSD Scale for DSM–5 (CAPS-5): Development and initial psychometric evaluation in military veterans. *Psychological Assessment*, *30*(3), 383–395. doi:10.1037/pas0000486

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

Wechsler, D. (2001). *Wechsler Test of Adult Reading: WTAR*. San Antonio, TX: Psychological Corporation.

Wolf, E. J., Lunney, C. A., Miller, M. W., Resick, P. A., Friedman, M. J., & Schnurr, P. P. (2012a). The dissociative subtype of PTSD: A replication and extension. *Depression and Anxiety*, *29*(8), 679–688. doi:10.1002/ da.21946

Wolf, E. J., Miller, M., Reardon, A., Ryabchenko, K. A., Castillo, D., & Freund, R. (2012b). A latent class analysis of dissociation and posttraumatic stress disorder. *Archives of General Psychiatry*, *69* (7), 698–705. doi:10.1001/archgenpsychiatry.2011.1574

World Health Organization. (2000, February). World Health Organization disability assessment schedule: WHODAS II. Phase 2 field trials. Health services research. *Health Services Research*.

Wortmann, J. H., Jordan, A. H., Weathers, F. W., Resick, P. A., Dondanville, K. A., Hall-Clark, B., . . . Mintz, J. (2016). Psychometric analysis of the PTSD Checklist-5 (PCL-5) among treatment-seeking military service members. *Psychological Assessment*, *28*(11), 1392. doi:10.1037/pas0000260

Chapter 3:

Dissociative symptoms and emotion dysregulation contribute to alterations in cognitive performance among military members, Veterans, and public safety personnel with a presumptive diagnosis of post-traumatic stress disorder

Park, A. H., Protopopescu, A., Pogue, M. E., Boyd, J. E., O'Connor, C., Lanius, R. A., & McKinnon, M. C. (2024). *Dissociative symptoms and emotion dysregulation contribute to alterations in cognitive performance among military members, Veterans, and public safety personnel with a presumptive diagnosis of post-traumatic stress disorder*. [Manuscript submitted for publication].

Abstract

Background

Cognitive dysfunction is a hallmark feature of post-traumatic stress disorder (PTSD), contributing to significant functional impairment. Trauma-related dissociative symptoms and emotion dysregulation are associated with greater PTSD severity and functional impairment. Yet, little is known about the role of dissociation and emotion dysregulation symptoms in cognitive dysfunction among individuals with PTSD.

Objective

We examined whether emotion dysregulation and dissociation predict impairments in cognitive functioning among individuals with PTSD, beyond any portion of variance explained by PTSD severity.

Methods

Self-reported clinical symptom scores and neuropsychological assessment data were collected from 61 current or former military members, veterans, and/or public safety personnel seeking treatment for PTSD. Hierarchical multiple linear regressions assessed whether dissociative symptoms and emotion dysregulation explained unique variance in six domains of cognitive functioning and functional impairment beyond that explained by PTSD symptom severity scores, while controlling for biological sex, patient status (i.e., inpatient or outpatient), and premorbid intelligence.

Results

Dissociative symptoms accounted for unique variance in executive functioning, processing speed, and intellectual functioning. Emotion dysregulation accounted for unique variance in processing speed and subjective cognitive impairment. PTSD symptom severity accounted for unique variance in subjective cognitive impairment and functional impairment.

Conclusions

Dissociative symptoms and emotion dysregulation explained, in part, cognitive dysfunction in PTSD, even after accounting for the effects of PTSD symptom severity and control variables. This work highlights the need to assess for symptoms of trauma-related dissociation and emotion dysregulation during neuropsychological and functional assessments, as these may exacerbate cognitive dysfunction among individuals experiencing PTSD.

Clinical Impact Statement

Trauma-related dissociative symptoms uniquely contributed to cognitive difficulties. Specifically, executive functioning, intellectual functioning, and processing speed worsened with increasing dissociation, whereas self-reported cognitive abilities worsened with increasing emotion regulation difficulties. Dissociative symptoms and emotion dysregulation explained, in part, impairments in cognitive functioning in PTSD, even after accounting for the effects of PTSD symptom severity, biological sex, patient status, and premorbid intelligence. This work highlights the importance of assessing for symptoms of trauma-related dissociation and emotion dysregulation during neuropsychological and functional assessments, as these may exacerbate cognitive dysfunction among individuals experiencing PTSD.

Introduction

Cognitive dysfunction is a hallmark symptom of post-traumatic stress disorder (PTSD) that can impair daily functioning (Alexis et al., 2023; American Psychiatric Association [APA], 2013; Banich et al., 2009; McKinnon et al., 2016). One meta-analysis of 60 studies (N = 4108) reported that individuals with PTSD showed impaired performance with moderate to large effect sizes in verbal learning (d = -.62), processing speed (d = -.59), attention (d = -.50), memory (d = -.46), and executive functioning (d = -.45), among others (Scott et al., 2015). Although associations with specific cognitive domains are mixed, comprehensive reviews indicate that higher levels of PTSD symptom severity are associated with heightened overall deficits in neuropsychological performance (Qureshi et al., 2011; Wrocklage et al., 2016). A similar pattern has emerged among Veteran samples, with higher levels of PTSD symptoms associated with greater impairments in attention and executive functioning (Qureshi et al., 2011). As compared to Veterans without PTSD, those with PTSD demonstrate poorer performance in tasks of processing speed and executive functioning, but not in attention or memory (Wrocklage et al., 2016). Here, poor performance on measures of executive functioning and processing speed are associated with decrements in quality-of-life domains such as self-reported physical and occupational functioning (Wrocklage et al., 2016). Thus, individuals with PTSD demonstrate impaired cognitive functioning that can worsen with increasing PTSD symptom severity.

A key correlate of PTSD symptom severity is the experience of persistent trauma-related dissociation, affecting up to approximately 30% of individuals with PTSD and associated with greater PTSD symptom severity and emotion dysregulation (APA, 2013; McKinnon et al., 2016; Lanius et al., 2010; Park et al., 2021, 2023; Stein et al., 2013; White et al., 2022). In general, dissociation is a transdiagnostic phenomenon occurring on a spectrum from non-pathological (i.e.,

daydreaming) to disruptive experiences involving disordered sensory integration that interfere with functioning (i.e., divisions of personality; Bernstein & Putnam, 1986; Dell, 2006). In the PTSD literature, dissociative symptoms have been further conceptualized as a psychological escape when no physical escape is possible and often experienced as a sense of derealization and/or depersonalization. Derealization may be experienced as if one was outside of their physical self, for example a feeling of watching the event as if it were a movie scene, rather than happening to oneself in the present reality, whereas depersonalization may be felt as numbness and disconnection from one's own body.

Notably, military members, veterans, and public safety personnel experience high rates of trauma exposure and/or heightened rates of exposure to childhood adverse events (Affifi et al., 2016; Roth et al., 2022), and report greater persistent symptoms of dissociation (Tsai et al., 2015; White et al., 2022). For example, among a sample of 1484 veterans, veterans with the dissociative subtype of PTSD reported greater anxiety, depression, problematic alcohol use, hostility, and PTSD symptom severity as compared to those without the subtype (Tsai et al., 2015). Even after adjusting for PTSD symptom severity, these Veterans demonstrated more severe symptoms of depression and problematic alcohol use as compared to those without the subtype.

Relatedly, dissociation has been postulated to disrupt the integration of information related to traumatic experiences (Bernstein & Putnam, 1986; Fink, 1988), and is associated with aberrations in intrinsic functional connectivity networks that are thought to interfere with cognition among individuals with PTSD (Cavicchioli et al., 2023). Individuals with the more typical non-dissociative presentation of PTSD show a pattern of neural response associated with emotion under-modulation in response to trauma cues (Lanius et al., 2010; Nicholson et al., 2019). Emotion under-modulation involves hyperactivation of limbic regions, such as the amygdala, that appear in

tandem with the under-activation of frontal regions that regulate intense fear in response to trauma-related stimuli (Lanius et al., 2010) and are often associated with higher-order cognitive functioning (e.g., executive functioning). Consistent with classic PTSD symptoms, these individuals present with hyper-arousal (e.g., startle reactivity, hypervigilance, etc.). By contrast, individuals with the dissociative subtype of PTSD demonstrate a pattern of neural response consistent with emotion over-modulation (i.e., hyperactivation of frontal regions involved in emotion regulation and hypoactivation of limbic regions), a pattern consistent with the presentation of hypo-arousal observed in the dissociative subtype of PTSD (e.g., emotional numbness, dissociation, etc.; Lanius et al., 2010). In general, these findings suggest that trauma-related dissociation is associated with a distinct pattern of affective disruptions that occurs alongside an often chronic and severe clinical presentation.

Despite dissociation being associated with a more severe illness presentation and functional impairments, relatively less is known about cognitive dysfunction among individuals experiencing persistent trauma-related dissociation symptoms (see McKinnon et al., 2016 for a review). Among healthy individuals without a history of trauma, individuals high in dissociation demonstrate greater impairments in verbal-associated context memory, executive functioning, and working memory as compared to individuals low in dissociation (Amrhein et al., 2008). In a sample of undergraduate students, Giesbrecht et al., (2004) found that executive dysfunction was associated with symptoms of dissociation such as dissociative amnesia, but not depersonalization or absorption (e.g., being so preoccupied with something, causing distraction from your immediate environment). Similarly, among clinical samples, heightened levels of dissociative symptoms are associated with greater cognitive complaints among patients with PTSD and depersonalization disorder (Simeon, 2009). Veterans with PTSD and comorbid dissociative disorders also

demonstrate impairments in verbal memory, autobiographical memory, attention, and some executive functions as compared to veterans with PTSD but not a comorbid dissociative disorder diagnosis, suggesting further that dissociation may be a driver of neurocognitive impairment in PTSD (Roca et al., 2006). Finally, among Latina survivors with childhood sexual abuse-related PTSD, both dissociation and PTSD symptom severity were correlated with impaired neuropsychological performance in verbal memory, visual memory, attention, and executive functioning (Rivera-Vélez et al., 2014; Simeon, 2009). Taken together, these studies suggest neurocognitive dysfunction may be present among individuals with high levels of trauma-related dissociation.

Although previous studies have linked PTSD severity and cognitive dysfunction, many have not accounted for symptoms of dissociation, nor studied the association between dissociation and cognitive dysfunction while accounting for PTSD symptoms. To our knowledge, no study to date has distinguished the role of dissociation in cognitive dysfunction from the effects of PTSD symptom severity. Furthermore, despite cognitive performance often varying as a function of emotional material, research has inconsistently accounted for the role of emotion in the association between cognition and dissociation (Alexis et al., 2023). Given the distinct affective presentations seen across traumatized individuals with and without dissociation symptoms (Lanius et al., 2010), more research is thus needed to understand the impact of dissociation and emotion regulation on cognitive functioning among individuals experiencing PTSD. As such, this study examined how emotion dysregulation and dissociation symptoms can predict impairments in cognition, beyond that explained by PTSD symptoms. We hypothesized that dissociation would be a significant predictor of neuropsychological impairment. Given the mixed literature, we did not have specific predictions about each cognitive domain. We also hypothesized that emotion dysregulation and

PTSD symptom severity would be significant predictors of self-reported impairments in cognition and daily functioning.

Method

Participants

Baseline participant data were combined from two studies assessing the efficacy of a psychological intervention for PTSD in an inpatient and outpatient unit (n = 96). The studies were approved by the Homewood Health Centre Research Ethics Board (REB #17-03 and REB #15-29 respectively). For both studies, participants were eligible if they were aged 18-65, provided written informed consent, fluent in written and spoken English, reported a history of trauma exposure, and denied having a medical disorder within the past 12 months known to negatively impact cognitive functioning. Inpatients were ineligible for the study if they reported participating in electroconvulsive therapy or taking anti-psychotic or anti-cholinergic medication in the past year. Outpatients were ineligible if they reported problematic alcohol and/or substance use in the last 3 months. Both studies administered the same clinical symptom and neuropsychological functioning measures at baseline (prior to any intervention) and these data were the focus of the study. Data from participants with a presumptive diagnosis of PTSD and self-identification as a current or former military member, Veteran, and/or public safety personnel were analyzed in the current study.

Measures

Participants completed a 4–6-hour baseline testing session with a clinician in training. Demographic information (biological sex, age, and years of education), self-reported clinical symptoms and functioning, and performance on a battery of neuropsychological tests were collected.

Self-Reported Clinical Symptoms

The PTSD Checklist for Diagnostic and Statistical Manual of Mental Disorders (DSM) 5th edition (PCL-5; Weathers et al., 2013) is a valid and reliable 20-item tool assessing PTSD symptomatology over the past month. Each item evaluates symptom severity (0 = *not at all* to 4 = *extremely*) and total scores range from 0-80. Symptom clusters are categorized in accordance with the DSM-5: intrusions, avoidance, negative alterations in mood and cognition, and alterations in arousal and reactivity. The PCL-5 has good convergent validity with the gold standard Clinician-Administered PTSD Scale for DSM-5 (CAPS-5) and a score of 33 or greater has been found to determine a presumptive diagnosis of PTSD (Wortman et al., 2016). Signal detection analyses also indicate PCL-5 scores of 31-33 as ideal for diagnosing PTSD, including in veterans (Bovin et al., 2016). The Multiscale Dissociation Inventory (MDI; Brière, 2002) is a 30-item measure of dissociative symptomatology across six different domains: disengagement, depersonalization, derealisation, emotional constricting/numbing, memory disturbance, and identity dissociation. Each item evaluates symptom occurrence (1 = *never* and 5 = *very often*) and total scores range from 30-150. The Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2003) is a 36-item measure of emotional regulation difficulties (1 = *almost never* and 5 = *almost always*). The total DERS score ranges from 36-180 and combines six subscales: nonacceptance of emotional responses, difficulty engaging in goal-directed behaviour, impulse control difficulties, lack of emotional awareness, limited access to emotion regulation strategies, and lack of emotional clarity.

Functional Impairment

The World Health Organization Disability Assessment Schedule 2.0 (WHODAS 2.0; World Health Organization, 2010) is a 12-item measure of difficulties in functioning (each item is

rated from 1 = *none* to 5 = *extreme or cannot do*), and the extent to which they interfere with daily living during the past 30 days. Total scores range from 12-60, which combine six domains: cognition (i.e., understanding and communicating with others), mobility (i.e., moving and getting around one's home), self-care (i.e., hygiene, dressing, eating, and staying alone), getting along with others (i.e., maintaining and creating relationships), life activities (i.e., domestic responsibilities, leisure, work, and school), and participation in the community (i.e., how others and the world around them contribute to participation restrictions). The Cognitive Failures Questionnaire (CFQ; Broadbent et al., 1982) is a 25-item measure of daily cognitive failures within the past 6 months. Each item evaluates symptom occurrence (0 = *never* to 4 = *very often*) and total scores range from 0-100. Lastly, the Dysexecutive Questionnaire (DEX; Burgess et al., 1996) is a self- or informant-reported 20-item measure assessing impairments in executive functioning. Each item evaluates symptom occurrence (0 = *never* to 4 = *very often*) and total scores range from 0-80. Responses indicate impairments in everyday problems in the domains of emotional, motivational, behavioural, and cognitive functioning.

Neuropsychological Battery

The neuropsychological measures assessed various domains of cognitive functioning, including executive functioning, cognitive processing speed, attention, declarative memory, and intellectual functioning. Of note, pre-morbid intellectual functioning was estimated using the Wechsler Test of Adult Reading (WTAR; Wechsler, 2001), a reading task of 50 irregular words.

Executive functioning was measured through a combination of various subtests. The Controlled Oral Word Association Test's (COWAT; Reitan & Wolfson, 1985) FAS & Animals subtests measures phonetic and semantic verbal fluency within a specified time limit. The Stroop Color and Word Test (Stroop; Reitan & Wolfson, 1985) assesses abilities in cognitive processing

and inhibition of information through both speed and response accuracy. Trail Making Test B (Reitan & Wolfson, 1985) requires a participant to complete a visuospatial letter-number sequence as quickly as possible. The Delis-Kaplan Executive Function System's (D-KEFS) Tower Test (Delis et al., 2001) requires participants to recreate tower designs using as few moves as possible within a time limit and with abiding by specified task rules.

Processing speed measures included Trail Making Test A (Reitan & Wolfson, 1985) and the Wechsler Adult Intelligence Scale Fourth Edition's (WAIS-IV) Coding subtest (Wechsler, 2008). The former requires a participant to complete a visuospatial number sequence as quickly as possible, and the latter requires participants to use a number-symbol key to draw in as many symbols with its respective number within a specified time limit.

The Conners Continuous Performance Third Edition (Conners CPT 3; Conners, 2014) is a target-based computer task that served as a measure of overall attention, as well as levels of inattention, impulsivity, sustained attention, and vigilance.

Declarative memory was assessed using the California Verbal Learning Task Second Edition (CVLT-II; Delis et al., 2000). This test is a measure of verbal learning and memory deficits using a word list-learning task, assessing for abilities in immediate recall, short-delayed recall, long-delayed recall, and recognition.

Data Preparation

Sum scores of the WHODAS 2.0, PCL-5, and DERS were used as variables for analyses. The MDI *Depersonalization* and *Derealization* subscale scores were summed to create a PTSD-specific measure of dissociation for our current analyses, consistent with the DSM-5 criteria (APA, 2013).

Neuropsychological Measures

Cognitive functioning was assessed using multiple self-report and neuropsychological measures. Therefore, to reduce the likelihood of Type I error, composite scores were created for specific domains of cognitive functioning: (1) executive functioning; (2) processing speed; (3) attention; (4) declarative memory; (5) intellectual functioning; and (6) subjective report of cognitive functioning. Scores used to calculate the domain of (1) *executive functioning* included T-scores of the COWAT FAS and Animals subtests; Stroop Word, Color, Color-Word, and interference subtests; Trail Making Test B, and scaled scores for the D-KEFS Tower Test's first move time, time per move, move accuracy, rule violations per item, and total scores. The composite score for (2) *processing speed* included the Trail Making Test A T-score and the WAIS-IV Digit Symbol Coding subtest score. *Attention* (3) was composed of 5 measures from the Conners CPT 3 (i.e., detectability between targets and non-targets, omission errors, commission errors, hit reaction time standard deviation in assessing consistency in reaction times, and variability in reaction time consistencies). *Declarative memory* (4) included all 16 measures from the CVLT-II. The composite score for (5) *intellectual functioning* included the FSIQ-II score**.** Lastly, subjective cognitive functioning (6) included total scores of the CFQ and DEX. To calculate a composite score for each cognitive domain, all individual scores mentioned above were scaled ($M = 0$ and $SD = 1$), grouped into one of the six cognitive functioning domains, and then a single score was created by calculating the mean of all scaled scores within each domain. Therefore, a total of 6 composite scores were created, corresponding to each cognitive domain. Lower (more negative) values indicated poor performance for all domains except for attention and subjective cognitive functioning, wherein higher (more positive) values indicated poor performance.

Statistical Analyses

Statistical analyses were conducted using R (version 4.0.0; R Core Team, 2019) and missing data were imputed using the *missForest* package (Stekhoven & Bühlmann, 2012). The *missForest* (version 4.1) algorithm is a nonparametric method of imputation using random forests to predict missing values (Stekhoven & Bühlmann, 2012), and was selected for its superior ability to handle missing data with mixed variables and high dimensionality over other existing imputation methods (Emmanuel et al., 2021). Missing data ranged from 0 to 82.1% across participants and 0 to 31.3 % across 56 variables. Individuals with more than 40% missing data were excluded from imputation (Liao et al., 2014; Misztal, 2013), resulting in a sample size of 72. The normalized-root mean squared error (NRMSE) and the proportion of false classification (PFC) are out-of-bag error estimates for continuous and categorical missing values respectively, ranging from 0-1, where good performance approaches 0 (Stekhoven & Bühlmann, 2012). Under the default *missForest* algorithm, the stopping criterion was reached at 8 iterations (NRMSE = 0.205, PFC = 0.114). However, the lowest estimated NRMSE occurred after two iterations, suggesting that two iterations resulted in the most optimal performance. The imputation was re-run specifying two iterations, resulting in an estimated final NRMSE of 0.203 and PFC of 0.100. From this completed dataset, only participants with a presumptive diagnosis of PTSD (PCL score $\geq$ 33) were selected for further analysis (Bovin et al., 2016; Wortman et al., 2016), resulting in a final sample of 61 for subsequent analyses (23 females; 30 inpatients; ages 21-62).

Hierarchical multiple linear regressions were conducted to assess whether dissociation and emotion dysregulation would explain unique variance in each of the six domains of cognitive functioning and functional impairment, over and above that explained by PTSD symptom severity. Given the differential effects of biological sex, patient status, and premorbid intelligence on PTSD

(Christiansen & Berke, 2020; Kremen et al., 2007; McFarlane et al., 2001), all statistical models controlled for their potential effects. Thus, there was a total of seven hierarchical regression models. In Step 1, PTSD symptom severity (PCL-5), biological sex (0 = *female*, 1 = *male*), patient status (0 = *inpatient*, 1 = *outpatient*), and premorbid intelligence (WTAR) were entered. Dissociation was entered in Step 2, with emotion dysregulation being added in Step 3. All continuous variables entered into the regression models were scaled (mean set to zero) for easier interpretation of the magnitude of effects. To account for multiple predictors, the adjusted R^2 was reported. All statistical tests were two-tailed at $\alpha = 0.05$, 95% CI, $p < .05$. Correlations between variables are shown in Table 1.

Table 1

Correlation table between variables, n = *61*

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**
1. Sex	-													
2. Patient status	-0.02	-												
3. Age	0.25	-0.04	-											
4. WTAR	0.04	0.59	-0.07	-										
5. PCL-5	-0.08	-0.37	-0.12	-0.36	-									
6. MDI	-0.19	-0.16	-0.13	-0.20	0.53	-								
7. DERS	-0.08	-0.34	-0.02	-0.23	0.52	0.37	-							
8. Executive functioning	-0.17	0.07	0.05	0.14	-0.1	-0.34	-0.2	-						
9. Processing speed	-0.13	0.04	-0.09	0.05	-0.07	-0.34	-0.28	0.58	-					
10. Attention	0.02	0.13	-0.19	-0.12	0.04	0.16	0.06	-0.24	-0.11	-				
11. Declarative memory	-0.11	0.06	0.15	0.13	-0.26	-0.29	-0.1	0.4	0.29	-0.3	-			
12. Intellectual functioning	-0.1	0.12	-0.01	0.22	-0.2	-0.37	-0.06	0.24	0.24	-0.1	0.37	-		
13. Subjective cognitive impairment	-0.03	-0.19	-0.13	-0.28	0.54	0.34	0.53	-0.07	-0.15	0.16	-0.23	-0.18	-	
14. Functional impairment	-0.1	-0.08	-0.03	-0.22	0.55	0.28	0.43	0.02	-0.03	-0.13	-0.25	-0.04	0.53	-

Note. Sex = biological sex (0 = *female*, 1 = *male*); Patient status: 0 = *inpatient*, 1 = *outpatient*; WTAR = premorbid IQ; PCL-5 = PTSD Checklist for DSM-5 (PCL-5); MDI = sum of Derealization and Depersonalization subscales of the Multiscale Dissociation Inventory; DERS = Difficulties in Emotion Regulation Scale; Functional impairment = WHO Disability Assessment Schedule 2.0 (WHODAS 2.0).

Results

Demographic and clinical characteristics of the sample are shown in Table 2. See Table 3 for a summary of all hierarchical regression analyses' results.

Table 2

Demographic and clinical characteristics of the sample

	Total *n* = 61	Female *n* = 23	Male *n* = 38
	M (SD)		
Age	43.7 (7.8)	41.2 (8.2)	45.2 (7.3)
Years of education	16.8 (3.1)	17.4 (2.9)	16.4 (3.2)
PTSD symptom severity	51.3 (10.8)	52.4 (10.8)	50.6 (10.8)
Functional impairment	20.2 (7.0)	21.1 (6.8)	19.7 (7.2)
Emotion dysregulation	113.8 (21.8)	116 (23.3)	112.5 (21)
Dissociation			
Depersonalization	8.6 (3.3)	9.4 (3.1)	8.1 (3.4)
Derealization	9.7 (3.8)	10.6 (3.2)	9.4 (4)
	n (% of sample)		
Patient Status			
Inpatient	30 (49.2)	11 (47.8)	19 (50.0)
Outpatient	31 (50.8)	12 (52.2)	19 (50.0)
Occupation			
Military or Veteran	9 (14.8)	3 (13.0)	6 (15.8)
PSP	34 (55.7)	13 (56.5)	21 (55.3)
Both PSP and military/Veteran	6 (9.8)	1 (4.3)	5 (13.2)
Other	12 (19.7)	6 (26.1)	6 (15.8)

Note. PTSD symptom severity = Post-traumatic Stress Disorder Checklist for DSM-5 (PCL-5); Functional impairment = WHO Disability Assessment Schedule 2.0 (WHODAS 2.0); Emotion dysregulation = Difficulties in Emotion Regulation Scale (DERS); Dissociation = Multiscale Dissociation Inventory (MDI); Depersonalization = Depersonalization subscale of MDI; Derealization = Derealization subscale of MDI; PSP = Public safety personnel.

Executive Functioning

In Step 1, PTSD symptom severity was added as a predictor, controlling for biological sex, patient status, and premorbid IQ. This model was not significant (p = .509), suggesting that PTSD

symptom severity did not account for the variance in executive functioning. In Step 2, dissociation was added as a predictor. This model was significant (p = .036), and entering dissociation explained an additional 13% of the variance in executive functioning (ΔR_{adj}^2 = .13, p = .004). Specifically, for a one-unit increase in dissociation score, there was a 0.19-unit decrease in executive functioning score, even after accounting for PTSD symptom severity, biological sex, patient status, and premorbid IQ (p = .004). In Step 3, emotion dysregulation was added as a predictor. This model was significant (p = .042), but it did not significantly explain additional variance in executive functioning (ΔR_{adj}^2 = .00, p = .278). Therefore, PTSD symptom severity and emotion dysregulation did not predict impairments in executive functioning, but dissociation accounted for unique variance in executive functioning, even after controlling for biological sex, patient status, and premorbid IQ (Table 3).

