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Analysis of Discourse Production to Assess Cognitive Communication Deficits Following Mild Traumatic Brain Injury With and Without Posttraumatic Stress

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ABSTRACT

Purpose: Cognitive communication deficits can be difficult to assess in individuals with mild traumatic brain injury (mTBI). However, the use of discourse analysis as a direct and sensitive metric of cognitive communication skills has shown promising clinical utility for other TBI severity levels. This exploratory study investigated discourse production in service members and veterans (SMVs) with uncomplicated mTBI with and without posttraumatic stress disorder (PTSD) and SMVs with neither mTBI or PTSD.

Method: Fifteen SMVs with mTBI and PTSD, 26 with mTBI, and 25 controls with no brain injury (NBI) and without PTSD were given a wordless picture story to elicit spontaneous discourse. Discourse samples were analyzed for global coherence, word count, the use of negative emotion words, cognitive process words, nonfluencies, and story completeness.

Results: Results revealed a significant difference between the mTBI (*Mdn* = 3.33) and NBI (*Mdn* = 3.50) groups, $\chi^2(3) = 6.044$, $p = .017$, $\varepsilon^2 = .03$, for global coherence. Word count differed significantly between the mTBI + PTSD (*Mdn* = 135) and NBI (*Mdn* = 195) groups, $\chi^2(3) = 7.968$, $p = .006$, $\varepsilon^2 = .06$. No other group differences were observed.

Discussion: Structural features of discourse production may serve as potential markers of cognitive communication deficits in mTBI. Furthermore, PTSD may contribute to verbal fluency deficits in individuals with mTBI. Additional research is needed to develop discourse-related measures that are more sensitive to the effects of mTBI and PTSD.

One of the primary long-term deficits following traumatic brain injury (TBI) is difficulty with language use or pragmatics, considered to be a key component of social cognition (MacDonald, 2017; Neumann et al., 2019). Referred to as cognitive communication impairments, these difficulties stem from the disruption of cognitive processes such as attention, memory, executive function, and processing speed, all common sequelae of TBI (Togher et al., 2014). Cognitive communication deficits can be difficult to evaluate. Standardized aphasia batteries, which evaluate vocabulary and grammatical abilities at the single-word and sentence levels, are not sensitive to the subtle nature of these impairments (Coelho et al., 2005). Other TBI-specific assessments examine dimensions of

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cognition but not communication directly (e.g., Adamovich & Henderson, 1992; MacDonald & Johnson, 2005). Therefore, researchers have shifted their focus to longer units of language, specifically discourse (Duff et al., 2012). Discourse is defined as a series of related linguistic units that convey a message, with its length determined by the purpose of the communication (Cherney et al., 1998). It has been described as "real-world language use" (Kemmerer, 2015, pp. 471–488). Studying pragmatics through discourse involves the consideration of both linguistic and cognitive components for successful social interactions.

Stories are an essential aspect of everyday communication (Mar, 2004); they convey actions and events that unfold over time (Cherney et al., 1998). Story retelling is one way to assess discourse, as it allows the examiner to have a specific target story against which the participant's story may be compared. Thus, the onus for retelling the story is solely on the participant. Story retelling has been shown to be sensitive to communicative breakdown following TBI and has been investigated in numerous previous studies (e.g., Coelho et al., 2013; Lê, Coelho, et al., 2011). The present investigation utilized story retelling for eliciting discourse.

There are at least 1.6 million new cases of TBI each year in the United States (Faul et al., 2010). In addition, TBI has been designated the signature injury of the Iraq and Afghanistan conflicts with at least 350,000 diagnoses of TBI in the U.S. military since 2000 (Department of Defense, 2021). Of those diagnosed with TBI, 75%–90% are designated as having mild TBI (mTBI; Leo & McCrea, 2016). In the military, mTBI is often compounded by unique risks such as blast exposure, which has been shown to exacerbate the effects of mTBI on cognitive function (Martindale et al., 2020). Although the vast majority of service members and veterans (SMVs) with mTBI recover quickly, a substantial minority of these individuals continue to report long-term symptoms. Specifically, studies have documented difficulty with clear expression of ideas, poor text organization, incomplete content, abrupt topic shifts, and poor overall coherence (Body & Perkins, 2004; Lindsey et al., 2018; Jorgensen & Togher, 2009; King et al., 2006; Snow et al., 1997; Tucker & Hanlon, 1998). This is in line with other TBI-related studies that have reported particular difficulty with discourse organization, inclusion of salient content, productivity, and topic maintenance following TBI (Coelho, 2002; Coelho et al., 2013; Galetto et al. 2013; Lê, Mozeiko, & Coelho, 2011; Norman et al., 2013). Such cognitive communication impairments have been shown to impact TBI outcomes as diverse as job attainment and the development and maintenance of social relationships (Brooks et al., 1987; Cornis-Pop et al., 2012; Galski et al., 1998; Norman et al., 2013).