Table 3

Results of hierarchical regression analyses predicting various domains of cognitive functioning and functional impairment

Predictor	Executive functioning	Processing speed	Attention	Declarative memory	Intellectual functioning	Subjective cognition	Functional impairment
				β			
Step 1							
PTSD severity	-.04	-.06	.04	-.14	-.16	.46***	.57***
Sex	-.16	-.23	.06	-.15	-.25	.03	-.09
Patient status	-.04	-.00	.48*	-.10	-.14	.14	.39
Premorbid IQ	.06	.02	-.22	.05	.21	-.13	-.13
R_{adj}^2	-.01	-.05	.02	.03	.02	.25***	.28***
Step 2							
PTSD severity	.06	.15	-.03	-.07	.05	.43**	.58***
Sex	-.21	-.34	.10	-.18	-.37	.05	-.10
Patient status	-.03	.03	.47	-.09	-.10	.14	.40
Premorbid IQ	.06	.01	-.21	.04	.20	-.13	-.13
Dissociation	-.19**	-.39**	.14	-.12	-.40**	.07	-.02
R_{adj}^2	.12*	.10	.03	.05	.12*	.24**	.26***

Step 3							
PTSD severity	.09	.24	-.06	-.08	.00	.30*	.48**
Sex	-.22*	-.36	.11	-.18	-.36	.07	-.08
Patient status	-.06	-.08	.50*	-.08	-.05	.28	.51
Premorbid IQ	.06	.03	-.22	.04	.19	-.15	-.15
Dissociation	-.18**	-.36**	.13	-.13	-.42**	.02	-.06
Emotion dysregulation	-.07	-.25*	.07	.03	.11	.33**	.26
R_{adj}^2	**.12***	**.15***	.01	.04	**.12***	**.33*****	**.30*****

Note. Beta coefficients are standardized. Functional impairment = WHO Disability Assessment Schedule 2.0; PTSD severity = PTSD Checklist for DSM-5; Sex = biological sex (0 = *female*, 1 = *male*); Patient status: 0 = *inpatient*, 1 = *outpatient*; Premorbid IQ = Wechsler Test of Adult Reading; Dissociation = sum of Derealization and Depersonalization subscales of the Multiscale Dissociation Inventory; Emotion dysregulation = Difficulties in Emotion Regulation Scale.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Processing Speed

In Step 1, the model was not significant ($p = .859$), and PTSD symptom severity did not account for the variance in processing speed. In Step 2, the model was still not significant ($p = .052$), but entering dissociation explained an additional 15% of the variance in processing speed ($\Delta R_{adj}^2 = .15$, $p = .002$). In Step 3, dissociation and emotion dysregulation were significant predictors and the model was significant ($p = .019$). After accounting for all other variables, emotion dysregulation accounted for an additional 5% of the variance in processing speed ($\Delta R_{adj}^2 = .05$, $p = .041$). In other words, after accounting for all other variables, for a one-unit increase in dissociation score, there was a 0.36-unit decrease in processing speed ($p = .004$). Similarly, for a one-unit increase in emotion dysregulation score, there was a 0.25-unit decrease in processing speed ($p = .041$; Table 3). Thus, although PTSD symptom severity did not predict impairments in processing speed, dissociation and emotion dysregulation accounted for unique variance in processing speed, even after controlling for biological sex, patient status, and premorbid IQ (Table 3).

Attention

None of the models in Steps 1, 2, and 3 were significant ($p \geq .270$), and adding dissociation or emotion dysregulation did not significantly improve the models ($p \geq .223$). Thus, PTSD symptom severity, dissociation, and emotion dysregulation did not predict attentional impairment scores (Table 3).

Declarative Memory

None of the models in Steps 1, 2, and 3 were significant ($p \geq .156$). Neither dissociation nor emotion dysregulation significantly improved the models ($p \geq .114$). Therefore, PTSD symptom severity, dissociation, and emotion dysregulation did not predict declarative memory scores (Table 3).

Intellectual Functioning

In Step 1, the model was not significant ($p = 0.254$), and PTSD symptom severity did not account for the variance in intellectual functioning. In Step 2, dissociation was added as a predictor. This model was significant ($p = .030$) and entering dissociation explained an additional 11% of the variance in intellectual functioning ($\Delta R_{adj}^2 = .11$, $p = .007$). Specifically, for a one unit increase in dissociation score, there was a corresponding 0.40 unit decrease in intellectual functioning score, even after accounting for PTSD symptom severity, biological sex, patient status, and premorbid IQ ($p = .007$). In Step 3, emotion dysregulation was added as a predictor. This model was significant ($p = .044$), but it did not significantly explain additional variance in intellectual functioning ($\Delta R_{adj}^2 = -.01$, $p = .550$). Thus, similar to the model predicting executive functioning, neither PTSD symptom severity nor emotion dysregulation predicted impairments in intellectual functioning. However, dissociation accounted for unique variance in intellectual functioning, even after controlling for biological sex, patient status, and premorbid IQ (Table 3).

Subjective Cognitive Impairment

In Step 1, PTSD symptom severity was a significant predictor of subjective cognitive impairment, explaining 25% of its variance ($p < .001$). For a one-unit increase in PTSD symptom severity, there was a 0.46-unit increase in subjective cognitive impairment, after controlling for biological sex, patient status, and premorbid IQ ($p < .001$). In Step 2, dissociation was added as a predictor. This model was significant ($p = .001$), but it did not explain additional variance in subjective cognitive impairment ($\Delta R_{adj}^2 = -.01$, $p = .580$). In Step 3, emotion dysregulation was added as a predictor. This model was significant ($p < .001$), and entering emotion dysregulation explained an additional 9% of the variance in subjective cognitive impairment ($\Delta R_{adj}^2 = .09$, $p = .005$). Here, a one-unit increase in emotion dysregulation was associated with a 0.33-unit increase in subjective cognitive impairment ($p = .005$), after accounting for all other variables. Similarly, a one-unit increase in PTSD symptom severity was associated with a 0.30-unit increase in subjective cognitive impairment ($p = .022$). Therefore, although dissociation did not predict subjective cognitive impairment, both PTSD symptom severity and emotion dysregulation explained unique variance in subjective cognitive impairment after controlling for biological sex, patient status, and premorbid IQ (Table 3).

Functional Impairment

In Step 1, PTSD symptom severity was a significant predictor of functional impairment, explaining 28% of its variance ($p < .001$). A one-unit increase in PTSD symptom severity score was associated with a 0.57-unit increase in functional impairment score ($p < .001$). In Step 2, dissociation was added as a predictor. This model was significant ($p < .001$), but it did not explain additional variance in functional impairment ($\Delta R_{adj}^2 = -.01$, $p = .857$). In Step 3, emotion dysregulation was added as a predictor. This model was still significant ($p < .001$), but it did not

significantly explain additional variance in functional impairment (ΔR_{adj}^2 = .04, p = .052). Thus, neither dissociation nor emotion dysregulation accounted for unique variance in functional impairment after accounting for PTSD symptom severity. PTSD severity alone predicted greater functional impairment, after controlling for biological sex, patient status, and premorbid IQ.

Conclusions

The purpose of this study was to examine impairments in specific domains of cognitive dysfunction that were driven by trauma-related dissociative symptoms, after accounting for the impact of PTSD symptom severity. We found that elevations in dissociative symptoms predicted decreasing performance on neuropsychological functioning on measures of executive functioning, intellectual functioning, and processing speed. These findings are consistent with the literature that dissociative symptoms are associated with a severe illness presentation (Park et al., 2021, 2023; Stein et al., 2013). This work expands the literature by highlighting the specific impact of trauma-related dissociation on cognition among those experiencing PTSD. Neurobiological studies support this differentiation, with the experience of trauma-related dissociation (e.g., depersonalization and derealization) being associated with specific neural network patterns that are distinct from those experiencing PTSD without dissociation (Daniels et al., 2016; Lanius et al., 2010; Lebois et al., 2021; Nicholson et al., 2015, 2020; Tursich et al., 2015).

Interestingly, emotion dysregulation further exacerbated problems with efficient processing of information and worsened self-perceived cognitive impairment. Given that emotion dysregulation accounted for unique variance in these cognitive domains, this finding points to the complex role of emotion in cognition among individuals experiencing PTSD.

Despite evidence of a strong association between dissociation and cognitive functioning, neither dissociation nor emotion dysregulation accounted for unique variance in functional

impairment after accounting for PTSD symptom severity. Similarly, neither dissociation nor emotion dysregulation explained the presence of functional impairment among individuals with PTSD, after accounting for PTSD symptom severity.

Neuropsychological Functioning

Dissociation explained 12% of the variance in executive functioning, as well as 12% of the variance in intellectual functioning in our study. This suggests that higher-order tasks, planning, and general intellectual functioning become significantly more impaired with worsening dissociative symptoms. Neither were meaningfully affected by increasing symptoms of PTSD severity or emotion dysregulation, indicating that dissociation was a unique driver of cognitive dysfunction, even after controlling for sex, patient status, and premorbid IQ. This is consistent with studies that link PTSD symptoms with executive functioning deficits (Aupperle et al., 2012; Scott et al., 2015; Wrocklage et al., 2016) and general intelligence (Malarbi et al., 2017), but expands on this work by distinguishing the unique role of dissociation from PTSD symptom severity in cognitive dysfunction. Although previous research has identified lower IQ as both a potential risk factor for and consequence of PTSD (De Bellis & Zisk, 2014), we found that general intellectual functioning was still impaired after controlling for premorbid IQ.

Dissociative symptoms and emotion dysregulation collectively accounted for 15% of the variance in processing speed, after accounting for PTSD symptom severity and control variables. In other words, processing speed significantly slowed as individuals experienced greater dissociative symptoms, and further slowed as individuals reported greater emotion dysregulation symptoms. This is consistent with existing studies linking PTSD and impaired processing speed (Malarbi et al., 2017; Scott et al., 2015; Wrocklage et al., 2016) and dissociation with cognitive dysfunction (Dorahy et al., 2002; Guralnik et al., 2007), where individuals with dissociative

identity disorder demonstrated significantly slower processing speed than control participants in a negative priming task assessing one's ability to inhibit irrelevant information (Dorahy et al., 2002). Similarly, dissociation correlated with slowed processing speed among individuals with depersonalization disorder, an association that was not mediated by anxiety or depression symptoms (Guralnik et al., 2007). In another study of depressed individuals with a history of trauma, severe depersonalization symptoms were associated with significantly slowed processing speed (Parlar et al., 2013). Taken together, our findings support the idea that individuals with elevated trauma-related dissociation have difficulties with efficient processing of information, and that this may be further exacerbated by difficulties regulating emotions. Moreover, these findings highlight the complex interplay between cognition and emotion in PTSD, where the majority of accounts of cognitive dysfunction in PTSD highlight cognitive processes only while failing to account for the impact of emotion (e.g., the exacerbation of impulsive responding while in a triggered state).

Neither attention nor declarative memory impairments were explained by worsening symptoms of PTSD severity, dissociation, or emotion dysregulation. This is notable given the mixed literature in studies examining impairments in attention and memory in PTSD (Qureshi et al., 2011; Scott et al., 2015 vs. Wrocklage et al., 2016). In a literature review, Banich et al. (2009) suggested that emotions may affect how cognitive control is exerted, which can impact upon cognitive impairment in PTSD and dissociation. Indeed, there is some evidence suggesting that individuals high in dissociation can disengage attention in the presence of trauma-related stimuli more effectively than non-trauma-related stimuli (Banich et al., 2009), consistent with the function of dissociation in the face of overwhelming trauma (Lanius et al., 2002).

Self-Reported Cognitive and Functional Impairments

PTSD symptom severity accounted for 25% of the variance in self-reported cognitive functioning, suggesting that individuals perceived greater difficulties in cognition as their PTSD symptoms worsened. Difficulties regulating emotions explained an addition 12% of variance after accounting for other relevant variables in the model. This indicates that as either PTSD or emotion dysregulation symptoms worsen, individuals view their cognitive functioning as increasingly impaired. However, unlike dissociation's role in worsening intellectual functioning, executive functioning, and processing speed (when measured by neuropsychological tests as discussed above), self-reported cognitive impairment was not accounted for by dissociative symptoms. Thus, in contrast to the poorer neuropsychological test performance found among those with high dissociation, dissociative symptoms did not explain cognitive impairment when individuals self-reported their symptoms.

Interestingly, although our study included both subjective and neuropsychological measures of cognitive dysfunction by including self-report questionnaires and a clinician-administered neuropsychological test battery, PTSD severity and dissociative symptoms differentially contributed to cognitive impairment. Specifically, whereas dissociation emerged as a significant predictor of impaired neuropsychological performance but not self-reported cognitive impairment, PTSD symptom severity significantly predicted impairment on self-reported measures but not neuropsychological tests. Here, it is possible that whereas PTSD symptom severity worsens one's perceptions of cognitive and daily impairment, dissociative symptoms more greatly interfere with cognitive performance.

Notably, some research indicates a low concordance between self-reported and neuropsychological test performance (French et al., 2014; Jamora et al., 2012; Soble et al., 2013;

Stulemeijer et al., 2007), suggesting that emotional distress or problems impact significantly upon self-perceived cognitive impairment. This is consistent with our findings that emotion dysregulation had detrimental impacts on both neuropsychological tests and cognitive complaints. In larger samples, it will be important to confirm the differential impacts of dissociation, PTSD severity, and emotion dysregulation on cognitive dysfunction, as they each played a unique role in worsening cognition in our study. Moreover, it is critical not to ignore the influence of other potential factors on the discordance between self-reported cognitive functioning and objective neuropsychological impairment, which may include the testing milieu that is intended to be free of distractors (such as those present in the workplace environment), the absence of triggering stimuli, and the presence of a supportive examiner who may assist in keeping the mind in the present moment while undergoing neuropsychological testing.

Finally, PTSD symptom severity accounted for 28% of the variance in self-reported functional impairment, after controlling for biological sex, patient status, and premorbid IQ. Individuals reported greater functional impairment as PTSD symptoms became more severe. However, neither dissociation nor emotion dysregulation explained additional variance above and beyond that explained by PTSD symptom severity. These results are supported by previous findings that PTSD symptom severity is a major driver of self-reported impairments in functioning across multiple domains of life, including cognition (Harper et al., 2022; Knowles et al., 2019; Sareen et al., 2007). Overall, although PTSD severity and emotion regulation difficulties worsened self-perceptions of cognitive impairment, and PTSD alone was associated with greater functional impairment, dissociation uniquely appeared to be the key driver of dysfunction when cognition was measured by neuropsychological tests.

Limitations

Given our limited sample size and demographic categorizations (i.e., binary response options for biological sex), it will be important for future studies to confirm our findings using larger sample sizes and inclusive questionnaires that assess diverse and intersectional gender, race, and ethnic identities. Additionally, the neuropsychological tests used in the study did not include trauma-related stimuli or induce emotional valence. Individuals with PTSD may experience heightened threat detection, biased attention toward or recall of negatively valenced stimuli, or difficulties disengaging from emotionally-charged stimuli (Banich et al., 2009; Hayes et al., 2012). Given that our study did not employ negatively-valenced stimuli, nor induce negative emotional states via trauma-relevant cues, in future studies, it may be helpful to examine how cognitive performance is impacted differently by dissociative symptoms across a range of emotional cues and contexts. Nonetheless, the current study included emotion dysregulation in all models to help account for the probable role that emotion plays in cognition and general functioning (Banich et al., 2009; Boyd et al., 2018; Hayes et al., 2012; Messman-Moore & Bhuptani, 2017).

Clinical Implications

Clinically, it will be critical to assess for dissociative symptoms and emotion dysregulation among individuals experiencing PTSD, particularly among those reporting cognitive impairment or presenting with high clinical severity. Moreover, targeting specific symptoms of dissociation and emotion dysregulation may help reduce cognitive difficulties among individuals experiencing PTSD. Relatedly, negative self-appraisals and trauma coping self-efficacy have been found to moderate the effect of PTSD symptom severity on self-reported cognitive dysfunction (Samuelson et al., 2017). Adjunctive skills from evidence-based interventions such as cognitive restructuring may in turn, be helpful for individuals in reducing distress and maladaptive beliefs regarding their

cognitive functioning. In addition, the integration of evidence-based skills that are designed to improve emotion regulation may benefit individuals experiencing PTSD, regardless of whether their cognitive dysfunction is self-reported or observed in neuropsychological testing. According to a recent systematic review, Dialectical Behavior Therapy (DBT), which includes modules to improve emotion regulation skills, was an effective transdiagnostic intervention for improving cognitive functioning in multiple domains, as assessed by self-report and neuropsychological tests (Vijayapriya & Tamarana, 2023). Cognitive remediation therapies such as Goal Management Training (GMT) have also been associated with improvements in cognitive functioning among military members, veterans, and first responders with PTSD (Boyd et al., 2019; Millman et al., 2023; Protopopescu et al., 2022). In addition to improvements in executive functioning, participants in GMT demonstrated reductions in cognitive complaints, functional impairment, dissociation, emotion dysregulation, depression, and anxiety symptoms (Protopopescu et al., 2022), indicating that GMT may be helpful in improving both cognitive and affective domains that are negatively impacted in PTSD, particularly when individuals present with elevated levels of dissociation.

Other novel adjunctive treatments that may improve cognitive functioning in PTSD include non-invasive electroencephalography- or functional magnetic resonance imaging (fMRI)-neurofeedback training (Nicholson et al., 2022; Ros et al., 2014; van der Kolk et al., 2016). In samples of individuals with mild cognitive impairment, neurofeedback training was associated with improved executive functioning, attention, cognitive flexibility, and processing efficiency (Jang et al., 2019; Lavy et al., 2019; Marlats et al., 2019). Among individuals with PTSD, neurofeedback training has been associated with greater improvements in emotion regulation and PTSD symptoms, as compared to waitlist-controls (Gapen et al., 2016; van der Kolk et al., 2016).

Thus, neurofeedback training may be a valuable intervention for ameliorating both cognitive and affective impairments experienced by individuals with elevated trauma-related dissociation. Although most research in PTSD has historically focused on the non-dissociative subtype of PTSD, the current study's findings add to a growing body of literature expanding our understanding of PTSD as a highly heterogeneous disorder (Glatzer-Levy & Bryant, 2013). In addition to shedding light on the cognitive impairments faced by individuals experiencing persistent trauma-related dissociation, our results emphasize the importance of continuing to assess for symptoms of dissociation and emotion dysregulation to reduce the burden of trauma. Developing effective evidence-based interventions for individuals across the spectrum of PTSD will require the consideration of how persistent-trauma related dissociation impacts symptom presentation, including cognitive dysfunction.

Disclosure statement

The authors do not have any conflicts of interest to report.

Funder Information

Margaret C. McKinnon (MM) is supported by the Homewood Chair in Mental Health and Trauma at McMaster University. Ruth A. Lanius (RL) is supported by the Harris-Woodman Chair in Psyche and Soma. We are grateful to the Homewood Research Institute for their generous infrastructure support of this research and to Homewood Health Centre for allowing us access to their inpatient treatment setting. This research was supported by Canadian Institutes of Health Research grants to MM and RL.

References

Afifi, T. O., Taillieu, T., Zamorski, M. A., Turner, S., Cheung, K., & Sareen, J. (2016). Association of child abuse exposure with suicidal ideation, suicide plans, and suicide attempts in military personnel and the general population in Canada. *JAMA Psychiatry*, *73*(3), 229-238. http://dx.doi.org/10.1001/jamapsychiatry.2015.2732

Alexis, V., Géraldine, T., David, C., Camille, R., & Wissam, E. H. (2023). Association between cognitive impairments and dissociation: a PRISMA systematic review. *European Journal of Trauma & Dissociation*, *7*(3), 100341. http://dx.doi.org/10.1016/j.ejtd.2023.100341

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders. *Arlington* (5th Edition: DSM-5). doi:10.1176/appi.books.9780890425596.893619

Amrhein, C., Hengmith, S., Maragkos, M., & Hennig-Fast, K. (2008). Neuropsychological characteristics of highly dissociative healthy individuals. *Journal of Trauma & Dissociation*, *9*(4), 525-542. http://dx.doi.org/10.1080/15299730802226332

Aupperle, R. L., Ravindran, L., Tankersley, D., Flagan, T., Stein, N. R., Simmons, A. N., Stein, M. B., & Paulus, M. P. (2011). Pregabalin influences insula and amygdala activation during anticipation of emotional images. *Neuropsychopharmacology*, *36*(7). https://doi.org/10.1038/npp.2011.32

Banich, M. T., Mackiewicz, K. L., Depue, B. E., Whitmer, A. J., Miller, G. A., & Heller, W. (2009). Cognitive control mechanisms, emotion and memory: a neural perspective with implications for psychopathology. *Neuroscience & Biobehavioral Reviews*, *33*(5), 613-630. http://dx.doi.org/10.1016/j.neubiorev.2008.09.010

Bernstein, E.M., & Putnam, F.W. (1986). Development, reliability, and validity of a dissociation scale. *Journal of Nervous and Mental Disease, 174*(12),727-734. http://dx.doi.org/10.1097/00005053-198612000-00004

Bovin, M. J., Marx, B. P., Weathers, F. W., Gallagher, M. W., Rodriguez, P., Schnurr, P. P., & Keane, T. M. (2016). Psychometric properties of the PTSD checklist for diagnostic and statistical manual of mental disorders–fifth edition (PCL-5) in veterans. *Psychological Assessment, 28*(11), 1379–1391. doi:10.1037/pas0000254

Boyd, J. E., O'Connor, C., Protopopescu, A., Jetly, R., Rhind, S. G., Lanius, R. A., & McKinnon, M. C. (2019). An open-label feasibility trial examining the effectiveness of a cognitive training program, goal management training, in individuals with posttraumatic stress disorder. *Chronic Stress, 3*, 2470547019841599. http://dx.doi.org/10.1177/2470547019841599

Boyd, J. E., Protopopescu, A., O'Connor, C., Neufeld, R. W., Jetly, R., Hood, H. K., ... & McKinnon, M. C. (2018). Dissociative symptoms mediate the relation between PTSD symptoms and functional impairment in a sample of military members, veterans, and first responders with PTSD. *European Journal of Psychotraumatology, 9*(1), 1463794. http://dx.doi.org/10.1080/20008198.2018.1463794

Briere, J., Weathers, F.W., & Runtz, M. (2005). Is dissociation a multidimensional construct? Data from the Multiscale Dissociation Inventory. *Journal of Traumatic Stress, 18*(3), 221–231. https://doi.org/10.1002/jts.20024

Broadbent, D. E., Cooper, P. F., FitzGerald, P., & Parkes, K. R. (1982). The cognitive failures questionnaire (CFQ) and its correlates. *British Journal of Clinical Psychology, 21*(1), 1–16. https://doi.org/10.1111/j.2044-8260.1982.tb01421.x

Burgess, P. W., Alderman, N., Evans, J. J., Wilson, B. A., & Emslie, H. (1996). "The dysexecutive questionnaire," in Behavioral Assessment of the Dysexecutive Syndrome, eds B. A. Wilson, N. Alderman, P. W. Burgess, H. Emslie, and J. J. Evans (Bury St. Edmunds: Thames Valley Test Company).

Cavicchioli, M., Ogliari, A., Maffei, C., Mucci, C., Northoff, G., & Scalabrini, A. (2023). Neural responses to emotional stimuli across the dissociative spectrum: Common and specific mechanisms. *Psychiatry and Clinical Neurosciences*, *77*(6), 315-329. http://dx.doi.org/10.1111/pcn.13547

Christiansen, D. M., & Berke, E. T. (2020). Gender-and sex-based contributors to sex differences in PTSD. *Current Psychiatry Reports*, *22*(4), 1-9. http://dx.doi.org/10.1007/s11920-020-1140-y

Conners, KC. (2014). Conners Continuous Performance Test 3rd Edition. Toronto, Canada: Multi-Health Systems.

Daniels, J. K., Frewen, P., Theberge, J., & Lanius, R. A. (2016). Structural brain aberrations associated with the dissociative subtype of post-traumatic stress disorder. Acta *Psychiatrica Scandinavica*, *133*(3), 232-240. http://dx.doi.org/10.1111/acps.12464

De Bellis, M. D., & Zisk, A. (2014). The biological effects of childhood trauma. *Child and Adolescent Psychiatric Clinics*, *23*(2), 185-222. http://dx.doi.org/10.1016/j.chc.2014.01.002

Delis, D. C., Kramer, J. H., Kaplan, E., & Ober, B. A. (2000). California Verbal Learning Test – II (CVLT-II). San Antonio, TX: The Psychological Corporation.

Delis, D.C., Kaplan, E., & Kramer, D.C. (2001). Delis-Kaplan Executive Function System (DKEFS). San Antonia, TX: The Psychological Corporation.

Dell, P. F. (2006). The Multidimensional Inventory of Dissociation (MID): A comprehensive measure of pathological dissociation. *Journal of Trauma & Dissociation*, *7*(2), 77-106. http://dx.doi.org/10.1300/J229v07n02_06

Dorahy, M. J., Irwin, H. J., & Middleton, W. (2002). Cognitive inhibition in dissociative identity disorder (DID): Developing an understanding of working memory function in DID. *Journal of Trauma & Dissociation*, *3*(3), 111-132. http://dx.doi.org/10.1300/J229v03n03_07

Emmanuel, T., Maupong, T., Mpoeleng, D., Semong, T., Mphago, B., & Tabona, O. (2021). A survey on missing data in machine learning. *Journal of Big Data*, *8*(1), 1-37. http://dx.doi.org/10.1186/s40537-021-00516-9

Fink, D. L. (1988). The core self: A developmental perspective on the dissociative disorders. *Dissociation*, *1*(2), 43-47.

French, L. M., Lange, R. T., & Brickell, T. A. (2014). Subjective cognitive complaints and neuropsychological test performance following military-related traumatic brain injury. *Journal of Rehabilitation Research & Development*, *51*(6). http://dx.doi.org/10.1682/JRRD.2013.10.0226

Galatzer-Levy, I. R., & Bryant, R. A. (2013). 636,120 ways to have posttraumatic stress disorder. *Perspectives on Psychological Science*, *8*(6), 651-662. https://doi.org/10.1177/1745691613504115

Gapen, M., van der Kolk, B. A., Hamlin, E., Hirshberg, L., Suvak, M., & Spinazzola, J. (2016). A Pilot Study of Neurofeedback for Chronic PTSD. *Applied Psychophysiology Biofeedback*, *41*(3). https://doi.org/10.1007/s10484-015-9326-5

Giesbrecht, T., Merckelbach, H., Geraerts, E., & Smeets, E. (2004). Dissociation in undergraduate students: Disruptions in executive functioning. *The Journal of Nervous and Mental Disease, 192*(8), 567-569. http://dx.doi.org/10.1097/01.nmd.0000135572.45899.f2

Gratz, K. L.,&Roemer, L. (2004).Multidimensional assessment of emotion regulation and dysregulation: Development, factor structure, and initial validation of the difficulties in emotion regulation scale. *Journal of Psychopathology and Behavioral Assessment, 26*(1), 41–54. https://doi.org/10.1023/B:JOBA.00000 07455.08539.94

Guralnik, O., Giesbrecht, T., Knutelska, M., Sirroff, B., & Simeon, D. (2007). Cognitive Functioning in Depersonalization Disorder. *Journal of Nervous & Mental Disease, 195*(12), 983-988. http://dx.doi.org/10.1097/NMD.0b013e31815c19cd

Hanna-Pladdy, B. (2007). Dysexecutive syndromes in neurologic disease. *Journal of Neurologic Physical Therapy, 31*(3), 119–127. http://dx.doi.org/10.1097/NPT.0b013e31814a63c2

Harper, K. L., Moshier, S., Ellickson-Larew, S., Andersen, M. S., Wisco, B. E., Mahoney, C. T., Keane, T. M., Marx, B. P. (2022). A prospective examination of health care costs associated with posttraumatic stress disorder diagnostic status and symptom severity among veterans. *Journal of Traumatic Stress, 35,* 671-681. https://dx.doi.org/10.1002/jts.22785

Hayes, J. P., VanElzakker, M. B., & Shin, L. M. (2012). Emotion and cognition interactions in PTSD: a review of neurocognitive and neuroimaging studies. *Frontiers in Integrative Neuroscience, 6,* 89. http://dx.doi.org/10.3389/fnint.2012.00089

Jamora, C. W., Young, A., & Ruff, R. M. (2012). Comparison of subjective cognitive complaints with neuropsychological tests in individuals with mild vs more severe traumatic brain injuries. *Brain Injury*, *26*(1), 36-47. http://dx.doi.org/10.3109/02699052.2011.635352

Jang, J. H., Kim, J., Park, G., Kim, H., Jung, E. S., Cha, J. Y., ... & Yoo, H. (2019). Beta wave enhancement neurofeedback improves cognitive functions in patients with mild cognitive impairment: A preliminary pilot study. *Medicine*, *98*(50). http://dx.doi.org/10.1097/MD.0000000000018357

Knowles, K. A., Sripada, R. K., Defever, M., & Rauch, S. A. (2019). Comorbid mood and anxiety disorders and severity of posttraumatic stress disorder symptoms in treatment-seeking veterans. *Psychological Trauma: Theory, Research, Practice, and Policy*, *11*(4), 451. http://dx.doi.org/10.1037/tra0000383

Kremen, W. S., Koenen, K. C., Boake, C., Purcell, S., Eisen, S. A., Franz, C. E., ... & Lyons, M. J. (2007). Pretrauma cognitive ability and risk for posttraumatic stress disorder: a twin study. *Archives of General Psychiatry*, *64*(3), 361-368. http://dx.doi.org/10.1001/archpsyc.64.3.361

Lanius, R. A., Vermetten, E., Loewenstein, R. J., Brand, B., Schmahl, C., Bremner, J. D., & Spiegel, D. (2010). Emotion modulation in PTSD: Clinical and neurobiological evidence for a dissociative subtype. *American Journal of Psychiatry*, *167*(6), 640–647. http://dx.doi.org/10.1176/appi.ajp.2009.09081168

Lanius, R. A., Williamson, P. C., Boksman, K., Densmore, M., Gupta, M., Neufeld, R. W., ... & Menon, R. S. (2002). Brain activation during script-driven imagery induced dissociative responses in PTSD: a functional magnetic resonance imaging investigation. *Biological Psychiatry*, *52*(4), 305-311. http://dx.doi.org/10.1016/S0006-3223(02)01367-7

Lavy, Y., Dwolatzky, T., Kaplan, Z., Guez, J., & Todder, D. (2019). Neurofeedback improves memory and peak alpha frequency in individuals with mild cognitive impairment. *Applied Psychophysiology and Biofeedback*, *44*, 41-49. http://dx.doi.org/10.1007/s10484-018-9418-0

Lebois, L. A., Li, M., Baker, J. T., Wolff, J. D., Wang, D., Lambros, A. M., ... & Kaufman, M. L. (2021). Large-scale functional brain network architecture changes associated with trauma-related dissociation. *American Journal of Psychiatry*, *178*(2), 165-173. http://dx.doi.org/10.1176/appi.ajp.2020.19060647

Liao, S. G., Lin, Y., Kang, D. D., Chandra, D., Bon, J., Kaminski, N., ... & Tseng, G. C. (2014). Missing value imputation in high-dimensional phenomic data: imputable or not, and how?. *BMC Bioinformatics*, *15*(1), 1-12. http://dx.doi.org/10.1186/s12859-014-0346-6

Malarbi, S., Abu-Rayya, H. M., Muscara, F., & Stargatt, R. (2017). Neuropsychological functioning of childhood trauma and post-traumatic stress disorder: A meta-analysis. *Neuroscience & Biobehavioral Reviews*, *72*, 68-86. http://dx.doi.org/10.1016/j.neubiorev.2016.11.004

Marlats, F., Djabelkhir-Jemmi, L., Azabou, E., Boubaya, M., Pouwels, S., & Rigaud, A. S. (2019). Comparison of effects between SMR/delta-ratio and beta1/theta-ratio neurofeedback training for older adults with Mild Cognitive Impairment: A protocol for a randomized controlled trial. *Trials*, *20*, 1-12. http://dx.doi.org/10.1186/s13063-018-3170-x

McFarlane, A. C., Bookless, C., & Air, T. (2001). Posttraumatic stress disorder in a general psychiatric inpatient population. *Journal of Traumatic Stress*, *14*(4), 633-645. http://dx.doi.org/10.1023/A:1013077702520

Misztal, M. (2013). Some remarks on the data imputation using “missForest” method. *Acta Universitatis Lodziensis. Folia Oeconomica*, *285*.

McKinnon, M. C., Boyd, J. E., Frewen, P. A., Lanius, U. F., Jetly, R., Richardson, J. D., & Lanius, R. A. (2016). A review of the relation between dissociation, memory, executive functioning and social cognition in military members and civilians with neuropsychiatric conditions. *Neuropsychologia*, *90*, 210–234. doi:10.1016/j.neuropsychologia.2016.07.017

Messman-Moore, T. L., & Bhuptani, P. H. (2017). A Review of the Long-Term Impact of Child Maltreatment on Posttraumatic Stress Disorder and Its Comorbidities: An Emotion Dysregulation Perspective. *Clinical Psychology: Science and Practice, 24*(2). https://doi.org/10.1111/cpsp.12193

Millman, H., Ritchie, K., Vincent, C., Auger, E., Lavoie, V., Sanger, B., ... & McKinnon, M. (2023). Evaluating the implementation of virtual Goal Management Training among Veterans with posttraumatic stress disorder. *Journal of Military, Veteran and Family Health*, e20230003. http://dx.doi.org/10.3138/jmvfh-2023-0003

Nicholson, A. A., Densmore, M., Frewen, P. A., Théberge, J., Neufeld, R. W., McKinnon, M. C., & Lanius, R. A. (2015). The dissociative subtype of posttraumatic stress disorder: unique resting-state functional connectivity of basolateral and centromedial amygdala complexes. *Neuropsychopharmacology*, *40*(10), 2317-2326. http://dx.doi.org/10.1038/npp.2015.79

Nicholson, A. A., Densmore, M., McKinnon, M. C., Neufeld, R.W., Frewen, P. A., Théberge, J., Jetly, R., Richardson, J. D., & Lanius, R. A. (2019). Machine learning multivariate pattern analysis predicts classification of posttraumatic stress disorder and its dissociative

subtype: A multimodal neuroimaging approach. *Psychological Medicine*, *49*(12), 2049–2059. https://doi.org/10.1017/S0033291718002866

Nicholson, A. A., Harricharan, S., Densmore, M., Neufeld, R. W., Ros, T., McKinnon, M. C., ... & Lanius, R. A. (2020). Classifying heterogeneous presentations of PTSD via the default mode, central executive, and salience networks with machine learning. *NeuroImage: Clinical*, *27*, 102262. http://dx.doi.org/10.1016/j.nicl.2020.102262

Nicholson, A. A., Rabellino, D., Densmore, M., Frewen, P. A., Steryl, D., Scharnowski, F., Théberge, J., Neufeld, R. W. J., Schmahl, C., Jetly, R., & Lanius, R. A. (2022). Differential mechanisms of posterior cingulate cortex downregulation and symptom decreases in posttraumatic stress disorder and healthy individuals using real-time fMRI neurofeedback. *Brain and Behavior*, *12*(1). https://doi.org/10.1002/brb3.2441

Park, A. H., Patel, H., Mirabelli, J., Eder, S. J., Steyrl, D., Lueger-Schuster, B., ... & Nicholson, A. A. (2023). Machine learning models predict PTSD severity and functional impairment: A personalized medicine approach for uncovering complex associations among heterogeneous symptom profiles. *Psychological Trauma: Theory, Research, Practice, and Policy*. 19429681. http://dx.doi.org/10.1037/tra0001602

Park, A. H., Protopopescu, A., Pogue, M. E., Boyd, J. E., O'Connor, C., Lanius, R. A., & McKinnon, M. C. (2021). Dissociative symptoms predict severe illness presentation in Canadian public safety personnel with presumptive post-traumatic stress disorder (PTSD). *European Journal of Psychotraumatology*, *12*(1), 1953789. http://dx.doi.org/10.1080/20008198.2021.1953789

Parlar, M., Frewen, P. A., Oremus, C., Lanius, R. A., & McKinnon, M. C. (2016). Dissociative symptoms are associated with reduced neuropsychological performance in patients with

recurrent depression and a history of trauma exposure. *European Journal of Psychotraumatology, 7*(1), 29061. http://dx.doi.org/10.3402/ejpt.v7.29061

Protopopescu, A., O'connor, C., Cameron, D., Boyd, J. E., Lanius, R. A., & McKinnon, M. C. (2022). A Pilot Randomized Controlled Trial of Goal Management Training in Canadian Military Members, Veterans, and Public Safety Personnel Experiencing Post-Traumatic Stress Symptoms. *Brain Sciences*, *12*(3), 377. http://dx.doi.org/10.3390/brainsci12030377

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?. *The Journal of Neuropsychiatry and Clinical Neurosciences*, *23*(1), 16-28. http://dx.doi.org/10.1176/appi.neuropsych.23.1.16

R Core Team. (2019). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. https://www.R-project.org/

Reitan, R., & Wolfson, D. (1985). The Halstead-Reitan Neuropsychological Battery: Theory and Clinical Interpretation. Tucson, AZ: Neuropsychology Press.

Rivera-Vélez, G. M., González-Viruet, M., Martínez-Taboas, A., & Pérez-Mojica, D. (2014). Post-traumatic stress disorder, dissociation, and neuropsychological performance in Latina victims of childhood sexual abuse. *Journal of Child Sexual Abuse*, *23*(1), 55-73. https://doi.org/10.1080/10538712.2014.864746

Roca, V., Hart, J., Kimbrell, T., & Freeman, T. (2006). Cognitive function and dissociative disorder status among veteran subjects with chronic posttraumatic stress disorder: A preliminary study. *The Journal of Neuropsychiatry and Clinical Neurosciences*, *18*(2), 226-230. http://dx.doi.org/10.1176/jnp.2006.18.2.226

Ros, T., Lanius, R. A., & Vuilleumier, P. (2014). Tuning pathological brain oscillations with neurofeedback: a systems neuroscience framework. *Frontiers in Human Neuroscience, 8*, 1008-1008. http://dx.doi.org/10.3389/fnhum.2014.01008

Roth, S. L., Andrews, K., Protopopescu, A., Lloyd, C., O'Connor, C., Losier, B. J., ... & McKinnon, M. C. (2022). Mental health symptoms in public safety personnel: examining the effects of adverse childhood experiences and moral injury. *Child Abuse & Neglect, 123*, 105394. http://dx.doi.org/10.1016/j.chiabu.2021.105394

Samuelson, K. W., Abadjian, L., Jordan, J. T., Bartel, A., Vasterling, J., & Seal, K. (2017). The association between PTSD and functional outcome is mediated by perception of cognitive problems rather than objective neuropsychological test performance. *Journal of Traumatic Stress*, *30*(5), 521-530. http://dx.doi.org/10.1002/jts.22223

Sareen, J., Cox, B. J., Stein, M. B., Afifi, T. O., Fleet, C., & Asmundson, G. J. (2007). Physical and mental comorbidity, disability, and suicidal behavior associated with posttraumatic stress disorder in a large community sample. *Psychosomatic Medicine*, *69*(3), 242-248.

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. http://dx.doi.org/10.1037/a0038039

Simeon, D., Giesbrecht, T., Knutelska, M., Smith, R. J., & Smith, L. M. (2009). Alexithymia, absorption, and cognitive failures in depersonalization disorder: a comparison to posttraumatic stress disorder and healthy volunteers. *The Journal of Nervous and Nental Disease*, *197*(7), 492-498. http://dx.doi.org/10.1097/NMD.0b013e3181aaef6b

Soble, J. R., Spanierman, L. B., & Fitzgerald Smith, J. (2013). Neuropsychological functioning of combat veterans with posttraumatic stress disorder and mild traumatic brain injury. *Journal of Clinical and Experimental Neuropsychology*, *35*(5), 551-561. http://dx.doi.org/10.1080/13803395.2013.798398

Stein, D. J., Koenen, K. C., Friedman, M. J., Hill, E., McLaughlin, K. A., Petukhova, M., ... & Kessler, R. C. (2013). Dissociation in posttraumatic stress disorder: evidence from the world mental health surveys. *Biological Psychiatry*, *73*(4), 302-312. http://dx.doi.org/10.1016/j.biopsych.2012.08.022

Stekhoven, D. J., & Bühlmann, P. (2012). MissForest—non-parametric missing value imputation for mixed-type data. *Bioinformatics*, *28*(1), 112-118. http://dx.doi.org/10.1093/bioinformatics/btr597

Stulemeijer, M., Vos, P. E., Bleijenberg, G., & Van der Werf, S. P. (2007). Cognitive complaints after mild traumatic brain injury: things are not always what they seem. *Journal of Psychosomatic Research*, *63*(6), 637-645. http://dx.doi.org/10.1016/j.jpsychores.2007.06.023

Tsai, J., Armour, C., Southwick, S. M., & Pietrzak, R. H. (2015). Dissociative subtype of DSM-5 posttraumatic stress disorder in U.S. veterans. *Journal of Psychiatric Research, 66–67*, 67–74. https://doi.org/10.1016/j.jpsychires.2015.04.017

Tursich, M., Ros, T., Frewen, P. A., Kluetsch, R. C., Calhoun, V. D., & Lanius, R. A. (2015). Distinct intrinsic network connectivity patterns of post-traumatic stress disorder symptom clusters. *Acta Psychiatrica Scandinavica*, *132*(1), 29-38.

van der Kolk, B. A., Hodgdon, H., Gapen, M., Musicaro, R., Suvak, M. K., Hamlin, E., & Spinazzola, J. (2016). A randomized controlled study of neurofeedback for chronic PTSD. *PloS one, 11*(12), e0166752. http://dx.doi.org/10.1371/journal.pone.0166752

Vijayapriya, C. V., & Tamarana, R. (2023). Effectiveness of dialectical behavior therapy as a transdiagnostic treatment for improving cognitive functions: a systematic review. *Research in Psychotherapy: Psychopathology, Process, and Outcome*, *26*(2). http://dx.doi.org/10.4081/ripppo.2023.662

Weathers, F. W., Litz, B. T., Keane, T. M., Palmieri, P. A., Marx, B. P., & Schnurr, P. P. (2013). *The PTSD checklist for DSM-5 (PCL-5).* Scale Available from the National Center for PTSD at https://www.ptsd.va.gov/

Wechsler, D. (2001). Wechsler Test of Adult Reading (WTAR). San Antonio, TX: Psychological Corporation.

Wechsler, D. (2008). Wechsler Adult Intelligence Scale-Fourth Edition (WASI-IV). San Antonio, TX: Psychological Corporation.

Wechsler, D. (2011). Wechsler Abbreviated Scale of Intelligence-Second Edition (WASI-II). San Antonio, TX: NCS Pearson.

White, W. F., Burgess, A., Dalgleish, T., Halligan, S., Hiller, R., Oxley, A., ... & Meiser-Stedman, R. (2022). Prevalence of the dissociative subtype of post-traumatic stress disorder: a systematic review and meta-analysis. *Psychological Medicine*, 1-16. http://dx.doi.org/10.1017/S0033291722001647

World Health Organization. (2000, February). World Health Organization disability assessment schedule: WHODAS II. Phase 2 field trials. Health services research. *Health Services Research*.

Wortmann, J. H., Jordan, A. H., Weathers, F. W., Resick, P. A., Dondanville, K. A., Hall-Clark, B., . . . Mintz, J. (2016). Psychometric analysis of the PTSD Checklist-5 (PCL-5) among treatment-seeking military service members. *Psychological Assessment, 28*(11), 1392. doi:10.1037/pas0000260

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. http://dx.doi.org/10.1017/S1355617716000059

Chapter 4:

Machine learning models predict PTSD severity and functional impairment: A personalized medicine approach for uncovering complex associations among heterogeneous symptom profiles

Park, A. H., Patel, H., Mirabelli, J., Eder, S. J., Steyrl, D., Lueger-Schuster, B., Scharnowski, F., O'Connor, C., Martin, P., Lanius, R. A., McKinnon, M. C., & Nicholson, A. A. (2023). Machine learning models predict PTSD severity and functional impairment: A personalized medicine approach for uncovering complex associations among heterogeneous symptom profiles. *Psychological Trauma: Theory, Research, Practice, and Policy*. 19429681. http://dx.doi.org/10.1037/tra0001602

Abstract

Objective

Posttraumatic stress disorder (PTSD) is a debilitating psychiatric illness, experienced by approximately 10% of the population. Heterogeneous presentations that include heightened dissociation, comorbid anxiety and depression, and emotion dysregulation contribute to the severity of PTSD, in turn, creating barriers to recovery. There is an urgent need to use data-driven approaches to better characterize complex psychiatric presentations with the aim of improving treatment outcomes. We sought to determine if machine learning models could predict PTSD-related illness in a real-world treatment-seeking population using self-report clinical data.

Methods

Secondary clinical data from 2017 to 2019 included pretreatment measures such as trauma-related symptoms, other mental health symptoms, functional impairment, and demographic information from adults admitted to an inpatient unit for PTSD in Canada (n= 393). We trained two nonlinear machine learning models (extremely randomized trees) to identify predictors of (a) PTSD symptom severity and (b) functional impairment. We assessed model performance based on predictions in novel subsets of patients.

Results

Approximately 43% of the variance in PTSD symptom severity (R^2_{avg}=.43, R^2_{median}=.44, p=.001) was predicted by symptoms of anxiety, dissociation, depression, negative trauma-related beliefs about others, and emotion dysregulation. In addition, 32% of the variance in functional impairment scores (R^2_{avg} =.32, R^2_{median} =.33, p=.001) was predicted by anxiety, PTSD symptom severity, cognitive dysfunction, dissociation, and depressive symptoms.

Conclusions

Our results reinforce that dissociation, cooccurring anxiety and depressive symptoms, maladaptive trauma appraisals, cognitive dysfunction, and emotion dysregulation are critical targets for trauma-related interventions. Machine learning models can inform personalized medicine approaches to maximize trauma recovery in real-world inpatient populations.

Clinical Impact Statement

Machine learning models accurately predicted self-reported trauma symptom severity and functional impairment scores in a masked subset of data, consisting of a sample of adults seeking inpatient treatment for posttraumatic stress disorder (PTSD). In order of decreasing importance, anxiety, dissociation, depression, negative trauma-related beliefs about the world, and emotion dysregulation were the greatest contributors of PTSD symptom severity; whereas anxiety, PTSD symptom severity, cognitive dysfunction, dissociation, and depression best accounted for functional impairment. Evidence-based interventions that specifically target these symptoms may be important for reducing the severity and burden of trauma-related illness.

Background

Posttraumatic stress disorder (PTSD) is a heterogeneous disorder, where it is estimated that there are approximately 636,120 possible combinations of Diagnostic and Statistical Manual of Mental Disorders (fifth edition; DSM-5) PTSD presentations (Galatzer-Levy & Bryant, 2013; Neria, 2021; Newson et al., 2021). Given its complex associations with a wide range of symptoms, it is no surprise that PTSD is a debilitating disorder (Harper et al., 2022; Sareen et al., 2007). Individuals with PTSD experience significant functional impairments in well-being, distress, and disability, including greater suicide attempts and long-term reduction of activities (Sareen et al., 2007). Notably, up to 30% of individuals with PTSD exhibit the dissociative subtype, which is characterized by heightened symptoms of depersonalization and derealization (American Psychiatric Association [APA], 2013; Armour et al., 2014; McKinnon et al., 2016; Lanius, 2015; Stein et al., 2013; White et al., 2022; Wolf, Lunney, et al., 2012; Wolf, Miller, et al., 2012). This can present as emotion overmodulation with a constellation of altered psychosomatic perceptions, including out-of-body experiences, feeling disconnected from one's body, and feeling that one's surroundings are dream-like or unreal (Lanius et al., 2010, 2012). Dissociation has been correlated with greater PTSD symptom severity, emotion dysregulation, functional impairment, and neuropsychological impairment, as well as aberrant bodily self-consciousness, and sensorimotor integration (Boyd et al., 2018; Harricharan et al., 2020; Ozer et al., 2003; Park et al., 2021; Stein et al., 2013; Tanner et al., 2019;Warner et al., 2014), with unique neurobiological correlates (Lebois et al., 2021) that differentiate it from the nondissociative subtype of PTSD (Daniels et al., 2016; Lanius et al., 2010, 2012; Nicholson et al., 2015, 2020; Tursich et al., 2015).

In addition to dissociative symptomatology, factors that increase the risk and severity of PTSD include emotion dysregulation, preexisting mental health conditions, childhood adversity, and comorbid mood and anxiety disorders, among others (Able & Benedek, 2019; Brady et al., 2019; Brady & Back, 2012; Greene et al., 2016; Knowles et al., 2019; Norman et al., 2012; Obuobi-Donkor et al., 2022; Stein et al., 2013). Importantly, psychiatric comorbidity in PTSD is the norm, where up to 68.4% of individuals with PTSD have one or more comorbid mental health condition(s) (Greene et al., 2016). Comorbid mood and anxiety disorders have been associated with greater PTSD symptom severity (Knowles et al., 2019), and comorbid major depressive disorder significantly contributes to increasing the risk of suicidality among individuals with PTSD (Panagioti et al., 2012, 2015). Further complicating its presentation, PTSD is associated with impairments in attention, concentration, memory, and executive functioning (El Khoury-Malhame et al., 2011; Hayes et al., 2012; Scott et al., 2015; Vasterling & Brewin, 2005).

Several evidence-based treatments for PTSD exist, including trauma-focused psychotherapies (e.g., cognitive processing therapy, prolonged exposure, and eye-movement desensitization and reprocessing), which outperform pharmacotherapies on relevant PTSD outcome measures, even at 3–9 months posttreatment (Foa et al., 2007; Lee et al., 2016; Merz et al., 2019; Resick et al., 2008). However, approximately 33% of individuals will still meet the criteria for PTSD after completing psychotherapy for PTSD, and 22%– 30% of patients with PTSD will drop out of trauma-focused psychotherapies (Bradley et al., 2005; Eftekhari et al., 2020). Indeed, Bae et al. (2016) found that in a specialized trauma clinic, treatment nonresponders displayed significantly higher levels of dissociation symptoms and psychiatric

comorbidities, suggesting that more complex or severe symptom profiles respond poorly to existing first-line treatments for PTSD.

PTSD symptom heterogeneity presents challenges for effective recovery (Neria, 2021), and yet, the majority of extant literature has focused on the associations across variables in isolation, rendering it difficult to account for the complex relationships among relevant clinical variables. Data-driven analytical techniques, such as machine learning, can allow for a more accurate representation of complex nonlinear relations among PTSD symptoms and the disorder's correlates. For example, machine learning regression models can take input features to predict a continuous target feature, such as the severity score of PTSD symptoms. Here, permutation analyses of feature importance provide an easy-to-interpret way of accurately estimating the amount of variance that each input feature contributes to making correct predictions. Further, the use of multiple training sets provides machine learning regression an advantage over standard regression by mitigating the effects of missing or noisy data. Critically, unlike traditional multivariate statistical analyses using sample inference, machine learning algorithms are evaluated based on their performance in unseen/novel data (i.e., data that were not used to train the model), increasing generalizability of results; are equipped to handle a greater number of input features (i.e., independent variables) with complex, nonlinear associations; and are not constrained or biased by assumptions on variable interactions, variable scales, or model oversimplification (Chekroud et al., 2021; Dwyer et al., 2018). Thus, machine learning regression models are ideally suited to examine outcomes of a highly heterogeneous and complex psychiatric condition such as PTSD.

In the field of psychiatry, the machine learning knowledge base surrounding PTSD is limited, where many studies focus on PTSD diagnosis (i.e., classification) rather than PTSD

symptoms on a continuum (i.e., regression; Harricharan et al., 2020; Nicholson et al., 2019; Schultebraucks et al., 2021; Siegel et al., 2021; Wani et al., 2021; Zafari et al., 2021; Ziobrowski et al., 2021). For example, neuroimaging data have been used to classify the dissociative subtype of PTSD, nondissociative subtype of PTSD, and healthy controls with high accuracy (>90% balanced classification accuracy) by our group (Harricharan et al., 2020; Nicholson et al., 2019). However, to our knowledge, no study to date has examined whether PTSD symptom severity and functional impairment can be predicted on a continuum using a naturalistic sample seeking inpatient treatment for this disorder. Given the relative dearth of literature utilizing machine learning regression models, this article seeks to contribute to the field using a novel and versatile statistical method. Critically, most machine learning studies examining PTSD have done so among relatively homogeneous samples of individuals with PTSD, using stringent exclusion criteria (e.g., history of head trauma; neurological disorder; major medical illness; current or past diagnosis of bipolar disorder, schizophrenia, or other psychotic disorders; severe drug use in the past year; severe suicidality in the past 3 months, etc.; Harricharan et al., 2020; Nicholson et al., 2019; Schultebraucks et al., 2021; Siegel et al., 2021). However, this stringent approach may not be representative of the diverse presentations of PTSD in most treatment clinics, thereby limiting the generalizability of these previous results to clinical settings. Although heterogeneous samples may contribute to greater noise in empirical data, they are far more representative of the real-world treatment-seeking population and increase the ecological validity of a study.

Accordingly, the current study employed machine learning models among a sample of adults seeking inpatient treatment for PTSD, with relatively few exclusion criteria. The purpose of this study was to determine if the employed machine learning models could predict: (a) PTSD symptom severity and (b) functional impairment scores in novel samples significantly better than

trivial predictors, and at a practically relevant effect size. Ultimately, increasing our knowledge of how relevant variables uniquely predict severity and impairment in PTSD can inform the design of more effective interventions and facilitate a personalized medicine approach (i.e., pair specific clinical profiles with tailored treatment plans). Here, we hypothesized that our models would confirm features that have been identified in the literature as contributing to the severity of PTSD symptoms (e.g., dissociation, emotion dysregulation, depression, and anxiety). We also hypothesized that PTSD symptom severity and cognitive dysfunction would additionally contribute to predicting functional impairment among this sample, where symptom severity is often viewed in the absence of its real-world correlate, functional outcomes.

Method

Participants

This project was approved by the Homewood Health Centre Research Ethics Board (REB 20-04) and the Hamilton Integrated REB (Project Number 8289-C). Secondary clinical data from September 2017 to November 2019 were provided by the Homewood Health Centre, as part of standard clinical practice at admission to the posttraumatic stress recovery (PTSR) unit. The PTSR unit provides specialized inpatient mental health treatment for individuals with PTSD and trauma-related disorders. The data set consisted of treatment-seeking adults in Canada aged 18–80 (M = 43.7±9.9), referred to the program by clinicians for trauma-related distress (n = 393, 196 female). Individuals were required to be: (a) 18 years of age or older; (b) able to participate in group therapy in a mixed community milieu; (c) able to tolerate their emotions and manage basic personal safety; and (d) willing to abstain from all substances (e.g., alcohol, tobacco, etc.) throughout the duration of the program. Participants were not eligible for the current study if

they had placed exclusions on using their personal health information for research purposes. Demographic characteristics are reported in Table 1.

Table 1

Demographic and clinical characteristics of the sample

Variable	Total (*n* = 337)	Female (*n* = 169)	Male (*n* = 168)
	M (*SD*)		
Age	44.3 (9.8)	43.1 (10.7)	45.5 (8.6)
PCL-5	57.9 (11.1)	58.3 (10.5)	57.5 (11.7)
WHODAS 2.0	34.6 (8.1)	34.7 (7.3)	34.6 (8.9)
DERS	124.0 (23.6)	125.7 (23.6)	122.4 (23.7)
MDI (DP+DR)	23.4 (9.2)	24.5 (9.5)	22.3 (8.9)
DASS Anxiety	21.2 (10.1)	21.6 (10.3)	20.7 (10.0)
DASS Depression	23.1 (10.7)	22.9 (10.4)	23.3 (11.0)
TRGI	65.3 (20.5)	69.5 (20.1)	61.0 (20.1)
TRSI	39.6 (20.5)	42.0 (21.0)	37.3 (19.8)
PTCI (World)	5.8 (1.2)	5.8 (1.1)	5.8 (1.2)
CFQ	66.3 (17.4)	68.6 (16.9)	64.0 (17.6)
	n (percentage of sample)		
Education			
Eighth grade or less	2 (0.6)	0 (0)	2 (1.2)
Grades 9-11	13 (3.9)	7 (4.1)	6 (3.6)
High school	42 (12.5)	17 (10.1)	25 (14.9)
Technical or trade school	22 (6.5)	3 (1.8)	19 (11.3)
Some college/University	89 (26.4)	45 (26.3)	44 (26.2)
Diploma/bachelor's degree	131 (38.9)	74 (43.8)	57 (33.9)
Graduate degree	29 (8.6)	19 (11.2)	10 (6.0)
Unknown	9 (2.7)	4 (2.4)	5 (3.0)
Occupation			
Military member	158 (46.9)	118 (69.8)	40 (23.8)
Veteran	42 (12.5)	8 (4.7)	34 (20.2)
PSP	2 (0.6)	1 (0.6)	1 (0.6)
PSP and military/Veteran	130 (38.6)	39 (23.1)	91 (54.2)
Other	5 (1.5)	3 (1.8)	2 (1.2)

Note. PCL-5 = PTSD checklist for DSM-5; PTSD = posttraumatic stress disorder; DSM-5=*Diagnostic and Statistical Manual of Mental Disorders* (fifth edition); WHODAS 2.0 = World Health Organization disability assessment schedule 2.0; DERS = difficulties in emotion regulation scale; MDI (DP + DR) = sum of the depersonalization and derealization subscales of the multiscale dissociation inventory; DASS-21 anxiety = anxiety subscale of the depression, anxiety, and stress scale-21; DASS-21 depression = depression subscale of the DASS-21; TRGI = trauma-related guilt inventory; TRSI = trauma-related shame inventory; PTCI (World) = negative cognitions about the world subscale of the posttraumatic cognitions inventory; CFQ = cognitive failures questionnaire. "Military member" = current military member; "PSP" = current or former public safety personnel (e.g., paramedics, police officers, firefighters, emergency personnel, etc.).

Procedure

During the first week of their admission to the PTSR program, participants completed a battery of self-report questionnaires, administered electronically using Voxco Survey software (http://www.voxco.com). These questionnaires included assessing demographic variables (i.e., age and biological sex) and mental health symptoms. A subset of these measures was analyzed in the present study and described below.

Measures

All variables of interest were self-reported and included age, biological sex, trauma-related symptoms, other mental health symptoms, and functional measures. Biological sex was self-reported as a binary variable (i.e., male or female). Only data collected at admission to the PTSR program was used for the current study. Unless otherwise specified, sum scores on all the measures were used in our analyses.

Trauma-Related Symptoms

The *PTSD checklist for DSM-5* (PCL-5) assessed PTSD symptom severity on a list of 20 items with a total score ranging between 0 and 80 (Weathers et al., 2013). The *trauma-related guilt inventory* (TRGI) captured experiences of guilt related to traumatic events or their consequences on a list of 32 items with a total score ranging between 0 and 128 (Kubany et al., 1996). Relatedly, the *trauma-related shame inventory* (TRSI) assessed experiences of shame related to traumatic events such as feelings of personal failure or concerns about how others will evaluate them on a list of 24 items with a total score ranging between 0 and 72 (Øktedalen et al., 2014). Due to the potential for overlap between guilt and shame (Bannister et al., 2019) and to circumvent potential problems of dissociating the unique roles of two highly correlated features in machine learning analyses, the TRGI and TRSI were combined into one variable using a

composite score. In addition, the *posttraumatic cognitions inventory* (PTCI) evaluated trauma-related thoughts and beliefs about the self and others on a list of 33 items with a total score ranging between 33 and 231 (Foa et al., 1999). The PTCI has three subscales assessing negative cognitions about the world (seven items), negative cognitions about the self (21 items), and self-blame (five items). We extracted the "World" subscale to be included as a feature in the machine learning analyses only. Due to the conceptual overlap with the TRGI (e.g., "I blame myself for what happened") and TRSI (i.e., "Because of my traumatic experience, I feel inferior to others"), the PTCI "Blame" (e.g., "The event happened because of the way I acted") and "Self" (e.g., "I am inadequate") subscales were not included as features.

Other Mental Health Symptoms

Symptoms of depression and anxiety were assessed using the two corresponding subscales of the depression, anxiety, and stress scale (DASS-21; seven items per subscale) with a total score ranging between 0 and 21 for each (Parkitny & McAuley, 2010). The multiscale dissociation inventory (MDI) assessed symptoms of dissociation on a list of 30 items with a total score ranging between 30 and 150 (Briere et al., 2005). The MDI subscales of depersonalization and derealization were summed to create a single, PTSD-related measure of dissociation as defined by the DSM-5 (APA, 2013). In addition, the difficulties in emotion regulation scale (DERS) measured emotion regulation skills on a list of 36 items with a total score ranging between 36 and 180 (Gratz & Roemer, 2004). Adverse childhood events such as neglect and physical or sexual abuse were assessed using the adverse childhood experiences (ACEs) measured on a list of 10 items with a total score ranging between 0 and 10 (Felitti et al., 1998). The alcohol use disorders identification test (AUDIT) assessed problematic alcohol use over the past year, on a list of 10 items with a total score ranging between 0 and 40 (Babor et al., 2001).

Functioning and Impairment

Functional impairment was assessed using the World Health Organization disability assessment schedule 2.0 (WHODAS 2.0), measured on a list of 12 items with a total score ranging between 12 and 60 (Üstün et al., 2010). Finally, the cognitive failures questionnaire (CFQ) assessed cognitive dysfunction on the list of 25 items with a total score ranging between 0 and 100 (Broadbent et al., 1982).

Data Analytic Plan

These data were stored and analyzed using the secure research environment (SRE) service provided by the Canadian Primary Care Sentinel Surveillance Network (CPCSSN, n.d.). The SRE is based on a data safe haven developed at Queen's University, Canada, and hosted at the Queen's Centre for Advanced Computing in Ontario (Martin et al., 2021). This platform provides researchers with a secure environment for the storage and analysis of health data. The current project acted as a test case of the use of the SRE and in a separate study, will be used to assess its potential to enhance research in military and veteran health by providing a secure platform for advanced analytics.

Table 2

Zero-order correlations between all variables of interest, n = *337*

Variable	1	2	3	4	5	6	7	8	9	10	11
1. Biological sex	–										
2. Age	–.074	–									
3. PTSD symptoms	.015	–.044	–								
4. Functional impairment	.012	–.070	.527	–							
5. Anxiety	.049	–.136	.577	.500	–						
6. Depression	–.023	–.136	.532	.435	.600	–					
7. Dissociation	.116	–.109	.517	.435	.515	.417	–				
8. Emotion dysregulation	.082	–.211	.518	.416	.433	.495	.452	–			
9. Negative trauma-related cognitions (world)	–.002	–.104	.508	.311	.392	.392	.377	.404	–		
10. Cognitive dysfunction	.130	–.088	.471	.476	.404	.268	.510	.483	.369	–	

11. Trauma-related guilt and shame	.174	–.210	.459	.325	.419	.435	.445	.475	.385	.333	–

Note. PTSD symptoms = posttraumatic stress disorder checklist for DSM-5; DSM-5 = Diagnostic and Statistical Manual of Mental Disorders (fifth edition); functional impairment = World Health Organization disability assessment schedule 2.0; anxiety = anxiety subscale of the DASS-21; Depression = depression subscale of the DASS-21; dissociation = sum of the depersonalization and derealization subscales of the multiscale dissociation inventory; emotion dysregulation = difficulties in emotion regulation scale; negative trauma-related cognitions (world) = negative cognitions about the world subscale of the post-traumatic cognitions inventory; cognitive dysfunction = cognitive failures questionnaire; trauma-related guilt and shame=trauma-related guilt inventory and trauma-related shame inventory; DASS-21 = depression, anxiety, and stress scale-21.

Before conducting machine learning analyses, with the aim of balancing theory- and data-driven science, we also calculated intercorrelations of all clinical variables (features; Table 2). Here, we found that neither the ACE nor AUDIT correlated with other features as expected, such as PTSD symptom severity, emotion dysregulation, dissociation, depression, anxiety, and functional impairment, among others ($-.07 \leq r \leq .17$). The lack of, or weak correlations found in our sample were inconsistent with the current research consensus (see Messman-Moore & Bhuptani, 2017, for a review), suggesting that in our study, the ACE and AUDIT scales may not be accurately capturing ACE and alcohol use. Notably, the ACE contains 10 items that assess the presence or absence of an ACE (ranging from one's caregivers going through a divorce to experiencing sexual abuse) but it does not assess the frequency, severity, or psychological impact of such experiences. In this context, the ACE scale may not be ideally suited to accurately capture the direct impact of childhood adversity on our outcome measures of interest. Critically, however, our models included other influential variables that are significantly impacted by childhood adversity, such as emotion dysregulation, dissociation, and anxiety symptoms (Dvir et al., 2014; Messman-Moore & Bhuptani, 2017). Furthermore, a histogram plot revealed that the AUDIT scores were positively skewed ($M = 6.17$, $Mdn = 3$), indicating that most individuals reported low levels of problematic alcohol use. This was not surprising, given that reporting low levels of problematic alcohol use was required for entry into the PTSR program. As such, with

the aim of using only features with high construct/convergent validity, the ACE and AUDIT were excluded from our main analyses. This ensured that we avoided potential harm to the field by inaccurately inferring the lack of importance of childhood adversity and alcohol use in relation to PTSD (Brady & Back, 2012). Please refer to File A in the online supplemental materials where we conducted supplemental analyses that included ACE scores as an input feature. Here, prediction accuracy was not significantly affected.

On the other hand, very high correlations ($r > .50$) indicate 25% or more shared variance between features, making it difficult to dissociate unique feature contributions. As such, we also reported model-based feature importance to account for potential inaccuracy in the interpretation of unique contributions of highly intercorrelated features. After removing participants with missing data, the final sample consisted of 337 participants (169 female).

All machine learning analyses were conducted using *Python 3.7.9* (Van Rossum & Drake, 2009; *scikit-learn 1.0.1*, Pedregosa et al., 2011). Given that we wanted to make predictions about the severity of symptoms (continuous target features), we used supervised machine learning regression analyses. Specifically, two nonlinear, decision tree-based machine learning models were trained (extremely randomized trees [ERT]; Geurts et al., 2006). The first model was trained to predict PTSD symptom severity (PCL-5 sum score) and the second model to predict functional impairment (WHODAS 2.0 sum score). ERT was selected for its computational efficiency and strong randomization method, the details of which are outlined by Geurts et al. (2006). This method has also been shown to account for complex nonlinear relations that exist between features, as demonstrated by Eder et al. (2021). Briefly, ERT randomly shuffles out features after training the model, and measures the resulting reduction in model performance (Breiman, 2001; Louppe et al., 2013). Each feature is then rank-ordered based on

average contributions to model performance over all iterations of the algorithm. This method highlights the intricacies of features underlying the target variable. Although a fulsome description of ERT is beyond the scope of this article, Geurts et al. (2006) describe the methodology used in this study. To ensure generalizability, we assessed model performance based on predictions in a novel subset of patients by employing a nested cross-validation procedure (80/20 split with 100 iterations each). Cross-validation ensures that the predictions of the model are tested only in the patients (data points) that are not used for training the models, while simultaneously maximizing the amount of data available for training and testing. Nesting this cross-validation (inner and outer loops) allows for hyperparameter tuning in the inner loops. In the case of ERT, these hyperparameters were the number of samples per leaf and the number of features per node. Model performance was compared to that of a model employing trivial predictions (i.e., always predicts a mean value of the target feature). The contribution of each input feature was assessed using permutation feature importance, which measures the relative reduction in the explained variance of the model if a given input feature cannot be used meaningfully by the models (i.e., the relation between this input and target feature is made meaningless by randomly shuffling values of this input). Given that the permutation feature importance is sensitive to high intercorrelations among input features, the model-based feature importance was also calculated. The model-based feature importance is a similar indicator of feature importance but measures the relative reduction in the mean squared error at a given branch when using that input. All features of the model are then rank-ordered based on contributions to variance in the case of permutation feature importance, and on mean squared error in the case of model-based feature importance. Both of our models included eight input features: biological sex, age, DERS, MDI (sum of subscales *depersonalization* and

derealization), DASS *anxiety*, DASS *depression*, a composite TRGI and TRSI score, and PTCI *negative cognitions about the world*. For the second model predicting functional impairment, there were ten input features with the addition of PCL-5 and CFQ (Table 3).

Table 3

Features included in machine learning regression models predicting ptsd symptom severity and functional impairment

	PTSD Symptom Severity	Functional Impairment
Input feature	Age	Age
	Biological sex	Biological sex
	Dissociation (depersonalization/derealization)	Dissociation (depersonalization/derealization)
	Emotion dysregulation	Emotion dysregulation
	Anxiety	Anxiety
	Depression	Depression
	Trauma-related guilt and shame	Trauma-related guilt and shame
	Negative beliefs about the world	Negative beliefs about the world
		Cognitive dysfunction
		PTSD symptom severity

Note. Dissociation = sum of the depersonalization and derealization subscales of the multiscale dissociation inventory; emotion dysregulation = difficulties in emotion regulation scale; anxiety = anxiety subscale of the DASS-21; depression = depression subscale of the DASS-21; trauma-related guilt and shame = composite score of the trauma-related guilt inventory and trauma-related shame inventory; negative beliefs about the world = negative cognitions about the world subscale of the posttraumatic cognitions inventory; cognitive dysfunction = cognitive failures questionnaire; PTSD symptom severity = PTSD checklist for *DSM-5*; PTSD = posttraumatic stress disorder; *DSM-5 = Diagnostic and Statistical Manual of Mental Disorders* (fifth edition); DASS-21 = depression, anxiety, and stress scale-21.

Results

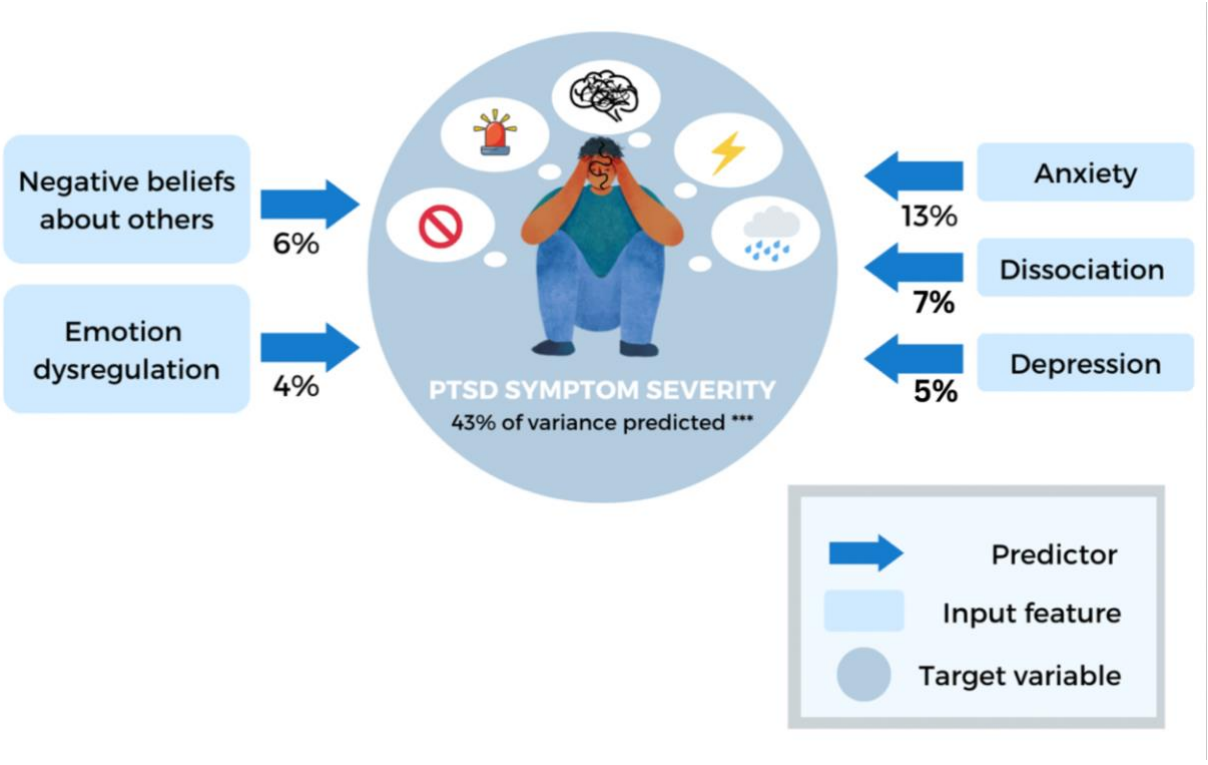
Predicting PTSD Symptom Severity

Our model predicted an average of 43% of the variance in PTSD symptom severity in novel subsets of patients (R^2_{avg} = .43 [SD= 0.084], R^2_{median} = .44, p = .001). When predicting PTSD symptom severity scores, a scale ranging from 0 to 80, our models were off by an average of 6.5 ± 0.55 points (mean absolute error [MAE]). As measured by the permutation feature importance, the predictors contributing to the most variance of the target feature were symptoms of anxiety (12.6%), dissociation (7.2%), negative trauma-related beliefs about others (6.0%), depression

(4.7%), and emotion dysregulation (4.1%; Figure 1). Consistent with the permutation feature importance, the model-based feature importance indicated that the features enhancing accuracy the most were symptoms of anxiety (13.1), dissociation (7.7), negative trauma-related beliefs about others (6.4), depression (6.0), and emotion dysregulation (4.3). Information contained in the variables of trauma-related guilt and shame, biological sex, and age did not significantly aid in the prediction in these models in this context.

Figure 1

Summary of most important features predicting ptsd symptom severity, according to permutation-based feature importance



Note. PTSD=posttraumatic stress disorder. See the online article for the color version of this figure. *** p= .001.

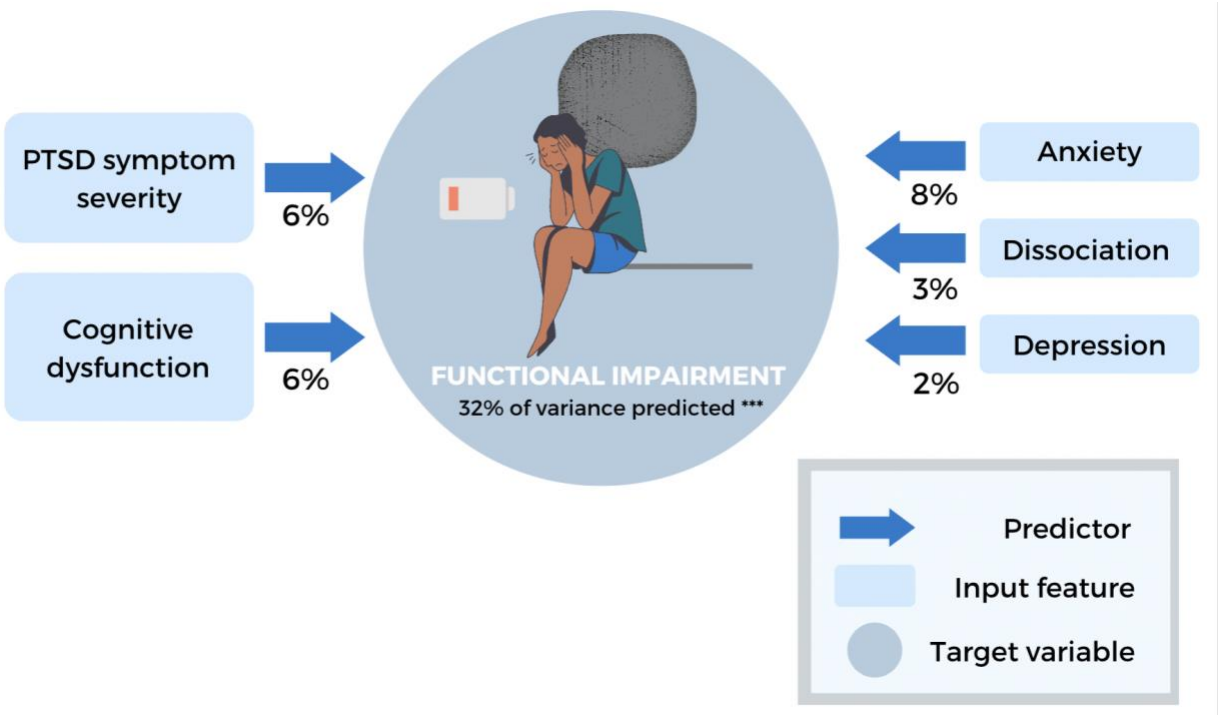
Predicting Functional Impairment

Our model predicted an average of 32% of the variance in functional impairment scores in novel subsets of patients (R^2_{avg} = .32 [SD= 0.085], R^2_{median} = .33, p = .001). When predicting

functional impairment scores, a scale ranging from 12 to 60, our models were off by an average of 5.4 ± 0.39 points (MAE). The predictors contributing to the most variance in functional impairment scores, according to the permutation feature importance, were anxiety (8.1%), PTSD symptom severity (6%), cognitive dysfunction (5.8%), dissociation (2.9%), and depression (2.0%; Figure 2). Again, both permutation and model-based feature importance converged, such that the same features contributed most to the accuracy of our target feature: anxiety (5.5), PTSD symptom severity (4.5), cognitive dysfunction (3.2), dissociation (2.3), and depression (1.4). Information contained in the variables of emotion dysregulation, negative trauma-related beliefs about others, trauma-related guilt and shame, biological sex, and age did not significantly aid in the prediction in these models.

Figure 2

Summary of most important features predicting ptsd functional impairment, according to permutation-based feature importance



Note. PTSD=posttraumatic stress disorder. See the online article for the color version of this figure. *** p= .001.

Discussion

The purpose of this study was to examine the extent to which clinically relevant variables predicted PTSD symptom severity and functional impairment using machine learning algorithms in a real-world clinical sample of adults seeking inpatient treatment for PTSD in Canada. Our machine learning models predicted PTSD symptom severity and functional impairment (e.g., difficulties with getting dressed, bathing, learning a new task, dealing with unfamiliar people, maintaining friendships, taking care of household responsibilities and self-care, etc.) with high accuracy. Our findings may help to inform personalized medicine approaches for PTSD in such contexts. Below, we expand upon the clinical implications of such findings.

Predicting PTSD Symptom Severity

Symptom-based measures including anxiety, dissociation, depression, negative trauma-related beliefs about others, and emotion dysregulation, were most influential in making accurate predictions about PTSD symptom severity. Specifically, our model accurately predicted PTSD symptom severity scores within approximately 6.5 points on the PCL-5 (a scale ranging from 0 to 80) in a novel subset of patients. Anxiety and depression symptoms collectively predicted approximately 17% of the variance, adding to the literature demonstrating that they are associated with greater PTSD symptom severity (Knowles et al., 2019). This is in line with another machine learning study that classified PTSD cases using clinical symptom measures and blood biomarkers (Siegel et al., 2021). This group found that depression was an important predictor in classifying the clinical severity of PTSD, with 94% of individuals in the severe group experiencing current or lifetime depression, as compared to 64% among the group characterized by less severe PTSD (Siegel et al., 2021). Moreover, our findings point toward the

particular importance of anxiety symptoms, relative to depression, in contributing to PTSD symptom severity. Anxiety and PTSD both share fear and avoidance of triggers, which may account, in part, for the greater contribution of anxiety symptoms than depression in predicting PTSD symptom severity. Furthermore, the DASS-21 anxiety subscale assesses physiological arousal and anxiety sensitivity, which is a core component of PTSD symptomatology. The fact that anxiety symptoms emerged as an important predictor in our model highlights how physiological reactivity and fear responses may play a key role in worsening PTSD symptoms.

Importantly, our finding that dissociation was an important predictor of PTSD symptom severity supports a growing body of literature on trauma-related dissociation. Dissociation has been associated with trauma memory fragmentation and disruptions in self-referential processes (Halligan et al., 2003; Huntjens et al., 2013; Kleim et al., 2008; Lanius et al., 2011), thereby significantly impairing the formation of an integrated and cohesive sense-of-self. These alterations may interfere with the contextualization of trauma-related memories and cues (i.e., in person, place, and time; Ehlers & Clark, 2000; Huntjens et al., 2013; Rothschild, 2009) and often disrupt bodily self-consciousness across the domains of time, thought, body, and emotions (Frewen & Lanius, 2015). Interestingly, a study by Halligan et al. (2003) found that dissociative experiences of *emotional numbing, confusion* and *altered sense of time* were highly predictive of chronic PTSD. Rothschild (2009) contends that dissociation disrupts the ability to locate oneself in both time and place, which is required for self-awareness and self-reflection. The ability to elaborate on the traumatic event and assimilate it into one's narrative is likely also impeded by dissociation (Ehlers & Clark, 2000; Huntjens et al., 2013). This is clinically relevant, as the elaboration of trauma memories, experience of primary emotions related to the memory, and assimilation into one's narrative are the key goals of cognitive processing therapy (Resick et al.,

2008). Currently, essentially all existing trauma-focused psychotherapies require an active approach toward trauma cues (i.e., recalling and examining the trauma memory and its associated triggers, emotions, thoughts, and behaviors). This is in direct opposition to trauma memory and emotion processing barriers facilitated by dissociative symptoms (i.e., involving detachment/derealization, depersonalization, emotional numbing, blunted arousal, and fragmented trauma memories). Taken together, our results further reinforce the notion that addressing dissociative symptoms is a critical step toward optimizing trauma recovery.

Negative trauma-related beliefs about others also predicted PTSD symptom severity. These beliefs are extreme assumptions about the world and other people that became cemented following the traumatic event(s) (e.g., “people can’t be trusted,” “you never know who will harm you,” “the world is a dangerous place,” “I can’t rely on other people,” etc.; Foa et al., 1999). Although these negative appraisals may instill a sense of control, safety, and predictability in the short-term, they are associated with avoidance of potential triggers, which may prevent fear extinction and maintain PTSD symptoms (see Bryant, 2019, for a review). Such beliefs can lead to isolation and an associated reduction in social support, which has been shown not only to be protective against the development of PTSD following trauma exposure but also to be beneficial for posttraumatic growth and recovery (Dai et al., 2016; Prati & Pietrantoni, 2009). Notably, empirically supported trauma-focused psychotherapies such as cognitive processing therapy and prolonged exposure either directly or indirectly target these catastrophic thoughts, with the aim to make them more accurate or adaptive (Foa et al., 2007; Resick et al., 2008).

Another important predictor of PTSD symptom severity was emotion dysregulation, which is characterized by difficulties with impulse control, emotional awareness, emotional clarity, accepting emotional experiences, engaging in goal-directed behavior, and accessing

emotion regulation strategies (Gratz & Roemer, 2004). In line with our findings, a meta-analysis by Seligowski et al. (2015) reported that PTSD symptoms had the largest association with general emotion dysregulation, followed by rumination, thought suppression, and experiential avoidance. Powers et al. (2015) also found that difficulties obtaining emotional clarity and negative beliefs about being able to regulate their emotions were associated with greater PTSD severity. Our findings here confirm the notion that emotion dysregulation uniquely contributes to predicting PTSD symptom severity and may be an important target for intervention.

Interestingly, age, biological sex, and trauma-related guilt and shame collectively accounted for only 2% of the variance in our machine-learning models, despite being associated with PTSD symptom severity in statistical models (Badour et al., 2017; Bannister et al., 2019; Konnert & Wong, 2014; Olff, 2017). Dynamic factors (i.e., mental health symptoms), rather than biologically predisposed factors (i.e., sex and age), were most important in predicting the severity of PTSD symptoms in a novel subset of patients. To illustrate, women or older individuals may experience higher rates or severity of PTSD, but variable factors such as the severity of anxiety or dissociation (i.e., rather than by virtue of being a woman or of their age) appear more important in predicting whether they will experience greater mental health burdens in this context. Critically, however, more research is required to confirm whether trauma-related guilt and shame contribute to predictive accuracy of PTSD severity in machine learning models. It is possible that patients are experiencing high emotion dysregulation and thus have impaired awareness and clarity of trauma-related emotions (i.e., identifying or naming the emotion). This may lead to reduced reporting of trauma-related guilt and shame, despite the direct experience of these emotions.

Predicting Functional Impairment

Anxiety, PTSD severity, cognitive dysfunction, dissociation, and depression were most important in predicting functional impairment. Specifically, our model accurately predicted functional impairment scores within approximately 5.5 points on the WHODAS (a scale ranging from 12 to 60) in a novel subset of patients experiencing symptoms of PTSD. Emotion dysregulation, biological sex, trauma-related guilt and shame, age, and negative beliefs about the world did not add predictive value to our model (collectively accounted for less than 1% of variance). Although these variables have been linked to greater functional impairment across studies using statistical models, our results from machine learning analyses, which are better at making more accurate predictions based on such associations, found that other symptom measures were more influential.

As discussed above, it is not surprising that symptoms of anxiety and PTSD severity predicted functional impairment. This link has been extensively studied and supported (Knowles et al., 2019; Sareen et al., 2007). Our findings confirm the associations between anxiety, PTSD severity, and functional impairment, and further add to the literature, showing that symptoms of anxiety and PTSD symptom severity were the most important predictors of functional impairment (collectively predicting 15% of the variance). Again, anxiety emerged as an important predictor suggesting that physiological reactivity and fear responses in PTSD exacerbate day-to-day impairment. Our finding also confirms that cognitive dysfunction symptoms (e.g., forgetting appointments, accidentally throwing away the wrong items, starting one thing and becoming unintentionally distracted into doing something else) contributes to impaired day-to-day functioning among individuals experiencing PTSD. This is in line with previous studies that show self-reported cognitive dysfunction as being associated with

psychological and emotional distress, symptoms of depression, as well as poor physical functioning (Donnelly et al., 2018; Stulemeijer et al., 2008).

Dissociation was another important predictor of functional impairment, confirming that dissociation is associated with a more severe illness presentation (Boyd et al., 2018; Lebois et al., 2021; Ozer et al., 2003; Park et al., 2021; Stein et al., 2013; Tanner et al., 2019). The core features of the dissociative subtype of PTSD are depersonalization and derealization, both of which involve a disconnect between the external physical environment and the intrapsychic experience. In this way, PTSD-related dissociation can be understood as a *disorder of sensory integration* (Scalabrini et al., 2020). Such interruptions in sensorimotor processing are demonstrated by the highly specific neural reorganization seen in dissociation and among those with PTSD and a history of childhood sexual and emotional abuse (Harricharan et al., 2020; Heim et al., 2013; Nicholson et al., 2016; Rabellino et al., 2018; Reinders et al., 2006). For example, patients in a state of dissociation from trauma memories experienced decreased sensorimotor reactivity (e.g., visual, auditory, olfactory, pain, etc.) and reduced regional cerebral blood flow to regions associated with somatosensory awareness (Reinders et al., 2006). Much like dissociation, poor sensory processing has also been hypothesized to impair adaptive behaviors such as cognitive and physiological self-control, self-other processing, cooperation, and well-being (Acevedo et al., 2018). Our finding highlights the importance of paying particular attention to individuals with heightened dissociation, as they not only experience more severe PTSD symptoms, but may also experience significant impairments in activities of daily living.

Symptoms of depression also contributed to functional impairment in our study. In addition to anhedonia, depressive symptoms include fatigue, hopelessness, sense of worthlessness, and lack of future-oriented thinking (APA, 2013). Given that these symptoms can

facilitate PTSD-related avoidance and exacerbate existing difficulties in engaging in self-care or previously enjoyed activities among those with PTSD, the consideration of comorbid depression will be important for improving overall life functioning.

Implications and Clinical Applications

Currently, treatment planning for trauma-related disorders typically involves a categorical approach, with standardized intervention protocols assigned to those diagnosed with a trauma- and stressor-related disorder. This approach focuses on the presence or absence of amental health diagnosis rather than the heterogeneity of symptom patterns among individuals. Critically, however, the consideration of unique symptom profiles at the individual level will be important for maximizing treatment gains. This is illustrated by Cloitre et al.'s (2012) study, where women with childhood abuse-related PTSD were randomly assigned to one of three types of sequential treatment that involved: (a) improving emotion regulation and interpersonal functioning, followed by a modified version of prolonged exposure; (b) improving emotion regulation and interpersonal functioning, followed by supportive counseling; or (c) supportive counseling, followed by a modified version of prolonged exposure. Here, improvements in PTSD symptoms were the greatest among women receiving the first type of treatment, where those with higher baseline levels of dissociation showed faster and greater improvements in both dissociation and PTSD symptoms. These results suggest that the combination of trauma-focused therapy, with sessions targeting emotion regulation and interpersonal functioning, can significantly benefit individuals with PTSD, particularly when they present with severe dissociation (Cloitre et al., 2012). Taken together with the results of the current study, this body of evidence points clearly toward the importance of matching specific clinical symptom profiles with tailored evidence-based interventions.

Our work highlights further how the consideration of heterogeneous symptom presentations can help identify a targeted intervention approach that best suits an individual's needs. Existing trauma-focused therapies target negative appraisals and extinguish fear responses using an active approach toward processing trauma memories, which are beneficial for trauma recovery (Bisson et al., 2007; Lee et al., 2016). However, our findings that anxiety and emotion dysregulation predict greater illness severity highlight the potential importance of scaffolding these existing interventions with skills that improve physiological and emotional regulation. These skills can be found in evidence-based interventions such as dialectical behaviour therapy, acceptance and commitment therapy, and mindfulness-based cognitive therapy, which may provide additional benefit for clients with heightened physiological reactivity and emotion dysregulation (Goldberg et al., 2018; Hayes et al., 1999; Lynch et al., 2007). For example, dialectical behaviour therapy, originally tailored to treat borderline personality disorder, includes specific modules for building emotion regulation, distress tolerance, and mindfulness skills (Lynch et al., 2007). It has since been adapted for PTSD and shown to significantly reduce dissociation symptoms, emotion dysregulation, self-harming behaviors, and improve PTSD symptom remission (Bohus et al., 2013, 2020).

Critically, dissociation emerged as a potential target for intervention in reducing both PTSD symptom severity and functional impairment. Dissociation has been shown to interfere with sensory-motor integration and bodily self-consciousness across the domains of time, thought, body, and emotions (Frewen & Lanius, 2015). A sense of disembodiment can also arise, in which an individual experiences a disconnection from their hands and feet or a lack of boundary around one's body (Blanke & Arzy, 2005; Schimmenti & Caretti, 2016; van der Kolk et al., 2016; Warner et al., 2014). As such, those with chronic trauma and symptoms of

dissociation may benefit from sensory-based approaches that facilitate bodily awareness and target traumatic memories through bottom-up processing (Kaiser et al., 2010; McGreevy & Boland, 2020). Specifically, approaches that involve improving embodiment, awareness, reflection, and regulation of the self in time and place (such as therapies that target dysregulated brain regions in dissociative PTSD patients) may be helpful (Frewen & Lanius, 2015; McGreevy & Boland, 2020; Warner et al., 2014, 2020). In a safe and controlled environment, this might be done through body scans that build awareness of one's body in the present moment, grounding exercises that engage the five senses, and attending to the present moment (Frewen & Lanius, 2015; McGreevy & Boland, 2020). For instance, sensory motor arousal regulation treatment, which focuses on strengthening bottom-up processing (i.e., awareness, regulation, and integration of somatosensory experiences), has been shown to reduce somatic, depression, and anxiety symptoms, as well as PTSD-related hyperarousal (Warner et al., 2014, 2020). Relatedly, sensory integration treatment among traumatized individuals has been associated with improvements in affect and impulse regulation, as well as negative self-perceptions such as believing oneself as helpless or ineffectual (Kaiser et al., 2010). Given that improved sensory processing is intrinsically tied to emotion processing and adaptive engagement with the environment (Gogolla, 2017; Straube & Miltner, 2011), sensory-based therapies may be a strong candidate for improving symptoms of PTSD with elevated dissociation.

Finally, novel adjunctive treatments tailored to regulate the neural mechanisms associated with specific PTSD symptom profiles may be beneficial for improving treatment outcomes. For example, neurofeedback is a noninvasive method by which individuals can learn to regulate brain signals associated with unique symptom presentations in real time through biofeedback (i.e., with functional magnetic resonance imaging or electroencephalography; Nicholson et al.,

2022; Ros et al., 2014; van der Kolk et al., 2016). Randomized controlled trials of novel adjunctive treatments such as neurofeedback also show that polytraumatized adults with chronic PTSD show significant reductions in PTSD symptom severity, emotion dysregulation, and identity impairment following neurofeedback training, as compared to waitlist-controls (Gapen et al., 2016; van der Kolk et al., 2016). Such interventions may be particularly useful among those individuals who may be too anxious, dissociated or emotionally dysregulated to tolerate exposure-based treatments or trauma focused psychotherapies (van der Kolk et al., 2016). Moreover, given that dissociative versus nondissociative PTSD has been shown to be related to opposing neural substrates of emotion over- and undermodulation (Lanius et al., 2010; Nicholson et al., 2019), treatment interventions such as neurofeedback that can target unique neural mechanisms associated with specific symptom profiles (i.e., dissociation, emotion dysregulation, anxiety, depression) may be beneficial for reducing PTSD symptoms within this highly heterogeneous disorder. Thus, scaffolding trauma-focused therapy with skills that regulate emotional and physiological arousal (i.e., via bottom-up approaches that anchor patients in person, place, and the present moment) may provide a more stable foundation from which patients can begin to effectively engage, examine, process, and integrate their trauma-related memories into a coherent narrative (i.e., via top-down cognitive approaches of trauma memory processing; Kaiser et al., 2010).

Limitations and Future Directions

Our data were cross-sectional such that we could not draw conclusions about any changes in symptoms over time or the outcome of a specific intervention. Leveraging machine learning algorithms to predict symptom-based changes throughout and after the completion of trauma-focused interventions will be a key step toward identifying variables that predict treatment

response at the individual level. Patients in our study were also asked to identify their biological sex from a binary category at the time the questionnaires were administered. In future studies, it will be critical to examine the roles of diverse sex and gender, ethnic, and racial identities. They may also consider investigating resiliency factors (i.e., perceived social support, cognitive flexibility, self-efficacy, etc.; Gallagher et al., 2020; Kashdan & Rottenberg, 2010; Lee, 2019; Richardson & Jost, 2019) in predicting PTSD symptom severity and functional impairment. Although it was not possible to examine the effect of problematic alcohol use in our models, it would be fruitful to conduct studies that can disentangle the role that substance use plays in predicting trauma-related outcomes, given that higher rates of alcohol and substance use have been associated with PTSD, depression symptoms, negative emotionality, and childhood trauma (Brady & Back, 2012; Brady et al., 2019; Greene et al., 2016). Additional research will be needed to elucidate how guilt and shame interact with trauma-related variables such as emotion dysregulation and the type of traumatic event exposure (Bannister et al., 2019). It will also be important for future machine learning studies to assess the extent to which childhood abuse and neglect predicts these outcomes. Finally, variables that were not able to be assessed in the current study may be considered in future studies, such as the type and severity of traumatic event(s), medical and psychiatric comorbidities, including sleep problems (Dewar et al., 2020; Miles et al., 2022).

Conclusion

This was the first study to utilize machine learning algorithms to predict PTSD symptom severity and functional impairment in a clinical sample of adults seeking treatment for PTSD. Our machine learning models predicted PTSD symptom severity and functional impairment with high accuracy in a novel subset of patients, accounting for 43% and 32% of their respective

variances. Specifically, our models accurately predicted PTSD symptom severity scores within approximately 6.5 points (a scale ranging from 0 to 80), and functional impairment scores within approximately 5.5 points (a scale ranging from 12 to 60). This study highlights the clinical utility of machine learning methods in uncovering unique contributors of mental illness burdens and potential targets for their interventions. Dissociation emerged as an important predictor in both models, indicating that dissociative symptomatology may be a critical target for trauma-based interventions. Moreover, our results point to the importance of targeting maladaptive trauma appraisals, cognitive dysfunction, and emotion dysregulation in order to decrease the severity of trauma-related illness.

Critically, the consideration of unique symptom profiles of individuals with PTSD will help guide tailored treatment plans to maximize trauma recovery. In addition to existing trauma-focused therapies that facilitate top-down processing of traumatic memories, individuals with PTSD may further benefit from bottom-up approaches (i.e., emotional and physiological regulation strategies) as well as novel adjunctive treatments such as neurofeedback training, particularly when they present with high clinical severity. Overall, this research demonstrates that machine learning models are a powerful tool for elucidating the complex associations between trauma-related symptoms, and for informing a personalized medicine approach in a highly heterogenous psychiatric disorder such as PTSD.

Disclosure statement

The authors report there are no competing interests to declare.

Funder Information

This work was supported by the Canadian Institute for Military and Veteran Health Research (CIMVHR) under Grant 6023235-986402; by Mitacs through the Mitacs Accelerate

Ph.D. Thesis - A. Park; McMaster University - Psychology, Neuroscience & Behaviour program under Grant IT19554; and the Swiss National Science Foundation under Grant BSSG10_155915 and 100014_178841. We are grateful to the Homewood Research Institute for their generous infrastructure support of this research and to Homewood Health Centre for allowing us access to their inpatient treatment setting. We thank Jillian Lopes (McMaster University) for assisting with the design of the figures in our Results. We also thank Ann Malain, Alexandra Heber, and Hugo Schielke for their support in this project.

Supplemental File A

Results Including ACE Scores

The following section uses identical methodology as the main study, except for the addition of the Adverse Childhood Experiences (ACE) scale as an input variable to machine learning models. The main study excluded the use of ACE scores as an input feature due to its problematic weak associations with other clinically relevant features. This may have resulted from inappropriate use of the ACE as a scale-based evaluation of childhood adversity. Specifically, the ACE may be appropriately used as a measure to capture the presence of childhood adversity, but not necessarily the severity of childhood adversity (please see main text for details). Nevertheless, addition of the ACE scale to our models resulted in negligible changes in predictive utility. When predicting PTSD symptom severity, R^2 changed from .43 to .42 with the addition of the ACE. When predicting functional impairment, R^2 changed from .32 to .30 with the addition of the ACE. In response to potential issues that may arise from exclusion of the ACE scale, this section includes the study's results section, including the ACE scale.

Predicting PTSD Symptom Severity

Our model predicted an average of 42% of the variance in PTSD symptom severity in novel subsets of patients (R^2_{avg} = .42 [SD = .079], R^2_{median} = .427, $p \leq .001$). When predicting PTSD symptom severity scores, a scale ranging from 0 to 80, our models were off by an average of 6.4 ± 0.52 points (mean absolute error [MAE]). As measured by the permutation feature importance, the predictors contributing to the most variance of the target feature were symptoms of anxiety (10.9%), dissociation (7.8%), negative trauma-related beliefs about others (5.2%), depression (4.2%), and emotion dysregulation (3.9%). Consistent with the permutation feature importance, the model-based feature importance indicated that the features enhancing accuracy

the most were symptoms of anxiety (11.3), dissociation (7.3), negative trauma-related beliefs about others (4.8), depression (4.3), and emotion dysregulation (3.8). Information contained in the variables of trauma-related guilt and shame, biological sex, adverse childhood experiences, and age did not significantly aid in the prediction in these models in this context.

Predicting Functional Impairment

Our model predicted an average of 30% of the variance in functional impairment scores in novel subsets of patients (R^2_{avg} = .30 [SD = .082], R^2_{median} = .303, $p \leq .001$). When predicting functional impairment scores, a scale ranging from 12 to 60, our models were off by an average of 5.44 ± .43 points (MAE). The predictors contributing to the most variance in functional impairment scores, according to the permutation feature importance, were anxiety (7.1%), PTSD symptom severity (5.6%), cognitive dysfunction (5.6%), dissociation (3.7%), depression (1.9%), and emotion dysregulation (1.0%). Again, both permutation and model-based feature importance converged, such that the top five features found using permutation-based feature importance contributed most to the accuracy of our target feature: anxiety (4.1), PTSD symptom severity (3.6), cognitive dysfunction (2.8), dissociation (1.9), and depression (0.9). Information contained in the variables of, negative trauma-related beliefs about others, trauma-related guilt and shame, adverse childhood experiences, biological sex, and age did not significantly aid in the prediction in these models.

References

Able, M. L., & Benedek, D. M. (2019). Severity and symptom trajectory in combat-related PTSD: a review of the literature. *Current Psychiatry Reports*, *21*(7), Article 58. http://dx.doi.org/10.1007/s11920-019-1042-z

Acevedo, B., Aron, E., Pospos, S., & Jessen, D. (2018). The functional highly sensitive brain: a review of the brain circuits underlying sensory processing sensitivity and seemingly related disorders. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *373*(1744), Article 20170161. http://dx.doi.org/10.1098/rstb.2017.0161

American Psychiatric Association. (2013). Diagn*ostic and statistical manual of mental disorders.* (5th ed.). https://doi.org/10.1176/appi.books.9780890425596

Armour, C., Karstoft, K.-I., & Richardson, J. D. (2014). The co-occurrence of PTSD and dissociation: Differentiating severe PTSD from dissociative-PTSD. *Social Psychiatry and Psychiatric Epidemiology*, *49*(8), 1297–1306. doi:10.1007/s00127-014-0819-y

Babor, T. F., Higgins-Biddle, J. C., Saunders, J. B., & Monteiro, M. G. (2001). *The Alcohol Use Disorders Identification Test: Guidelines for use in primary care* (2nd ed.). Geneva, Switzerland: World Health Organization.

Badour, C. L., Resnick, H. S., & Kilpatrick, D. G. (2017). Associations Between Specific Negative Emotions and DSM-5 PTSD Among a National Sample of Interpersonal Trauma Survivors. *Journal of Interpersonal Violence, 32*(11), 1620-1641. https://doi.org/10.1177/0886260515589930

Bae, H., Kim, D., & Park, Y. C. (2016). Dissociation predicts treatment response in eye-movement desensitization and reprocessing for posttraumatic stress disorder. *Journal of*

Trauma & Dissociation, *17*(1), 112-130. http://dx.doi.org/10.1080/15299732.2015.1037039

Bannister, J. A., Colvonen, P. J., Angkaw, A. C., & Norman, S. B. (2019). Differential relationships of guilt and shame on posttraumatic stress disorder among veterans. *Psychological Trauma: Theory, Research, Practice, and Policy, 11*(1), 35-42. https://doi.org/10.1037/tra0000392

Bisson, J. I., Ehlers, A., Matthews, R., Pilling, S., Richards, D., & Turner, S. (2007). Psychological treatments for chronic post-traumatic stress disorder. Systematic review and meta-analysis. *The British Journal of Psychiatry: the Journal of Mental Science, 190*(2), 97-104. https://doi.org/10.1192/bjp.bp.106.021402

Blanke, O., & Arzy, S. (2005). The out-of-body experience: Disturbed self-processing at the temporo-parietal junction. *The Neuroscientist, 11*(1), 16– 24. https://doi.org/10.1177/1073858404270885

Bohus, M., Dyer, A. S., Priebe, K., Krüger, A., Kleindienst, N., Schmahl, C., Niedtfeld, I., & Steil, R. (2013). Dialectical behaviour therapy for post-traumatic stress disorder after childhood sexual abuse in patients with and without borderline personality disorder: A randomised controlled trial. *Psychotherapy and Psychosomatics, 82*(4), 221-233. https://doi.org/10.1159/000348451

Bohus, M., Kleindienst, N., Hahn, C., Müller-Engelmann, M., Ludäscher, P., Steil, R., Fydrich, T., Kuehner, C., Resick, P. A., Stiglmayr, C., Schmahl, C., & Priebe, K. (2020). Dialectical Behavior Therapy for Posttraumatic Stress Disorder (DBT-PTSD) Compared with Cognitive Processing Therapy (CPT) in Complex Presentations of PTSD in Women

Survivors of Childhood Abuse: A Randomized Clinical Trial. *JAMA Psychiatry, 77*(12), 1235–1245. https://doi.org/10.1001/jamapsychiatry.2020.2148

Boyd, J. E., Protopopescu, A., O'Connor, C., Neufeld, R. W., Jetly, R., Hood, H. K., ... & McKinnon, M. C. (2018). Dissociative symptoms mediate the relation between PTSD symptoms and functional impairment in a sample of military members, veterans, and first responders with PTSD. *European Journal of Psychotraumatology*, *9*(1), Article 1463794. http://dx.doi.org/10.1080/20008198.2018.1463794

Bradley, R., Greene, J., Russ, E., Dutra, L., & Westen, D. (2005). A multidimensional meta-analysis of psychotherapy for PTSD. *American Journal of Psychiatry*, *162*(2), 214-227. http://dx.doi.org/10.1176/appi.ajp.162.2.214

Brady, K. T., & Back, S. E. (2012). Childhood trauma, posttraumatic stress disorder, and alcohol dependence. *Alcohol Research: Current Reviews*, *34*(4), 408-413.

Brady, L. L., Credé, M., Harms, P. D., Bachrach, D. G., & Lester, P. B. (2019). Meta-analysis of risk factors for substance abuse in the US military. *Military Psychology*, *31*(6), 450-461. http://dx.doi.org/10.1080/08995605.2019.1657754

Breiman, L (2001). Random Forests. *Machine learning, 45*(1), 5-32. https://doi.org/10.1023/A:1010933404324

Briere, J., Weathers, F. W., & Runtz, M. (2005). Is dissociation a multidimensional construct? Data from the Multiscale Dissociation Inventory. *Journal of Traumatic Stress: Official Publication of the International Society for Traumatic Stress Studies*, *18*(3), 221-231. http://dx.doi.org/10.1002/jts.20024

Broadbent, D. E., Cooper, P. F., FitzGerald, P., & Parkes, K. R. (1982). The cognitive failures questionnaire (CFQ) and its correlates. *British Journal of Clinical Psychology*, *21*(1), 1-16.

http://dx.doi.org/10.1111/j.2044-8260.1982.tb01421.x

Bryant, R. A. (2019). Post-traumatic stress disorder: A state-of-the-art review of evidence and challenges. *World Psychiatry, 18*(3), 259–269. https://doi.org/10.1002/wps.20656

Canadian Primary Care Sentinel Surveillance Network (CPCSSN). (n.d.). *SRE Access Request*. http://cpcssn.ca/sre-access-request/

Chekroud, A. M., Bondar, J., Delgadillo, J., Doherty, G., Wasil, A., Fokkema, M., ... & Choi, K. (2021). The promise of machine learning in predicting treatment outcomes in psychiatry. *World Psychiatry*, *20*(2), 154-170. http://dx.doi.org/10.1002/wps.20882

Cloitre, M., Petkova, E.,Wang, J.,& Lu Lassell, F. (2012). An examination of the influence of a sequential treatment on the course and impact of dissociation among women with PTSD related to childhood abuse. *Depression and Anxiety, 29(*8). 709-717. https://doi.org/10.1002/da.21920

Dai, W., Chen, L., Tan, H., Wang, J., Lai, Z., Kaminga, A. C., Li, Y., & Liu, A. (2016). Association between social support and recovery from post-traumatic stress disorder after flood: A 13-14 year follow-up study in Hunan, China Chronic Disease epidemiology. *BMC Public Health, 16*(1). Article 194. https://doi.org/10.1186/s12889-016-2871-x

Daniels, J. K., Frewen, P., Theberge, J., & Lanius, R. A. (2016). Structural brain aberrations associated with the dissociative subtype of post-traumatic stress disorder. *Acta Psychiatrica Scandinavica*, *133*(3), 232-240. https://doi.org/10.1111/acps.12464

Dewar, M., Paradis, A., & Fortin, C. A. (2020). Identifying trajectories and predictors of response to psychotherapy for post-traumatic stress disorder in adults: A systematic review of literature. *The Canadian Journal of Psychiatry, 65*(2), 71–86. https://doi.org/10.1177/0706743719875602

Donnelly, K., Donnelly, J. P., Warner, G. C., Kittleson, C. J., & King, P. R. (2018). Longitudinal study of objective and subjective cognitive performance and psychological distress in OEF/OIF veterans with and without traumatic brain injury. *The Clinical Neuropsychologist, 32*(3), 436-455. http://dx.doi.org/10.1080/13854046.2017.1390163

Dvir, Y., Ford, J. D., Hill, M., & Frazier, J. A. (2014). Childhood maltreatment, emotional dysregulation, and psychiatric comorbidities. *Harvard Review of Psychiatry*, *22*(3), Article 149. http://dx.doi.org/10.1097/HRP.0000000000000014

Dwyer, D. B., Falkai, P., & Koutsouleris, N. (2018). Machine Learning Approaches for Clinical Psychology and *Psychiatry*. *Annual Review Of Clinical Psychology, 14*(1), 91-118. https://doi.org/10.1146/annurev-clinpsy-032816-045037

Eder, S. J., Steyrl, D., Stefanczyk, M. M., Pieniak, M., Martínez Molina, J., Pešout, O., Binter, J., Smela, P., Scharnowski, F., & Nicholson, A. A. (2021). Predicting fear and perceived health during the COVID-19 pandemic using machine learning: A cross-national longitudinal study. *PloS ONE*, *16*(3), Article e0247997. http://dx.doi.org/10.1371/journal.pone.0247997

Eftekhari, A., Crowley, J. J., Mackintosh, M. A., & Rosen, C. S. (2020). Predicting treatment dropout among veterans receiving prolonged exposure therapy. *Psychological Trauma: Theory, Research, Practice, and Policy*, *12*(4), 405-412. http://dx.doi.org/10.1037/tra0000484

Ehlers, A., & Clark, D. M. (2000). A cognitive model of posttraumatic stress disorder. *Behaviour Research and Therapy, 38*(4). 319–345. https://doi.org/10.1016/S0005-7967(99)00123-0

El Khoury-Malhame, M., Lanteaume, L., Beetz, E. M., Roques, J., Reynaud, E., Samuelian, J. C., ... & Khalfa, S. (2011). Attentional bias in post-traumatic stress disorder diminishes

after symptom amelioration. *Behaviour Research and Therapy*, *49*(11), 796-801. http://dx.doi.org/10.1016/j.brat.2011.08.006

Felitti, V. J., Anda, R. F., Nordenberg, D., Williamson, D. F., Spitz, A. M., Edwards, V., & Marks, J. S. (1998). Relationship of childhood abuse and household dysfunction to many of the leading causes of death in adults: The Adverse Childhood Experiences (ACE) Study. *American Journal of Preventive Medicine*, *14*(4), 245-258. http://dx.doi.org/10.1016/j.amepre.2019.04.001

Foa, E. B., Chrestman, K. R., & Gilboa-Schechtman, E. (2007). *Prolonged Exposure Therapy for Adolescents with PTSD Emotional Processing of Traumatic Experiences*. Oxford University Press.

Foa, E. B., Ehlers, A., Clark, D. M., Tolin, D. F., & Orsillo, S. M. (1999). The posttraumatic cognitions inventory (PTCI): Development and validation. *Psychological Assessment*, *11*(3), 303-314. http://dx.doi.org/10.1037/1040-3590.11.3.303

Frewen, P., & Lanius, R. (2015). *The Norton series on interpersonal neurobiology. Healing the traumatized self: Consciousness, neuroscience, treatment*. W. W. Norton.

Galatzer-Levy, I. R., & Bryant, R. A. (2013). 636,120 ways to have posttraumatic stress disorder. *Perspectives on Psychological Science*, *8*(6), 651-662. https://doi.org/10.1177/1745691613504115

Gallagher, M. W., Long, L. J., & Phillips, C. A. (2020). Hope, optimism, self-efficacy, and posttraumatic stress disorder: A meta-analytic review of the protective effects of positive expectancies. *Journal of Clinical Psychology, 76*(3), 329–355. https://doi.org/10.1002/jclp.22882

Gapen, M., van der Kolk, B. A., Hamlin, E., Hirshberg, L., Suvak, M., & Spinazzola, J. (2016). A Pilot Study of Neurofeedback for Chronic PTSD. *Applied Psychophysiology Biofeedback*, *41*(3), 251-261. https://doi.org/10.1007/s10484-015-9326-5

Geurts, P., Ernst, D., & Wehenkel, L. (2006). Extremely randomized trees. *Machine Learning*, *63*(1), 3-42. http://dx.doi.org/10.1007/s10994-006-6226-1

Gogolla, N. (2017). The insular cortex. *Current Biology*, *27*(12), R580–R586. https://doi.org/https://doi.org/10.1016/j.cub.2017.05.010

Goldberg, S. B., Tucker, R. P., Greene, P. A., Davidson, R. J., Wampold, B. E., Kearney, D. J., & Simpson, T. L. (2018). Mindfulness-based interventions for psychiatric disorders: A systematic review and meta-analysis. *Clinical Psychology Review*, *59*, 52-60. https://doi.org/10.1016/j.cpr.2017.10.011

Gratz, K. L., & Roemer, L. (2004). Multidimensional Assessment of Emotion Regulation and Dysregulation: Development, Factor Structure, and Initial Validation of the Difficulties in Emotion Regulation Scale. *Journal of Psychopathology and Behavioral Assessment*, *26*(1), 41–54. https://doi.org/10.1023/B:JOBA.0000007455.08539

Greene, T., Neria, Y., & Gross, R. (2016). Prevalence, detection and correlates of PTSD in the primary care setting: A systematic review. *Journal of Clinical Psychology in Medical Settings*, *23*(2), 160-180. http://dx.doi.org/10.1007/s10880-016-9449-8

Halligan, S. L., Michael, T., Clark, D. M., & Ehlers, A. (2003). Posttraumatic stress disorder following assault: The role of cognitive processing, trauma memory, and appraisals. *Journal of Consulting and Clinical Psychology, 71*(3), 419–431. https://doi.org/10.1037/0022-006X.71.3.419

Harper, K. L., Moshier, S., Ellickson-Larew, S., Andersen, M. S., Wisco, B. E., Mahoney, C. T., Keane, T. M., Marx, B. P. (2022). A prospective examination of health care costs associated with posttraumatic stress disorder diagnostic status and symptom severity among veterans. *Journal of Traumatic Stress, 35,* 671-681. https://dx.doi.org/10.1002/jts.22785

Harricharan, S., Nicholson, A. A., Thome, J., Densmore, M., McKinnon, M. C., Théberge, J., ... & Lanius, R. A. (2019). PTSD and its dissociative subtype through the lens of the insula: Anterior and posterior insula resting-state functional connectivity and its predictive validity using machine learning. *Psychophysiology*, *57*(1), Article e13472. http://dx.doi.org/10.1111/psyp.13472

Hayes, J. P., VanElzakker, M. B., & Shin, L. M. (2012). Emotion and cognition interactions in PTSD: a review of neurocognitive and neuroimaging studies. *Frontiers in Integrative Neuroscience*, *6,* Article 89. http://dx.doi.org/10.3389/fnint.2012.00089

Hayes, S. C., Strosahl, K. D., & Wilson, K. G. (1999). *Acceptance and commitment therapy: An experiential approach to behavior change.* Guilford Press.

Heim, C. M., Mayberg, H. S., Mletzko, T., Nemeroff, C. B., & Pruessner, J. C. (2013). Decreased cortical representation of genital somatosensory field after childhood sexual abuse. *American Journal of Psychiatry, 170*(6), 616–623. https://doi.org/10.1176/appi.ajp.2013.12070950

Huntjens, R. J. C., Dorahy, M. J., & van Wees-Cieraad, R. (2013). Dissociation and memory fragmentation. In F. Kennedy, H. Kennerley, & D. Pearson (Eds.), *Cognitive Behavioural Approaches to Understanding the Treatment of Dissociation* (pp. 92–103). Routledge.

Kaiser, E. M., Gillette, C. S., & Spinazzola, J. (2010). A controlled pilot-outcome study of sensory integration (SI) in the treatment of complex adaptation to traumatic stress. *Journal of Aggression, Maltreatment and Trauma, 19*(7), 699–720. https://doi.org/10.1080/10926771.2010.515162

Kashdan, T. B., & Rottenberg, J. (2010). Psychological flexibility as a fundamental aspect of health. *Clinical Psychology Review, 30*(7), 865–878. https://doi.org/10.1016/j.cpr.2010.03.001

Kleim, B., Wallott, F., & Ehlers, A. (2008). Are Trauma Memories Disjointed from other Autobiographical Memories in Posttraumatic Stress Disorder? An Experimental Investigation. *Behavioural and Cognitive Psychotherapy*, *36*(2), 221-234. http://dx.doi.org/10.1017/S1352465807004080.

Knowles, K. A., Sripada, R. K., Defever, M., & Rauch, S. A. (2019). Comorbid mood and anxiety disorders and severity of posttraumatic stress disorder symptoms in treatment-seeking veterans. *Psychological Trauma: Theory, Research, Practice, and Policy*, *11*(4), 451-458. http://dx.doi.org/10.1037/tra0000383

Konnert, C., & Wong, M. (2015). Age differences in PTSD among Canadian veterans: Age and health as predictors of PTSD severity. *International Psychogeriatrics*, *27*(2), 1-8. https://doi.org/10.1017/S1041610214001884

Kubany, E. S., Haynes, S. N., Abueg, F. R., Manke, F. P., Brennan, J. M., & Stahura, C. (1996). Development and validation of the trauma-related guilt inventory (TRGI). *Psychological Assessment*, *8*(4), 428-444. http://dx.doi.org/10.1037/1040-3590.8.4.428

Lanius, R. A. (2015). Trauma-related dissociation and altered states of consciousness: a call for clinical, treatment, and neuroscience research. *European Journal of Psychotraumatology*, *6*(1), Article 27905. http://dx.doi.org/10.3402/ejpt.v6.27905

Lanius, R. A., Bluhm, R. L., & Frewen, P. A. (2011). How understanding the neurobiology of complex post-traumatic stress disorder can inform clinical practice: a social cognitive and affective neuroscience approach. *Acta Psychiatrica Scandinavica, 124*(5), 331–348. https://doi.org/10.1111/j.1600-0447.2011.01755.x

Lanius, R. A, Brand, B., Vermetten, E., Frewen, P. A., & Spiegel, D. (2012). The dissociative subtype of posttraumatic stress disorder: Rationale, clinical and neurobiological evidence, and implications. *Depression and Anxiety*, *29*(8), 701–708. https://doi.org/10.1002/da.21889

Lanius, R. A., Vermetten, E., Loewenstein, R. J., Brand, B., Schmahl, C., Bremner, J. D., & Spiegel, D. (2010). Emotion modulation in PTSD: Clinical and neurobiological evidence for a dissociative subtype. *American journal of psychiatry*, *167*(6), 640-647. http://dx.doi.org/10.1176/appi.ajp.2009.09081168

Lebois, L. A., Li, M., Baker, J. T., Wolff, J. D., Wang, D., Lambros, A. M., ... & Kaufman, M. L. (2021). Large-scale functional brain network architecture changes associated with trauma-related dissociation. *American Journal of Psychiatry*, *178*(2), 165-173. http://dx.doi.org/10.1176/appi.ajp.2020.19060647

Lee, D. J., Schnitzlein, C. W., Wolf, J. P., Vythilingam, M., Rasmusson, A. M., & Hoge, C. W. (2016). Psychotherapy versus pharmacotherapy for posttraumatic stress disorder: Systemic review and meta-analyses to determine first-line treatments. *Depression and Anxiety*, *33*(9), 792-806. http://dx.doi.org/10.1002/da.22511

Lee, J. S. (2019). Perceived social support functions as a resilience in buffering the impact of trauma exposure on PTSD symptoms via intrusive rumination and entrapment in firefighters. *PLoS ONE, 14*(8), Article e0220454. https://doi.org/10.1371/journal.pone.0220454

Louppe, G., Wehenkel, L., Sutera, A., Geurts, P. (2013). Understanding variable importances in forests of randomized trees. *Advances in Neural Information Processing System, 1*, 431-439.

Lynch, T. R., Trost, W. T., Salsman, N., & Linehan, M. M. (2007). Dialectical behavior therapy for borderline personality disorder. *Annual Review of Clinical Psychology, 3*(1), 181-205. https://doi.org/10.1146/annurev.clinpsy.2.022305.095229

Martin, P., Rakha, M. S., & Whitnall, J. (2021). Data safe haven for military, Veteran, and family health research. *Journal of Military, Veteran and Family Health, 7*(1), 102-107. https://doi.org/10.3138/jmvfh-2020-0035

McGreevy, S., & Boland, P. (2020). Sensory-based interventions with adult and adolescent trauma survivors: An integrative review of the occupational therapy literature. *Irish Journal of Occupational Therapy, 48*(1), 31-54. http://dx.doi.org/10.1108/IJOT-10-2019-0014

McKinnon, M. C., Boyd, J. E., Frewen, P. A., Lanius, U. F., Jetly, R., Richardson, J. D., & Lanius, R. A. (2016). A review of the relation between dissociation, memory, executive functioning and social cognition in military members and civilians with neuropsychiatric conditions. *Neuropsychologia*, *90*, 210–234. doi:10.1016/j.neuropsychologia.2016.07.017

Merz, J., Schwarzer, G., & Gerger, H. (2019). Comparative efficacy and acceptability of pharmacological, psychotherapeutic, and combination treatments in adults with

posttraumatic stress disorder: a network meta-analysis. *JAMA Psychiatry, 76*(9), 904-913. https://doi.org/10.1001/jamapsychiatry.2019.0951

Messman-Moore, T. L., & Bhuptani, P. H. (2017). A Review of the Long-Term Impact of Child Maltreatment on Posttraumatic Stress Disorder and Its Comorbidities: An Emotion Dysregulation Perspective. *Clinical Psychology: Science and Practice, 24*(2), 154-169. https://doi.org/10.1111/cpsp.12193

Miles, S. R., Pruiksma, K. E., Slavish, D., Dietch, J. R.,Wardle-Pinkston, S., Litz, B. T., Rodgers, M., Nicholson, K. L., Young-McCaughan, S., Dondanville, K. A., Nakase-Richardson, R., Mintz, J., Keane, T. M., Peterson, A. L., Resick, P. A., Taylor, D. J., & Consortium to Alleviate PTSD. (2022). Sleep disorder symptoms are associated with greater posttraumatic stress and anger symptoms in US Army service members seeking treatment for posttraumatic stress disorder. *Journal of Clinical Sleep Medicine, 18*(6), 1617–1627. https://doi.org/10.5664/jcsm.9926

Neria, Y. (2021). Functional neuroimaging in PTSD: from discovery of underlying mechanisms to addressing diagnostic heterogeneity. *American Journal of Psychiatry*, *178*(2), 128-135. https://doi.org/10.1176/appi.ajp.2020.20121727

Newson, J. J., Pastukh, V., & Thiagarajan, T. C. (2021). Poor Separation of Clinical Symptom Profiles by DSM-5 Disorder Criteria. *Frontiers in Psychiatry*, *12*, Article 775762. https://doi.org/10.3389/fpsyt.2021.775762

Nicholson, A. A., Densmore, M., Frewen, P. A., Théberge, J., Neufeld, R. W., McKinnon, M. C., & Lanius, R. A. (2015). The dissociative subtype of posttraumatic stress disorder: unique resting-state functional connectivity of basolateral and centromedial amygdala

complexes. *Neuropsychopharmacology*, *40*(10), 2317-2326. http://dx.doi.org/10.1038/npp.2015.79

Nicholson, A. A., Densmore, M., McKinnon, M. C., Neufeld, R. W., Frewen, P. A., Théberge, J., ... & Lanius, R. A. (2018). Machine learning multivariate pattern analysis predicts classification of posttraumatic stress disorder and its dissociative subtype: a multimodal neuroimaging approach. *Psychological Medicine*, *49*(12), 2049-2059. https://doi.org/10.1017/S0033291718002866

Nicholson, A. A., Harricharan, S., Densmore, M., Neufeld, R. W., Ros, T., McKinnon, M. C., ... & Lanius, R. A. (2020). Classifying heterogeneous presentations of PTSD via the default mode, central executive, and salience networks with machine learning. *NeuroImage: Clinical*, *27*, Article 102262. http://dx.doi.org/10.1016/j.nicl.2020.102262

Nicholson, A. A., Rabellino, D., Densmore, M., Frewen, P. A., Steryl, D., Scharnowski, F., Théberge, J., Neufeld, R. W. J., Schmahl, C., Jetly, R., & Lanius, R. A. (2022). Differential mechanisms of posterior cingulate cortex downregulation and symptom decreases in posttraumatic stress disorder and healthy individuals using real-time fMRI neurofeedback. *Brain and Behavior, 12*(1), Article e2441. https://doi.org/10.1002/brb3.2441

Nicholson, A. A., Sapru, I., Densmore, M., Frewen, P. A., Neufeld, R. W., Théberge, J., ... & Lanius, R. A. (2016). Unique insula subregion resting-state functional connectivity with amygdala complexes in posttraumatic stress disorder and its dissociative subtype. *Psychiatry Research: Neuroimaging*, *250*, 61-72. http://dx.doi.org/10.1016/j.pscychresns.2016.02.002

Norman, R. E., Byambaa, M., De, R., Butchart, A., Scott, J., & Vos, T. (2012). The long-term health consequences of child physical abuse, emotional abuse, and neglect: a systematic review and meta-analysis. *PLoS Medicine*, *9*(11), Article e1001349. https://doi.org/10.1371/journal.pmed.1001349

Obuobi-Donkor, G., Oluwasina, F., Nkire, N., & Agyapong, V. I. (2022). A scoping review on the prevalence and determinants of post-traumatic stress disorder among military personnel and firefighters: implications for public policy and practice. *International Journal of Environmental Research and Public Health*, *19*(3), Aritlce 1565. http://dx.doi.org/10.3390/ijerph19031565

Øktedalen, T., Hagtvet, K. A., Hoffart, A., Langkaas, T. F., & Smucker, M. (2014). The Trauma Related Shame Inventory: Measuring trauma-related shame among patients with PTSD. *Journal of Psychopathology and Behavioral Assessment*, *36*(4), 600-615. http://dx.doi.org/10.1007/s10862-014-9422-5

Olff, M. (2017). Sex and gender differences in post-traumatic stress disorder: an update. *European Journal of Psychotraumatology*, *8*(Suppl. 4). Article 1351204. https://doi.org/10.1080/20008198.2017.1351204

Ozer, E. J., Best, S. R., Lipsey, T. L., & Weiss, D. S. (2003). Predictors of posttraumatic stress disorder and symptoms in adults: A meta-analysis. *Psychological Bulletin*, *129*(1), 52-73. doi:10.1037/0033-2909.129.1.52

Panagioti, M., Gooding, P. A., & Tarrier, N. (2012). A meta-analysis of the association between posttraumatic stress disorder and suicidality: the role of comorbid depression. *Comprehensive Psychiatry*, *53*(7), 915-930. http://dx.doi.org/10.1016/j.comppsych.2012.02.009

Panagioti, M., Gooding, P. A., Triantafyllou, K., & Tarrier, N. (2015). Suicidality and posttraumatic stress disorder (PTSD) in adolescents: a systematic review and meta-analysis. *Social Psychiatry and Psychiatric Epidemiology, 50*(4), 525-537. http://dx.doi.org/10.1007/s00127-014-0978-x

Park, A. H., Protopopescu, A., Pogue, M. E., Boyd, J. E., O'Connor, C., Lanius, R. A., & McKinnon, M. C. (2021). Dissociative symptoms predict severe illness presentation in Canadian public safety personnel with presumptive post-traumatic stress disorder (PTSD). *European Journal of Psychotraumatology*, *12*(1), Article 1953789. http://dx.doi.org/10.1080/20008198.2021.1953789

Parkitny, L., & McAuley, J. (2010). The Depression Anxiety Stress Scale (DASS). *Journal of Physiotherapy*, *56*(3), Article 204. http://dx.doi.org/10.1016/S1836-9553(10)70030-8

Pedregosa, F., Varoquaux, G., Gramfort, A., Michel, V., Thirion, B., Grisel, O., … & Duchesnay, E. (2011). Scikit-learn: Machine learning in Python. *Journal of Machine Learning Research*, *12*, 2825–2830. http://jmlr.csail.mit.edu/papers/volume12/pedregosa11a/pedregosa11a.pdf

Powers, A., Cross, D., Fani, N., & Bradley, B. (2015). PTSD, emotion dysregulation, and dissociative symptoms in a highly traumatized sample. *Journal of Psychiatric Research, 61*, 174-179. https://doi.org/10.1016/j.jpsychires.2014.12.011

Prati, G., & Pietrantoni, L. (2009). Optimism, social support, and coping strategies as factors contributing to posttraumatic growth: A meta-analysis. *Journal of Loss and Trauma, 14*(5)., 364-388. https://doi.org/10.1080/15325020902724271

Rabellino, D., Densmore, M., Harricharan, S., Jean, T., McKinnon, M. C., & Lanius, R. A. (2018). Resting-state functional connectivity of the bed nucleus of the stria terminalis in

post-traumatic stress disorder and its dissociative subtype. *Human Brain Mapping, 39*(3), 1367-1379. http://dx.doi.org/10.1002/hbm.23925

Reinders, A. S., Nijenhuis, E. R., Quak, J., Korf, J., Haaksma, J., Paans, A. M., ... & den Boer, J. A. (2006). Psychobiological characteristics of dissociative identity disorder: a symptom provocation study. *Biological Psychiatry, 60*(7), 730-740. http://dx.doi.org/10.1016/j.biopsych.2005.12.019

Resick, P. A., Galovski, T. E., Uhlmansiek, M. O. B., Scher, C. D., Clum, G. A., & Young-Xu, Y. (2008). A Randomized Clinical Trial to Dismantle Components of Cognitive Processing Therapy for Posttraumatic Stress Disorder in Female Victims of Interpersonal Violence. *Journal of Consulting and Clinical Psychology, 76*(2), 243-258. https://doi.org/10.1037/0022-006X.76.2.243

Richardson, C. M. E., & Jost, S. A. (2019). Psychological flexibility as a mediator of the association between early life trauma and psychological symptoms. *Personality and Individual Differences, 141*, 101-106. https://doi.org/10.1016/j.paid.2018.12.029

Ros, T., Lanius, R. A., & Vuilleumier, P. (2014). Tuning pathological brain oscillations with neurofeedback: a systems neuroscience framework. *Frontiers in Human Neuroscience, 8*, Article 1008. http://dx.doi.org/10.3389/fnhum.2014.01008

Rothschild, D. (2009). On becoming one-self: Reflections on the concept of integration as seen through a case of dissociative identity disorder. *Psychoanalytic Dialogues, 19*(2), 175-187. https://doi.org/10.1080/10481880902779786

Sareen, J., Cox, B. J., Stein, M. B., Afifi, T. O., Fleet, C., & Asmundson, G. J. (2007). Physical and mental comorbidity, disability, and suicidal behavior associated with posttraumatic

stress disorder in a large community sample. *Psychosomatic Medicine*, *69*(3), 242-248. https://doi.org/10.1097/PSY.0b013e31803146d8

Scalabrini, A., Mucci, C., Esposito, R., Damiani, S., & Northoff, G. (2020). Dissociation as a disorder of integration–On the footsteps of Pierre Janet. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, *101*, Article 109928. https://doi.org/10.1016/j.pnpbp.2020.109928

Schimmenti, A., & Caretti, V. (2016). Linking the overwhelming with the unbearable: Developmental trauma, dissociation, and the disconnected self. *Psychoanalytic Psychology, 33*(1), Article 106. http://dx.doi.org/10.1037/a0038019

Schultebraucks, K., Qian, M., Abu-Amara, D., Dean, K., Laska, E., Siegel, C., Gautam, A., Guffanti, G., Hammamieh, R., Misganaw, B., Mellon, S. H., Wolkowitz, O. M., Blessing, E. M., Etkin, A., Ressler, K. J., Doyle, F. J., Jett, M., Marmar, C. R. (2021). Pre-deployment risk factors for ptsd in active-duty personnel deployed to afghanistan: a machine-learning approach for analyzing multivariate predictors. *Molecular Psychiatry, 26*(9), 5011-5022. https://dx.doi.org/10.1038/s41380-020-0789-2

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. http://dx.doi.org/10.1037/a0038039

Seligowski, A. V., Lee, D. J., Bardeen, J. R., & Orcutt, H. K. (2014). Emotion regulation and posttraumatic stress symptoms: A meta-analysis. *Cognitive Behaviour Therapy*, *44*(2), 87-102. https://doi.org/10.1080/16506073.2014.980753

Siegel, C. E., Laska, E. M., Lin, Z., Xu, M., Abu-Amara, D., Jeffers, M. K., Qian, M., Milton, N., Flory, J. D., Hammamieh, R., Daigle, B. J., Gautam, A., Dean, K. R., Reus, V. I., Wolkowitz, O. M., Mellon, S. H., Ressler, K. J., Yehuda, R., Wang, K., Hood, L., Doyle, F. J., Jett, M., Marmar, C. R. (2021). Utilization of machine learning for identifying symptom severity military-related PTSD subtypes and their biological correlates. *Translational Psychiatry, 11*(1), Article 227. https://dx.doi.org/10.1038/s41398-021-01324-8

Stein, D. J., Koenen, K. C., Friedman, M. J., Hill, E., McLaughlin, K. A., Petukhova, M., ... & Kessler, R. C. (2013). Dissociation in posttraumatic stress disorder: evidence from the world mental health surveys. *Biological Psychiatry*, *73*(4), 302-312. https://doi.org/10.1016/j.biopsych.2012.08.02

Straube, T., & Miltner, W. H. R. (2011). Attention to aversive emotion and specific activation of the right insula and right somatosensory cortex. *NeuroImage, 54*(3), 2534-2538. https://doi.org/10.1016/j.neuroimage.2010.10.010

Stulemeijer, M., Van Der Werf, S., Borm, G. F., & Vos, P. E. (2008). Early prediction of favourable recovery 6 months after mild traumatic brain injury. *Journal of Neurology, Neurosurgery and Psychiatry, 79*(8), 936-942. https://doi.org/10.1136/jnnp.2007.131250

Tanner, J., Zeffiro, T., Wyss, D., Perron, N., Rufer, M., & Mueller-Pfeiffer, C. (2019). Psychiatric symptom profiles predict functional impairment. *Frontiers in Psychiatry*, *10*, Article 37. https://doi.org/10.3389/fpsyt.2019.00037

Tursich, M., Ros, T., Frewen, P. A., Kluetsch, R. C., Calhoun, V. D., & Lanius, R. A. (2015). Distinct intrinsic network connectivity patterns of post-traumatic stress disorder symptom

clusters. *Acta Psychiatrica Scandinavica*, *132*(1), 29-38. https://doi.org/10.1111/acps.12387

Üstün, T. B., Chatterji, S., Kostanjsek, N., Rehm, J., Kennedy, C., Epping-Jordan, J., ... & Pull, C. (2010). Developing the World Health Organization disability assessment schedule 2.0. *Bulletin of the World Health Organization*, *88*(11), 815-823. http://dx.doi.org/10.2471/BLT.09.067231

van der Kolk, B. A., Hodgdon, H., Gapen, M., Musicaro, R., Suvak, M. K., Hamlin, E., & Spinazzola, J. (2016). A randomized controlled study of neurofeedback for chronic PTSD. *PloS ONE*, *11*(12), Article e0166752. https://dx.doi.org/10.1371/journal.pone.0166752

Van Rossum, G., & Drake, F. L. (2009). *Python 3 Reference Manual*. CreateSpace.

Vasterling, J. J., & Brewin, C. (Eds.). (2005). *Neuropsychology of PTSD: Biological, cognitive, and clinical perspectives*. Guilford Press.

Wani, A. H., Aiello, A. E., Kim, G. S., Xue, F., Martin, C. L., Ratanatharathorn, A., Qu, A., Koenen, K., Galea, S., Wildman, D. E., Uddin, M. (2021). The impact of psychopathology, social adversity and stress-relevant dna methylation on prospective risk for post-traumatic stress: a machine learning approach. *Journal of Affective Disorders, 282*, 894-905. https://dx.doi.org/10.1016/j.jad.2020.12.076

Warner, E., Finn, H., Wescott, A., & Cook, A. (2020). *Transforming trauma in children and adolescents: An embodied approach to somatic regulation, trauma processing, and attachment-building*. North Atlantic Books.

Warner, E., Spinazzola, J., Westcott, A., Gunn, C., & Hodgdon, H. (2014). The Body Can Change the Score: Empirical Support for Somatic Regulation in the Treatment of

Traumatized Adolescents. *Journal of Child and Adolescent Trauma, 7*(4), 237-246. https://doi.org/10.1007/s40653-014-0030-z

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

White, W. F., Burgess, A., Dalgleish, T., Halligan, S., Hiller, R., Oxley, A., ... & Meiser-Stedman, R. (2022). Prevalence of the dissociative subtype of post-traumatic stress disorder: a systematic review and meta-analysis. *Psychological Medicine, 52*(9), 1-16. http://dx.doi.org/10.1017/S0033291722001647

Wolf, E. J., Lunney, C. A., Miller, M. W., Resick, P. A., Friedman, M. J., & Schnurr, P. P. (2012a). The dissociative subtype of PTSD: A replication and extension. *Depression and Anxiety*, *29*(8), 679–688. doi:10.1002/ da.21946

Wolf, E. J., Miller, M., Reardon, A., Ryabchenko, K. A., Castillo, D., & Freund, R. (2012b). A latent class analysis of dissociation and posttraumatic stress disorder. *Archives of General Psychiatry*, *69*(7), 698–705. doi:10.1001/archgenpsychiatry.2011.1574

Zafari, H., Kosowan, L., Zulkernine, F., Signer, A. (2021). Diagnosing post-traumatic stress disorder using electronic medical record data. *Health Informatics Journal, 27*(4), 14604582211053259. https://dx.doi.org/10.1177/14604582211053259

Ziobrowski, H. N., Kennedy, C. J., Ustun, B., House, S. L., Beaudoin, F. L., An, X., … & van Rooij, S. J. H. (2021). Development and validation of a model to predict posttraumatic stress disorder and major depression after a motor vehicle collision. *JAMA Psychiatry, 78*(11), 1228-1237. https://dx.doi.org/10.1001/jamapsychiatry.2021.2427

Chapter 5:

General Discussion

Summary of Findings

In this dissertation, I investigated the role of dissociation in post-traumatic stress disorder (PTSD), an underrecognized phenomenon in traumatic stress research and clinical practice (Brand, 2016). Dissociation in PTSD is characterized by symptoms of depersonalization (feeling detached from the self) and derealization (feeling detached from one's surroundings) and serves as a defensive mechanism against the impact of severe trauma or when physical escape is not possible (American Psychological Association [APA], 2013). Dissociative symptoms present as *hypoarousal* (e.g., emotional constriction, numbness, blunted affect) and is a contrast to the classic conceptualization of PTSD marked by *hyperarousal* (e.g., hypervigilance, physiological reactivity), which has historically dominated the literature. As such, there is a need to update our conceptualization of PTSD to encompass presentations of hypoarousal using empirical research. To meet this aim, I examined the impact of trauma-related dissociation symptoms on affective, cognitive, and daily functioning among adults seeking treatment for PTSD in Canada.

In the first study (Chapter 2), I sought to characterize the presence of elevated levels of trauma-related dissociation in a sample of current and former public safety personnel in Canada, whose symptoms of dissociation had not previously been reported (Park et al., 2021). Findings revealed that approximately 25% exhibited elevated levels of dissociation symptoms, which were associated with a greater burden of illness such as severe PTSD, problems regulating one's emotions, and difficulties managing daily activities including maintaining social relationships. These findings highlight the importance of screening for dissociation symptoms among public safety personnel, as it may be indicative of a heightened burden of illness and require specialized treatment. Building on these associations, the second study (Chapter 3) focused on cognitive dysfunction, a core symptom of PTSD (APA, 2013), in a sample of public safety personnel,

military members, and veterans seeking treatment for PTSD. Here, dissociation symptoms and emotion dysregulation independently contributed to cognitive dysfunction, above and beyond the effects of PTSD severity and control variables. This underscores dissociation's unique role in exacerbating cognitive impairment in PTSD, which is a novel finding in this area of research. Results from Chapters 2 and 3 were aligned, showing that dissociation is linked to a greater burden of illness in PTSD.

Given that the first two studies were exploratory and correlational, the third study (Chapter 4) explored the potential predictive power of these findings. In other words, rather than describing patterns among symptom variables, I tested whether a predictive model could be generated from these patterns, which could then be used to predict PTSD severity or impairment in new patients. Utilizing a large clinical dataset of military members, veterans, public safety personnel, and civilians seeking treatment for PTSD, two non-linear machine learning regression models (e.g., extremely randomized trees) were trained to predict (1) PTSD symptom severity and (2) functional impairment scores. Both models, using dissociation symptoms as significant predictors, were accurate in predicting PTSD symptom severity (43%) and functional impairment (32%). This finding illustrates that dissociation is a critical factor for predicting illness severity in PTSD and demonstrates the real-world clinical utility of machine learning models in the field of traumatic stress and recovery.

Overall, this dissertation advances our understanding of dissociation in PTSD, demonstrating its considerable impact on illness severity, cognitive dysfunction, and functional impairment. This work emphasizes that dissociation, among other clinical features, is a key feature that uniquely contributes to worsening clinical presentations of PTSD. These studies draw attention to the importance of further examining dissociative presentations in PTSD,

improving recognition of dissociation in clinical contexts, and exploring treatment approaches that are tailored for individuals experiencing trauma-related dissociation.

Discussion of Findings

The Role of Dissociation in Illness Severity

Despite high rates of traumatization and illness among public safety personnel (Carleton et al., 2018a), research on trauma-related dissociation and related clinical symptoms in treatment-seeking Canadian samples are relatively sparse (Boyd et al., 2018). Chapter 2 was the first study to assess elevated levels of trauma-related dissociation in Canadian public safety personnel, with 24.4% of the sample reporting such symptoms, consistent with the 15-30% rates observed in other populations (McKinnon et al., 2016; Wolf et al., 2012a, 2012b). Additionally, dissociation symptoms predicted heightened functional impairment (e.g., difficulties with self-care activities, work, maintaining relationships, community participation, etc.), including specific challenges in social functioning. This aligns with research noting global impairment in social functioning and intimate relationships among individuals with PTSD (Nazarov et al., 2014; 2015; Rodriguez et al., 2012; Scoglio et al., 2022). Thus, findings from Chapter 2 demonstrated that dissociation is linked to increased severity of PTSD symptoms, emotion dysregulation, and functional impairment (Park et al., 2021).

In Chapter 3, this pattern of impairment in PTSD was supported, but the independent role of dissociation in functional impairment was less clear. Here, daily functioning worsened as PTSD symptom severity increased, after controlling for biological sex, patient status, and premorbid intelligence (Knowles et al., 2019; Sareen et al., 2007). However, in Chapter 3, dissociation symptoms did not explain additional variance in functional impairment, after accounting for the significant influence of PTSD symptom severity and control variables. This

contrasted with previous findings where dissociation mediated the relation between PTSD symptom severity and functional impairment (Boyd et al., 2018). Despite the strong association between dissociation and functional impairment, this discrepancy in Chapter 3 suggested that PTSD symptom severity was perhaps more important than dissociation when predicting impairment. Taken together, these results highlighted the contributions of dissociation and PTSD severity to functional impairment, illustrating the potential need for treatment that addresses both symptoms in trauma recovery. Nonetheless, further research was required to examine their distinct roles in contributing to impairment, which was one of the aims in Chapter 4.

Expanding on these findings, Chapter 4 examined whether machine learning algorithms could provide insights into the relative importance of dissociation in PTSD severity and functional impairment, against other commonly reported correlates such as PTSD severity (when predicting functional impairment), emotion dysregulation, anxiety, and depression symptoms. Importantly, these models accurately predicted PTSD symptom severity (43% variance explained) and functional impairment scores (32% variance) in a novel subset of patients from a real-world clinical sample. Specifically, the first model accurately predicted PTSD symptom severity scores within 6.5 points on the PTSD checklist for DSM-5 (PCL-5; a scale ranging from 0 to 80), with dissociation being among the most influential predictors, alongside anxiety, negative trauma-related beliefs about the world, depression, and emotion dysregulation. Age and biological sex did not significantly contribute to model accuracy, indicating that pre-determined factors were relatively less important in determining illness severity than variable factors such as mental health symptoms. This is interesting because it suggests that pre-determined traits like biological sex and age may not uniquely predispose an individual to experiencing severe trauma-related health symptoms. The machine learning model also accurately predicted functional

impairment within 5.5 points on the World Health Organization Disability Assessment Schedule 2.0 (WHODAS 2.0; a scale ranging from 12 to 60). Again, dissociation emerged as one of the most influential predictors, alongside anxiety, PTSD severity, cognitive dysfunction, and depression. Importantly, in Chapter 4, both PTSD severity and dissociation symptoms were influential predictors of functional impairment, but PTSD severity was relatively more important than dissociation (6% vs 3% of variance). The greater importance of PTSD severity relative to dissociation symptoms in Chapter 4 is noteworthy, given the previous findings from Chapter 3, where PTSD severity, but not dissociation, predicted functional impairment. These findings can be reconciled by Chapter 4 findings, where both PTSD severity and dissociation symptoms were indeed important, albeit in differing degrees.

Collectively, these results substantiate the conclusions across my dissertation studies, pointing to dissociation symptoms as a unique driver of illness severity, independent from the effects of PTSD severity. In addition to estimating rates of elevated dissociation symptoms in Canadian public safety personnel for the first time, I consistently found evidence to suggest that populations experiencing trauma-related dissociation symptoms likely endure a higher burden of illness than currently recognized in research and clinical settings (Bae et al., 2016; Brand, 2016). With high rates of psychiatric comorbidity already documented (Greene et al., 2016; Knowles et al., 2019), this research emphasizes the need to address dissociation symptoms in treatment-seeking populations experiencing PTSD.

Cognitive Dysfunction and Dissociation

A common symptom domain affected in PTSD is cognitive functioning (Alexis et al., 2023; APA, 2013; Banich et al., 2009; McKinnon et al., 2016). Previous meta-analytic and review literature had established a robust link between cognitive dysfunction and PTSD

symptom severity, but no studies had parsed out the role of dissociation symptoms from PTSD severity (Aupperle et al., 2012; Scott et al., 2015; Wrocklage et al., 2016). I addressed this gap in Chapter 3 by examining the unique role of dissociation on specific domains of cognitive functioning (as measured by neuropsychological assessments), after accounting for the effects of PTSD symptom severity. I found that cognitive dysfunction significantly worsened with increasing levels of trauma-related dissociation, after accounting for PTSD severity and control variables including premorbid intelligence. Specifically, intellectual functioning, processing speed, and complex higher-order tasks and planning (i.e., executive functioning) were significantly more impaired as dissociation increased. This suggests that trauma-related dissociation is a unique driver of cognitive dysfunction, independent of PTSD symptom severity. This was a novel finding in the field, distinguishing the unique role of trauma-related dissociation from PTSD severity in cognitive dysfunction.

Whereas dissociation symptoms predicted impairment on neuropsychological assessments (Chapter 3), PTSD symptoms predicted self-reported cognitive impairment (e.g., forgetting appointments, accidentally throwing away the wrong items, starting one task then unintentionally becoming distracted into doing a different task). Here, individuals perceived greater problems with cognition as their PTSD symptoms worsened, but this was not accounted for by dissociation symptoms. This was an unexpected finding, suggesting that dissociation symptoms and PTSD symptom severity affect cognitive impairment differently depending on how cognition is measured. It is possible that dissociation symptoms directly impact upon neuropsychological test performance, whereas PTSD symptom severity influences maladaptive perceptions of cognitive impairment. Alternatively, the discrepancy may be explained by the low concordance between self-reported cognition and neuropsychological test performance (French

et al., 2014). Furthermore, the highly controlled and distraction-free testing environments of neuropsychological assessments may not reflect real-world conditions, influencing test outcomes. Future studies should examine how test administration and overall testing contexts impact measures of cognitive dysfunction. Critically, the assessment of cognitive impairment in PTSD will be essential, given their substantial combined impact on daily functioning. In fact, individual perceptions of cognitive dysfunction have been found to mediate the relationship between PTSD symptom severity and functional outcomes, such as occupational and social functioning (Samuelson et al., 2017). Relatedly, in Chapter 4, I found that both dissociation and cognitive impairment uniquely contributed to worsening general functioning. Here, self-reported cognitive dysfunction was an important predictor of functional impairment, alongside dissociation and PTSD symptom severity. This is consistent with research showing that dissociation and cognitive impairment negatively impact daily functioning (Donnelly et al., 2018; Stulemeijer et al., 2008). Again, these findings emphasize that dissociation symptoms are associated with a greater illness severity, and that the assessment of dissociation symptoms is crucial.

In addition to more automatic cognitive processes such as those assessed by neuropsychological tests, Chapter 4 examined persistent negative trauma-related cognitions that can develop from trauma-based learning. For example, individuals with PTSD often develop persistent negative beliefs about oneself, others, and the world that can influence their behaviours and cause significant daily impairment, such as “people can’t be trusted”, “you never know you will harm you”, and “the world is a dangerous place” (Foa et al., 1999). These negative appraisals heighten threat sensitivity and increase unhelpful avoidance behaviours, which can prevent trauma memory and emotion processing, thereby maintaining PTSD

symptoms (Bryant et al., 2019; Foa et al., 1989). In Chapter 4, these beliefs were highly predictive of PTSD symptom severity, uniquely accounting for 6% of its variance. Relatedly, a review found that the reduction of negative trauma-related beliefs not only predicted, but preceded, improvement in PTSD severity following treatment for PTSD (Brown et al., 2019), indicating that cognitive restructuring to make beliefs more helpful is a crucial component of PTSD recovery. My findings confirm the importance of addressing both cognitive dysfunction in PTSD and the broader cognitions that arise from trauma (e.g., beliefs about the world), given their role in contributing to illness severity.

This work also emphasized the complex associations between dissociation, cognition, and emotion dysregulation in PTSD. When examining cognitive dysfunction in Chapter 3, I found that problems with emotion dysregulation further contributed to impairments in self-reported cognition and neuropsychological test performance in PTSD. As emotion dysregulation increased, individuals with PTSD increasingly viewed their cognition as impaired and demonstrated slower processing speed. These impairments were independent of PTSD symptom severity, dissociation symptoms, biological sex, premorbid intelligence, and patient status (i.e., inpatient or outpatient). This indicates that emotion dysregulation is a key driver of impairment that is distinct from other intercorrelated factors such as dissociation and PTSD symptom severity. It will be essential for future studies to discern the role of dissociation from emotion dysregulation when examining cognition and overall impairment in PTSD.

In summary, this work revealed a novel finding that trauma-related dissociation symptoms uniquely contribute to worsening cognitive dysfunction in PTSD, a symptom domain only previously associated with PTSD severity. This research underlines the need to further examine the role of dissociation symptoms and cognitive impairment in PTSD recovery, given

their important roles in maintaining functioning in daily activities (Dossi et al., 2020). Additionally, the unique impact of emotion dysregulation on cognitive dysfunction in PTSD points to the complex interplay of cognition and emotion in PTSD.

Emotion Dysregulation and Dissociation

Difficulties with emotional awareness and lack of access to strategies to regulate emotions are predictive of trauma-related dissociation (Powers et al., 2015). Consistent with this, Chapter 2 found that highly dissociative individuals experience problems regulating their emotions, including difficulty accessing effective strategies to manage emotions (Park et al., 2021). Indeed, clinical presentations of dissociation including numbness, detachment, and hypoarousal are consistent with such individuals having problems identifying, clarifying, and managing their emotions (Powers et al., 2015) as well as the avoidance, suppression, and nonacceptance of emotions (Cavicchioli et al., 2021) among those experiencing dissociation. However, no previous study had used a data-driven, machine learning approach to test the predictive power of self-reported emotion dysregulation, dissociation, and their related correlates in forecasting PTSD-related outcomes. I addressed this gap in Chapter 4 by introducing a novel statistical method in PTSD research that accurately forecasted self-reported PTSD symptom severity and functional impairment scores at the individual level.

In Chapter 4, symptoms of anxiety and depression jointly accounted for 17% of the variance in predicting PTSD symptom severity in new patients (Park et al., 2023). This is consistent with research showing that PTSD is highly comorbid with anxiety and depressive disorders, which are also associated with more severe PTSD presentations (Knowles et al., 2019; Siegel et al., 2021). In addition, it highlights how elevated fear responses can contribute to more severe PTSD presentations and be an important target for treatment. Dissociation symptoms

accounted for an additional 7% of the variance in predicting PTSD severity, consistent with research noting that dissociation predicts chronic PTSD and maintains PTSD severity in cross-sectional and prospective longitudinal studies (Halligan et al., 2003). Furthermore, emotion dysregulation accounted for 4% of the variance in PTSD severity, corroborating the literature that emotion dysregulation is significantly impacted in PTSD. These findings stress the independent roles of both emotion dysregulation and dissociation in worsening illness in PTSD, illustrating the complex interplay between dissociation and emotion in PTSD. Machine learning models in Chapter 4 also accurately predicted functional impairment, where symptoms of anxiety, dissociation, and depression were among the most important features contributing to daily impairment (8%, 3%, and 2% respectively), consistent with previous research (Knowles et al., 2019; Siegel et al., 2021). For instance, greater emotion dysregulation in patients with dissociative disorder has been linked to dissociation severity and self-injurious behaviours (Nester et al., 2022). Among patients with PTSD, Boyd et al. (2020) also noted that, in addition to emotion dysregulation, symptoms of dissociation and physiological arousal/reactivity trended toward significantly contributing to functional impairment.

Notably, Chapter 4 built upon previous work by introducing a novel analytical approach to accurately estimating the relative importance of specific symptoms in PTSD illness. For example, machine learning models revealed that symptoms of anxiety were more influential than negative trauma-related cognitions when forecasting PTSD severity, accounting for 13% and 6% of the variance respectively. Although both were important predictors, suggesting that targeting the reduction of both may be helpful in treatment, the relative importance reveals which symptoms may be prioritized in treatment to optimize recovery. Thus, targeting the symptom reduction of physiological reactivity first may be more impactful in reducing PTSD symptoms,

as compared to targeting the reduction of negative cognitions such as “people can’t be trusted”. Nonetheless, longitudinal research to examine the predictive value of clinical features for the efficacy of interventions targeting dissociation and emotion dysregulation will be key next steps.

In summary, findings from my dissertation studies suggest that nearly a quarter of frontline personnel in Canada seeking treatment for PTSD exhibit elevated levels of dissociation symptoms, which are associated with increased illness severity. Symptoms of persistent trauma-related dissociation may aggravate problems with emotion regulation, cognitive dysfunction, and hinder daily functioning, which highlights the importance of assessing for dissociation symptoms in clinical settings. This work also uncovered complex associations between dissociation, emotion dysregulation, and cognition in PTSD, pointing to the need for a deeper exploration of their relationships. Targeting the improvement of persistent dissociation symptoms may be beneficial for trauma recovery, particularly among those experiencing high clinical severity. Clinical implications of these findings are explored below.

Study Limitations

One limitation in my dissertation studies was the reliance on self-reported measures of PTSD and dissociation instead of clinician-administered interviews, potentially limiting the generalizability of my findings among populations meeting full diagnostic criteria for PTSD. Throughout my work, I used the PTSD Checklist for Diagnostic and Statistical Manual of Mental Disorders (DSM) 5th edition (PCL-5), rather than the gold standard Clinician-Administered PTSD Scale for DSM-5 (CAPS-5; Weathers et al., 2018). Although the PCL-5 is a valid and reliable self-reported of PTSD symptom severity (Bovin et al., 2015; Wortmann et al., 2016), it provides a presumptive diagnosis of PTSD using optimal cut-off scores (Forkus et al., 2023) and is not interchangeable with the CAPS-5 (Kramer et al., 2023). Nonetheless, research

demonstrates close agreement with the PCL-5 and clinician ratings of the CAPS-5 (Lee et al., 2022; Monson et al., 2008), supporting its utility across a spectrum of PTSD severities (Bergman et al., 2017; Kim et al., 2020; Son et al., 2023).

Other trauma-relevant variables such as problematic alcohol use, problematic substance use, and details of trauma histories (e.g., childhood adversity) were not investigated in my dissertation. Childhood adversity is associated with severe PTSD and dissociative symptoms (De Bellis & Zisk, 2014; Herzog et al., 2018; Powers et al., 2015), and patterns of problematic alcohol/substance use are associated with PTSD severity, depression, emotion dysregulation, and childhood adversity (Brady & Back, 2012; Brady et al., 2019; Greene et al., 2016). Despite their absence, my studies included the examination of symptoms of emotion dysregulation and dissociation, which have been found to mediate the relations between these factors (Dvir et al., 2014; Messman-Moore & Bhuptani, 2017; Stellern et al., 2021; Weiss et al., 2017). For example, emotion dysregulation mediated the relation between emotional abuse and substance use (Mandavia et al., 2016), as well as between PTSD symptom severity and problematic substance use (Weiss et al., 2019). Poorer emotion regulation skills predict problematic alcohol use (Dvorak et al., 2014) even when accounting for age, gender, and alcohol consumption quantity/frequency (Kassel et al., 2000). Dissociation symptoms, but not PTSD or depression, also mediated the relation between childhood maltreatment and non-suicidal self-injury in a sample of female inpatients in a specialized trauma clinic (Boyd et al., 2018; Franzke et al., 2005), indicating that dissociation poses a unique risk to increased impairment (Franzke et al., 2005). Given that the current research emphasized a prominent role of depersonalization and derealization symptoms in PTSD, it may be interesting to broaden the study of dissociative experiences in PTSD to include symptoms that are observed transdiagnostically (e.g., amnesia,

identity dissociation, disengagement, etc.). Exploring additional dissociative experiences among individuals with PTSD may help further refine the dissociative subtype. Overall, it may be fruitful for future research to directly examine how particular trauma histories, substance use, and external support resources impact upon dissociative experiences in PTSD.

Demographic and sample characteristics, such as diverse and intersectional sex, gender, ethnic, racial, and cultural identities were not sufficiently explored in my studies. Ethnic and racial minorities reported increased PTSD symptom severity (Hall-Clark et al., 2016) and greater dissociative symptoms (Kirkinis et al., 2021; Polcano-Roman et al., 2016), and dissociation symptoms at 2-week post-trauma mediated the effect of racial discrimination on PTSD symptom severity at 6 months post-trauma (Harb et al., 2023). Importantly, traumatic events and related illnesses disproportionately affect historically marginalized populations, but they are highly underrepresented in treatment studies (McClendon et al., 2020). Thoughtful design of demographic questionnaires that are inclusive of diverse identities will be crucial to better understanding how PTSD presents across all populations.

Lastly, my studies were cross-sectional and conducted at baseline or pre-intervention, limiting our understanding of how symptoms impact future treatment outcomes. Results from machine learning analyses from Chapter 5 are promising, but the generalizability of my findings is limited without data across multiple time-points. Interestingly, results from a follow-up study to Chapter 4 suggest that changes in clinical symptoms across time may accurately predict improvement in PTSD symptoms and functional improvement in a clinical sample of adults completing inpatient treatment for PTSD (Park et al., in prep). Expanding our understanding of PTSD recovery and symptom trajectories will require longitudinal studies and intervention studies with follow-up assessments.

Clinical Implications

The specific treatment of dissociation symptoms may benefit individuals experiencing severe trauma-related illness. Highly dissociative individuals may have difficulties tolerating existing psychotherapies for PTSD, who report impaired self-awareness, emotion regulation, and a fragmented sense of self (Alpert et al., 2020; Brière & Runtz, 2002; van der Kolk et al., 2016). Dissociation appears to interfere with emotional learning, a critical component required for trauma memory processing in existing trauma-focused psychotherapies such as cognitive processing therapy (Ebner-Priemer et al. 2009). One intervention that may help reduce dissociation symptoms in PTSD is dialectical behavior therapy (DBT), which contains modules to improve distress tolerance, mindfulness, interpersonal effectiveness, and emotion regulation skills. DBT was originally designed for individuals experiencing borderline personality disorder, which is characterized by increased emotion dysregulation and dissociation (APA, 2013; Lynch et al., 2007), but recent treatment adaptations for PTSD are promising (Bohus et al., 2013, 2020). For example, women with childhood abuse-related PTSD completing DBT for PTSD experienced significant improvement in dissociation symptoms, PTSD severity, self-harming, and suicidal behaviors as compared to women completing cognitive processing therapy, a leading evidence-based treatment for PTSD (Bohus et al., 2013, 2020; Steil et al., 2013). Women who completed DBT for PTSD also reported greater rates of remission and lower drop-out rates, suggesting that DBT may be tolerable and effective for individuals with severe PTSD and dissociation symptoms.

Additionally, the integration of skills that improve emotion regulation may be critical to PTSD recovery. A prospective study by Bardeen et al. (2013) found that students' emotion regulation skills prior to a mass school shooting predicted their ability to recover from the

traumatic event, as measured by post-traumatic stress symptoms in the acute aftermath and at 8 months post-event. This suggests that emotion regulation skills can be protective against the effects of trauma (Bardeen et al., 2013), including cumulative trauma (Levy-Gigi et al., 2015). Relatedly, baseline emotion dysregulation symptoms were associated with drop-out from trauma-focused psychotherapy (prolonged exposure) in a sample of women veterans with military sexual trauma (Gilmore et al., 2020), emphasizing that reducing emotion dysregulation may improve tolerability and completion of PTSD treatment, including among those with chronic PTSD (Ehlers et al., 2014). Currently, protocols for transdiagnostic emotion regulation training exist, which contain skills that help to better identify, accept, tolerate, and manage emotions, and can go far to ameliorate PTSD severity (Sakiris & Berle, 2019). A systematic review and meta-analysis supported the benefits of transdiagnostic emotion regulation training for a range of disorders, including PTSD, which further reduced symptoms of anxiety and depression with moderate to large effect sizes, and these improvements were maintained up to 6 months follow-up (Sakiris & Berle, 2019). Thus, improving dissociation and emotion regulation skills are promising candidates for the treatment of severe PTSD and its associated impairments.

For PTSD treatment more broadly, the integration of multiple evidence-based interventions targeting emotional and physiological regulation may be helpful for PTSD recovery. For example, bottom-up processing therapies take a sensory-based approach to target regulation of physiological and emotional reactivity, improve body awareness, sensory processing, and embodiment (McGreevy & Boland, 2020). These bottom-up approaches can complement existing top-down processing therapies (e.g., cognitive therapies that process trauma memories and beliefs such as “people can’t be trusted”) by increasing the tolerability of difficult

emotions and facilitating trauma memory processing (Frewen & Lanius, 2015; Kaiser et al., 2010; McGreevy & Boland, 2020; Warner et al., 2014, 2020).

Overall, my dissertation studies underscore the importance of integrating dissociative symptoms into our understanding and treatment of PTSD. Currently, dissociation is insufficiently recognized and treated in clinical settings, which can contribute to significant health problems and costs (Atchley & Bedford, 2021; Boyer et al., 2022; Brand, 2016). Early detection of dissociation in PTSD can help guide early interventions, particularly for patients with high clinical severity. The emergence of dissociative symptoms and emotion dysregulation as major predictors of trauma-related illness highlight the potential benefits of stabilizing of physiological and emotional reactivity in individuals with severe PTSD. Enhanced recognition of trauma-related dissociative symptoms and the integration of evidence-based therapies tailored to treat these symptoms are essential to address the complex needs of individuals experiencing PTSD.

References

Alexis, V., Géraldine, T., David, C., Camille, R., & Wissam, E. H. (2023). Association between cognitive impairments and dissociation: a PRISMA systematic review. *European Journal of Trauma & Dissociation*, *7*(3), 100341. http://dx.doi.org/10.1016/j.ejtd.2023.100341

Alpert, E., Hayes, A. M., & Foa, E. B. (2023). Examining emotional processing theory and predictors of outcome in prolonged exposure for PTSD. *Behaviour Research and Therapy*, *167*, 104341. http://dx.doi.org/10.1016/j.brat.2023.104341

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders. (5th ed.). https://doi.org/10.1176/appi.books.9780890425596

Armour, C., Karstoft, K. I., & Richardson, J. D. (2014). The co-occurrence of PTSD and dissociation: Differentiating severe PTSD from dissociative-PTSD. *Social Psychiatry and Psychiatric Epidemiology*, *49*(8), 1297–1306. https://doi.org/10.1007/s00127-014-0819-y

Atchley, R., & Bedford, C. (2021). Dissociative symptoms in posttraumatic stress disorder: A systematic review. *Journal of Trauma & Dissociation*, *22*(1), 69-88. http://dx.doi.org/10.1080/15299732.2020.1760410

Aupperle, R. L., Ravindran, L., Tankersley, D., Flagan, T., Stein, N. R., Simmons, A. N., Stein, M. B., & Paulus, M. P. (2011). Pregabalin influences insula and amygdala activation during anticipation of emotional images. *Neuropsychopharmacology, 36*(7). https://doi.org/10.1038/npp.2011.32

Bae, H., Kim, D., & Park, Y. C. (2016). Dissociation predicts treatment response in eye-movement desensitization and reprocessing for posttraumatic stress disorder. *Journal of Trauma & Dissociation*, *17*(1), 112-130. http://dx.doi.org/10.1080/15299732.2015.1037039

Banich, M. T., Mackiewicz, K. L., Depue, B. E., Whitmer, A. J., Miller, G. A., & Heller, W. (2009). Cognitive control mechanisms, emotion and memory: a neural perspective with implications for psychopathology. *Neuroscience & Biobehavioral Reviews*, *33*(5), 613-630. http://dx.doi.org/10.1016/j.neubiorev.2008.09.010

Bardeen, J. R., Kumpula, M. J., & Orcutt, H. K. (2013). Emotion regulation difficulties as a prospective predictor of posttraumatic stress symptoms following a mass shooting. *Journal of Anxiety Disorders*, *27*(2), 188-196. http://dx.doi.org/10.1016/j.janxdis.2013.01.003

Bergman, H. E., Przeworski, A., & Feeny, N. C. (2017). Rates of subthreshold PTSD among US military veterans and service members: A literature review. *Military Psychology*, *29*(2), 117-127.

Bohus, M., Dyer, A. S., Priebe, K., Krüger, A., Kleindienst, N., Schmahl, C., ... & Steil, R. (2013). Dialectical behaviour therapy for post-traumatic stress disorder after childhood sexual abuse in patients with and without borderline personality disorder: A randomised controlled trial. *Psychotherapy and psychosomatics*, *82*(4), 221-233. http://dx.doi.org/10.1159/000348451

Bohus, M., Kleindienst, N., Hahn, C., Müller-Engelmann, M., Ludäscher, P., Steil, R., ... & Priebe, K. (2020). Dialectical Behavior Therapy for Posttraumatic Stress Disorder (DBT-PTSD) Compared With Cognitive Processing Therapy (CPT) in Complex Presentations of PTSD in Women Survivors of Childhood Abuse: A Randomized Clinical Trial. *JAMA Psychiatry*, *77*(12), 1235-1245. http://dx.doi.org/10.1001/jamapsychiatry.2020.2148

Bovin, M. J., Marx, B. P., Weathers, F. W., Gallagher, M. W., Rodriguez, P., Schnurr, P. P., & Keane, T. M. (2016). Psychometric properties of the PTSD checklist for diagnostic and

statistical manual of mental disorders–fifth edition (PCL-5) in veterans. *Psychological Assessment, 28*(11), 1379–1391. doi:10.1037/pas0000254

Boyd, J. E., O'Connor, C., Protopopescu, A., Jetly, R., Lanius, R. A., & McKinnon, M. C. (2020). The contributions of emotion regulation difficulties and dissociative symptoms to functional impairment among civilian inpatients with posttraumatic stress symptoms. *Psychological Trauma: Theory, Research, Practice, and Policy*, *12*(7), 739. http://dx.doi.org/10.1037/tra0000576

Boyd, J. E., Protopopescu, A., O'Connor, C., Neufeld, R. W., Jetly, R., Hood, H. K., ... & McKinnon, M. C. (2018). Dissociative symptoms mediate the relation between PTSD symptoms and functional impairment in a sample of military members, veterans, and first responders with PTSD. *European Journal of Psychotraumatology*, *9*(1), 1463794. http://dx.doi.org/10.1080/20008198.2018.1463794

Boyer, S. M., Caplan, J. E., & Edwards, L. K. (2022). Trauma-Related Dissociation and the Dissociative Disorders: Neglected Symptoms with Severe Public Health Consequences. *Delaware Journal of Public Health*, *8*(2), 78.

Brady, K. T., & Back, S. E. (2012). Childhood trauma, posttraumatic stress disorder, and alcohol dependence. *Alcohol Research: Current Reviews*, *34*(4), 408.

Brady, L. L., Credé, M., Harms, P. D., Bachrach, D. G., & Lester, P. B. (2019). Meta-analysis of risk factors for substance abuse in the US military. *Military Psychology*, *31*(6), 450-461. http://dx.doi.org/10.1080/08995605.2019.1657754

Brand, B. L. (2016). The necessity of clinical training in trauma and dissociation. *Journal of Anxiety and Depression*, *5*(4), 2167-1044. http://dx.doi.org/10.4172/2167-1044.1000251

Briere, J., & Runtz, M. (2015). Dissociation in individuals denying trauma exposure: Findings from two samples. *The Journal of Nervous and Mental Disease, 203*(6), 439-442. http://dx.doi.org/10.1097/NMD.0000000000000303

Bryant, R. A., Moulds, M. L., Mastrodomenico, J., Hopwood, S., Felmingham, K., & Nixon, R. D. (2007). Who drops out of treatment for post-traumatic stress disorder?. *Clinical Psychologist*, *11*(1), 13-15. http://dx.doi.org/10.1080/13284200601178128

Carleton, R. N., Afifi, T. O., Turner, S., Taillieu, T., Duranceau, S., LeBouthillier, D. M., … Asmundson, G. J. G. (2018). Mental Disorder Symptoms among Public Safety Personnel in Canada. *Canadian Journal of Psychiatry*, *63*(1), 54–64. https://doi.org/10.1177/0706743717723825

Cavicchioli, M., Ogliari, A., Maffei, C., Mucci, C., Northoff, G., & Scalabrini, A. (2023). Neural responses to emotional stimuli across the dissociative spectrum: Common and specific mechanisms. *Psychiatry and Clinical Neurosciences, 77*(6), 315-329. http://dx.doi.org/10.1111/pcn.13547

De Bellis, M. D., & Zisk, A. (2014). The biological effects of childhood trauma. *Child and Adolescent Psychiatric Clinics*, *23*(2), 185-222. http://dx.doi.org/10.1016/j.chc.2014.01.002

Donnelly, K., Donnelly, J. P., Warner, G. C., Kittleson, C. J., & King, P. R. (2018). Longitudinal study of objective and subjective cognitive performance and psychological distress in OEF/OIF veterans with and without traumatic brain injury. *The Clinical Neuropsychologist*, *32*(3), 436-455. http://dx.doi.org/10.1080/13854046.2017.1390163

Dossi, G., Delvecchio, G., Prunas, C., Soares, J. C., & Brambilla, P. (2020). Neural bases of cognitive impairments in post-traumatic stress disorders: a mini-review of functional

magnetic resonance imaging findings. *Frontiers in psychiatry*, *11*, 176. http://dx.doi.org/10.3389/fpsyt.2020.00176

Dvir, Y., Ford, J. D., Hill, M., & Frazier, J. A. (2014). Childhood maltreatment, emotional dysregulation, and psychiatric comorbidities. *Harvard Review of Psychiatry*, *22*(3), 149. http://dx.doi.org/10.1097/HRP.0000000000000014

Dvorak, R. D., Sargent, E. M., Kilwein, T. M., Stevenson, B. L., Kuvaas, N. J., & Williams, T. J. (2014). Alcohol use and alcohol-related consequences: Associations with emotion regulation difficulties. *The American Journal of Drug and Alcohol Abuse*, *40*(2), 125-130. http://dx.doi.org/10.3109/00952990.2013.877920

Ebner-Priemer, U. W., Mauchnik, J., Kleindienst, N., Schmahl, C., Peper, M., Rosenthal, M. Z., ... & Bohus, M. (2009). Emotional learning during dissociative states in borderline personality disorder. *Journal of Psychiatry and Neuroscience*, *34*(3), 214-222.

Ehlers, A., Hackmann, A., Grey, N., Wild, J., Liness, S., Albert, I., ... & Clark, D. M. (2014). A randomized controlled trial of 7-day intensive and standard weekly cognitive therapy for PTSD and emotion-focused supportive therapy. *American Journal of Psychiatry*, *171*(3), 294-304. http://dx.doi.org/10.1176/appi.ajp.2013.13040552

Foa, E. B., Ehlers, A., Clark, D. M., Tolin, D. F., & Orsillo, S. M. (1999). The posttraumatic cognitions inventory (PTCI): Development and validation. *Psychological Assessment*, *11*(3), 303. http://dx.doi.org/10.1037/1040-3590.11.3.303

Foa, E. B., Steketee, G., & Rothbaum, B. O. (1989). Behavioral/cognitive conceptualizations of post-traumatic stress disorder. *Behavior Therapy*, *20*(2), 155-176. http://dx.doi.org/10.1016/S0005-7894(89)80067-X

Forkus, S. R., Raudales, A. M., Rafiuddin, H. S., Weiss, N. H., Messman, B. A., & Contractor, A. A. (2023). The Posttraumatic Stress Disorder (PTSD) Checklist for DSM–5: A systematic review of existing psychometric evidence. *Clinical Psychology: Science and Practice*, *30*(1), 110. http://dx.doi.org/10.1037/cps0000111

Franzke, I., Wabnitz, P., & Catani, C. (2015). Dissociation as a mediator of the relationship between childhood trauma and nonsuicidal self-injury in females: A path analytic approach. *Journal of Trauma & Dissociation*, *16*(3), 286-302. http://dx.doi.org/10.1080/15299732.2015.989646

French, L. M., Lange, R. T., & Brickell, T. A. (2014). Subjective cognitive complaints and neuropsychological test performance following military-related traumatic brain injury. *Journal of Rehabilitation Research & Development*, *51*(6). http://dx.doi.org/10.1682/JRRD.2013.10.0226

Frewen, P., & Lanius, R. (2015). *The Norton series on interpersonal neurobiology. Healing the traumatized self: Consciousness, neuroscience, treatment.* W. W. Norton & Company.

Gilmore, A. K., Lopez, C., Muzzy, W., Brown, W. J., Grubaugh, A., Oesterle, D. W., & Acierno, R. (2020). Emotion dysregulation predicts dropout from prolonged exposure treatment among women veterans with military sexual trauma-related posttraumatic stress disorder. *Women's Health Issues*, *30*(6), 462-469.

Greene, T., Neria, Y., & Gross, R. (2016). Prevalence, detection and correlates of PTSD in the primary care setting: A systematic review. *Journal of Clinical Psychology in Medical Settings*, *23*(2), 160-180. http://dx.doi.org/10.1007/s10880-016-9449-8

Hall-Clark, B., Sawyer, B., Golik, A., & Asnaani, A. (2016). Racial/ethnic differences in symptoms of posttraumatic stress disorder. *Current Psychiatry Reviews*, *12*(2), 124-138. http://dx.doi.org/10.2174/1573400512666160505150257

Halligan, S. L., Michael, T., Clark, D. M., & Ehlers, A. (2003). Posttraumatic stress disorder following assault: The role of cognitive processing, trauma memory, and appraisals. *Journal of Consulting and Clinical Psychology, 71*(3). https://doi.org/10.1037/0022-006X.71.3.419

Harb, F., Bird, C. M., Webb, E. K., Torres, L., deRoon-Cassini, T. A., & Larson, C. L. (2023). Experiencing racial discrimination increases vulnerability to PTSD after trauma via peritraumatic dissociation. *European Journal of Psychotraumatology, 14*(2), 2211486. http://dx.doi.org/10.1080/20008066.2023.2211486

Herzog, S., DePierro, J., & D'Andrea, W. (2018). Driven to distraction: Childhood trauma and dissociation, but not PTSD symptoms, are related to threat avoidance. *European Journal of Trauma & Dissociation*, *2*(4), 179–187. https://doi.org/10.1016/j.ejtd.2018.03.001

Kaiser, E. M., Gillette, C. S., & Spinazzola, J. (2010). A controlled pilot-outcome study of sensory integration (SI) in the treatment of complex adaptation to traumatic stress. *Journal of Aggression, Maltreatment and Trauma, 19*(7). https://doi.org/10.1080/10926771.2010.515162

Kassel, J. D., Jackson, S. I., & Unrod, M. (2000). Generalized expectancies for negative mood regulation and problem drinking among college students. *Journal of Studies on Alcohol*, *61*(2), 332-340. http://dx.doi.org/10.15288/jsa.2000.61.332

Kim, J. I., Oh, S., Park, H., Min, B., & Kim, J. H. (2020). The prevalence and clinical impairment of subthreshold PTSD using DSM-5 criteria in a national sample of Korean firefighters. *Depression and Anxiety*, *37*(4), 375-385. http://dx.doi.org/10.1002/da.22998

Kirkinis, K., Pieterse, A. L., Martin, C., Agiliga, A., & Brownell, A. (2021). Racism, racial discrimination, and trauma: A systematic review of the social science literature. *Ethnicity & Health*, *26*(3), 392-412. http://dx.doi.org/10.1080/13557858.2018.1514453

Knowles, K. A., Sripada, R. K., Defever, M., & Rauch, S. A. (2019). Comorbid mood and anxiety disorders and severity of posttraumatic stress disorder symptoms in treatment-seeking veterans. *Psychological Trauma: Theory, Research, Practice, and Policy*, *11*(4), 451. http://dx.doi.org/10.1037/tra0000383

Kramer, L. B., Whiteman, S. E., Petri, J. M., Spitzer, E. G., & Weathers, F. W. (2023). Self-rated versus clinician-rated assessment of posttraumatic stress disorder: an evaluation of discrepancies between the PTSD checklist for DSM-5 and the clinician-administered PTSD scale for DSM-5. *Assessment*, *30*(5), 1590-1605. http://dx.doi.org/10.1177/10731911221113571

Lee, D. J., Weathers, F. W., Thompson-Hollands, J., Sloan, D. M., & Marx, B. P. (2022). Concordance in PTSD symptom change between DSM-5 versions of the Clinician-Administered PTSD Scale (CAPS-5) and PTSD Checklist (PCL-5). *Psychological Assessment*, *34*(6), 604. http://dx.doi.org/10.1037/pas0001130

Levy-Gigi, E., Bonanno, G. A., Shapiro, A. R., Richter-Levin, G., Kéri, S., & Sheppes, G. (2016). Emotion regulatory flexibility sheds light on the elusive relationship between repeated traumatic exposure and posttraumatic stress disorder symptoms. *Clinical Psychological Science*, *4*(1), 28-39. http://dx.doi.org/10.1177/2167702615577783

Lynch, T. R., Trost, W. T., Salsman, N., & Linehan, M. M. (2007). Dialectical behavior therapy for borderline personality disorder. *Annual Review of Clinical Psychology, 3,* 181-205. https://doi.org/10.1146/annurev.clinpsy.2.022305.095229

Mandavia, A., Robinson, G. G., Bradley, B., Ressler, K. J., & Powers, A. (2016). Exposure to childhood abuse and later substance use: Indirect effects of emotion dysregulation and exposure to trauma. *Journal of Traumatic Stress*, *29*(5), 422-429. http://dx.doi.org/10.1002/jts.22131

McGreevy, S., & Boland, P. (2020). Sensory-based interventions with adult and adolescent trauma survivors: An integrative review of the occupational therapy literature. *Irish Journal of Occupational Therapy, 48*(1), 31-54. http://dx.doi.org/10.1108/IJOT-10-2019-0014

Messman-Moore, T. L., & Bhuptani, P. H. (2017). A Review of the Long-Term Impact of Child Maltreatment on Posttraumatic Stress Disorder and Its Comorbidities: An Emotion Dysregulation Perspective. *Clinical Psychology: Science and Practice, 24*(2). https://doi.org/10.1111/cpsp.12193

McClendon, J., Dean, K. E., & Galovski, T. (2020). Addressing diversity in PTSD treatment: Disparities in treatment engagement and outcome among patients of color. *Current Treatment Options in Psychiatry, 7*, 275-290. http://dx.doi.org/10.1007/s40501-020-00212-0

McKinnon, M. C., Boyd, J. E., Frewen, P. A., Lanius, U. F., Jetly, R., Richardson, J. D., & Lanius, R. A. (2016). A review of the relation between dissociation, memory, executive functioning and social cognition in military members and civilians with neuropsychiatric conditions. *Neuropsychologia*, *90*, 210–234.

https://doi.org/10.1016/j.neuropsychologia.2016.07.017

Monson, C. M., Gradus, J. L., Young-Xu, Y., Schnurr, P. P., Price, J. L., & Schumm, J. A. (2008). Change in posttraumatic stress disorder symptoms: do clinicians and patients agree?. *Psychological Assessment, 20*(2), 131. http://dx.doi.org/10.1037/1040-3590.20.2.131

Nazarov, A., Frewen, P., Oremus, C., Schellenberg, E. G., McKinnon, M. C., & Lanius, R. (2015). Comprehension of affective prosody in women with post-traumatic stress disorder related to childhood abuse. Acta Psychiatrica Scandinavica, 131(5), 342-349. http://dx.doi.org/10.1111/acps.12364

Nazarov, A., Frewen, P., Parlar, M., Oremus, C., MacQueen, G., McKinnon, M., & Lanius, R. (2014). Theory of mind performance in women with posttraumatic stress disorder related to childhood abuse. *Acta Psychiatrica Scandinavica, 129*(3), 193–201. https://doi-org.libaccess.lib.mcmaster.ca/10.1111/acps.12142

Nester, M. S., Hawkins, S. L., & Brand, B. L. (2022). Barriers to accessing and continuing mental health treatment among individuals with dissociative symptoms. *European Journal of Psychotraumatology*, *13*(1). http://dx.doi.org/10.1080/20008198.2022.2031594

Park, A. H., Patel, H., Mirabelli, J., Eder, S. J., Steyrl, D., Lueger-Schuster, B., ... & Nicholson, A. A. (2023). Machine learning models predict PTSD severity and functional impairment: A personalized medicine approach for uncovering complex associations among heterogeneous symptom profiles. *Psychological Trauma: Theory, Research, Practice, and Policy*. 19429681. http://dx.doi.org/10.1037/tra0001602

Park, A. H., Protopopescu, A., Pogue, M. E., Boyd, J. E., O'Connor, C., Lanius, R. A., & McKinnon, M. C. (2021). Dissociative symptoms predict severe illness presentation in Canadian public safety personnel with presumptive post-traumatic stress disorder (PTSD). *European Journal of Psychotraumatology*, *12*(1), 1953789. http://dx.doi.org/10.1080/20008198.2021.1953789

Polanco-Roman, L., Danies, A., & Anglin, D. M. (2016). Racial discrimination as race-based trauma, coping strategies, and dissociative symptoms among emerging adults. *Psychological Trauma: Theory, Research, Practice, and Policy*, *8*(5), 609.

Powers, A., Cross, D., Fani, N., & Bradley, B. (2015). PTSD, emotion dysregulation, and dissociative symptoms in a highly traumatized sample. *Journal of Psychiatric Research, 61*. https://doi.org/10.1016/j.jpsychires.2014.12.011

Rodriguez, P., Holowka, D. W., & Marx, B. P. (2012). Assessment of posttraumatic stress disorder-related functional impairment: a review. *Journal of Rehabilitation Research & Development, 49*(5). http://dx.doi.org/10.1682/JRRD.2011.09.0162

Sakiris, N., & Berle, D. (2019). A systematic review and meta-analysis of the Unified Protocol as a transdiagnostic emotion regulation based intervention. *Clinical Psychology Review*, *72*, 101751. http://dx.doi.org/10.1016/j.cpr.2019.101751

Samuelson, K. W., Abadjian, L., Jordan, J. T., Bartel, A., Vasterling, J., & Seal, K. (2017). The association between PTSD and functional outcome is mediated by perception of cognitive problems rather than objective neuropsychological test performance. *Journal of Traumatic Stress*, *30*(5), 521-530. http://dx.doi.org/10.1002/jts.22223

Sareen, J., Cox, B. J., Stein, M. B., Afifi, T. O., Fleet, C., & Asmundson, G. J. (2007). Physical and mental comorbidity, disability, and suicidal behavior associated with posttraumatic stress disorder in a large community sample. *Psychosomatic Medicine*, *69*(3), 242-248.

Scoglio, A. A., Reilly, E. D., Girouard, C., Quigley, K. S., Carnes, S., & Kelly, M. M. (2022). Social functioning in individuals with post-traumatic stress disorder: A systematic review. *Trauma, Violence, & Abuse*, *23*(2), 356-371. http://dx.doi.org/10.1177/1524838020946800

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. http://dx.doi.org/10.1037/a0038039

Siegel, C. E., Laska, E. M., Lin, Z., Xu, M., Abu-Amara, D., Jeffers, M. K., Qian, M., Milton, N., Flory, J. D., Hammamieh, R., Daigle, B. J., Gautam, A., Dean, K. R., Reus, V. I., Wolkowitz, O. M., Mellon, S. H., Ressler, K. J., Yehuda, R., Wang, K., Hood, L., Doyle, F. J., Jett, M., Marmar, C. R. (2021). Utilization of machine learning for identifying symptom severity military-related PTSD subtypes and their biological correlates. *Translational Psychiatry, 11*(1), 227. https://dx.doi.org/10.1038/s41398-021-01324-8

Son, J. J., Schantell, M., Picci, G., Wang, Y. P., Stephen, J. M., Calhoun, V. D., ... & Wilson, T. W. (2023). Altered longitudinal trajectory of default mode network connectivity in healthy youth with subclinical depressive and posttraumatic stress symptoms. *Developmental Cognitive Neuroscience*, *60*, 101216. http://dx.doi.org/10.1016/j.dcn.2023.101216

Steil, R., Dittmann, C., Müller-Engelmann, M., Dyer, A., Maasch, A. M., & Priebe, K. (2018). Dialectical behaviour therapy for posttraumatic stress disorder related to childhood sexual abuse: A pilot study in an outpatient treatment setting. *European Journal of Psychotraumatology*, *9*(1), 1423832. http://dx.doi.org/10.1080/20008198.2018.1423832

Stellern, J., Xiao, K. B., Grennell, E., Sanches, M., Gowin, J. L., & Sloan, M. E. (2023). Emotion regulation in substance use disorders: A systematic review and meta-analysis. *Addiction*, *118*(1), 30-47. http://dx.doi.org/10.1111/add.16001

Stulemeijer, M., Van Der Werf, S., Borm, G. F., & Vos, P. E. (2008). Early prediction of favourable recovery 6 months after mild traumatic brain injury. *Journal of Neurology, Neurosurgery and Psychiatry, 79*(8). https://doi.org/10.1136/jnnp.2007.131250

van der Kolk, B. A., Hodgdon, H., Gapen, M., Musicaro, R., Suvak, M. K., Hamlin, E., & Spinazzola, J. (2016). A randomized controlled study of neurofeedback for chronic PTSD. *PloS one, 11*(12), e0166752. http://dx.doi.org/10.1371/journal.pone.0166752

Warner, E., Finn, H., Wescott, A., & Cook, A. (2020). *Transforming trauma in children and adolescents: An embodied approach to somatic regulation, trauma processing, and attachment-building*. North Atlantic Books.

Warner, E., Spinazzola, J., Westcott, A., Gunn, C., & Hodgdon, H. (2014). The Body Can Change the Score: Empirical Support for Somatic Regulation in the Treatment of Traumatized Adolescents. *Journal of Child and Adolescent Trauma, 7*(4). https://doi.org/10.1007/s40653-014-0030-z

Weathers, F. W., Litz, B. T., Keane, T. M., Palmieri, P. A., Marx, B. P., & Schnurr, P. P. (2013). *The PTSD checklist for DSM-5 (PCL-5).* Scale Available from the National Center for PTSD at https://www.ptsd.va.gov/

Weiss, N. H., Kiefer, R., Goncharenko, S., Raudales, A. M., Forkus, S. R., Schick, M. R., & Contractor, A. A. (2022). Emotion regulation and substance use: a meta-analysis. *Drug and Alcohol Dependence*, *230*, 109131. http://dx.doi.org/10.1016/j.drugalcdep.2021.109131

Wolf, E. J., Lunney, C. A., Miller, M. W., Resick, P. A., Friedman, M. J., & Schnurr, P. P. (2012a). The dissociative subtype of PTSD: A replication and extension. *Depression and Anxiety*, *29*(8), 679–688. doi:10.1002/ da.21946

Wolf, E. J., Miller, M., Reardon, A., Ryabchenko, K. A., Castillo, D., & Freund, R. (2012b). A latent class analysis of dissociation and posttraumatic stress disorder. *Archives of General Psychiatry*, *69* (7), 698–705. doi:10.1001/archgenpsychiatry.2011.1574

Wortmann, J. H., Jordan, A. H., Weathers, F. W., Resick, P. A., Dondanville, K. A., Hall-Clark, B., . . . Mintz, J. (2016). Psychometric analysis of the PTSD Checklist-5 (PCL-5) among treatment-seeking military service members. *Psychological Assessment*, *28*(11), 1392. doi:10.1037/pas0000260

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. http://dx.doi.org/10.1017/S1355617716000059