Posttraumatic Stress Disorder

In addition to blast exposure and other associated risks of being in the military, SMVs with mTBI may also experience psychological issues such as posttraumatic stress disorder (PTSD). SMVs with PTSD often experience problem-solving and emotional communication deficits (Monson et al., 2009). Like mTBI, social functioning (e.g., communication skills) has been difficult to assess within the PTSD population. There is little consistency or consensus regarding the best approach to assess deficits with self-report measures being the most common method (Frueh et al., 2001). As communication deficits in individuals with PTSD have been associated with social anxiety, difficulty maintaining interpersonal relationships, and employment (Frueh et al., 2001), it is important to explore the potential additive effect of psychological disorders on cognitive communication deficits in individuals with mTBI.

Historically, TBI and PTSD have been examined separately, yet complications from each can interact and exacerbate overall communication abilities. Sequelae from both TBI and PTSD can include cognitive deficits (e.g., memory and executive function) necessary for discourse production (Coelho et al., in press, 2013). Studies have shown that PTSD has a greater impact than mTBI on subjective and objective measures of cognition than mTBI alone. Lange et al. (2020) investigated the impact of PTSD and the full spectrum of TBI severity on long-term subjective neurobehavioral outcomes in SMVs. Individuals with concurrent TBI and PTSD had consistently worse outcomes on all measures, including those with uncomplicated and complicated mTBI. Furthermore, when controlling for PTSD, there were no differences across TBI severities. Combs et al. (2015) examined the neurocognitive and psychological effects of mTBI, PTSD, and mTBI + PTSD in 251 veterans from Operation Iraqi Freedom and Operation Enduring Freedom, compared to a veteran control group. Findings indicated that the mTBI + PTSD group demonstrated poorer executive function and memory performance than the mTBI-only group.

Deficits in executive function skills such as organization and decision making, in addition to information processing and recall, have been observed in the trauma-related discourse of individuals with PTSD (Foa et al., 1995, van Minnen et al., 2002). Extensive research has also been conducted on the linguistic characteristics of trauma narratives collected from individuals with symptoms of PTSD (see O'Kearney & Perrott, 2006). Linguistic characteristics commonly associated with trauma narratives include word count as a measure of verbal fluency; negative emotion words as part of the emotional processing of a traumatic event (e.g., hurt, upset, and anxious); cognitive process words that reflect how individuals process and interpret the traumatic event (e.g., cause, know, and believe); and nonfluencies, which denote a lack of cohesiveness within a narrative (e.g., –er and umm; Jaeger et al., 2014; Pennebaker et al., 2015). The trauma narratives of individuals diagnosed with PTSD are often fragmented and disorganized, with increased use of negative emotion words and decreased use of cognitive words (Brewin, 2011). Decreased narrative length (word count) and increased nonfluencies as structural features have also been associated with fragmented and disorganized trauma narratives (Jaeger et al., 2014). Structural features such as nonfluencies may be indicative of difficulty with memory encoding (Brewin et al., 1996; Ehlers & Clark, 2000). Conversely, content features such as negative emotion and cognitive process words have been associated with the development of PTSD symptoms (Jaeger et al., 2014).

Although linguistic analysis of trauma narratives has been part of psychological research since the turn of the 20th century (Djikic et al., 2006), little is known about the effect psychological trauma may have on general discourse production. One investigation that has examined linguistic characteristics in a non–trauma-related narrative task in individuals with PTSD was conducted by Papini et al. (2015). To elicit spontaneous speech, the investigators presented ambiguous visual cards from the Thematic Apperception Test (Murray, 1943) to trauma-exposed participants with and without PTSD. Participants with PTSD used more singular pronouns and death-related words (e.g., bury) and fewer plural pronouns. Additionally, specific symptoms were associated with specific word categories (e.g., increased hyperarousal symptoms were associated with fewer anxiety words). In total, the linguistic variables accounted for 53% of the variance in PTSD symptom severity, supporting their hypothesis that language can be a significant predictor of PTSD psychopathology (Papini et al., 2015). These findings highlight the importance of examining linguistic patterns from discourse tasks, whether or not related to trauma, produced by individuals with PTSD.

Purpose

Although the cognitive communication deficits of the mTBI population are often subtle and challenging to delineate, reports on the successful use of discourse analysis are encouraging and may hold promise for differential diagnostic purposes. With that in mind, the purpose of this study was to determine whether PTSD impacts discourse performance of individuals with mTBI. Such an investigation may prove valuable in developing more sensitive and comprehensive TBI assessment metrics especially in populations that are at high risk for PTSD.

We hypothesized that there would be significant differences in discourse production between groups of SMVs with mTBI + PTSD, those with mTBI, and those with no identifiable brain injury or PTSD (no brain injury [NBI]; control). Specifically, we predicted that SMVs with mTBI + PTSD would have the least cohesive and detailed discourse, lowest word count, fewest cognitive process words, most negative emotion words, and most nonfluencies. The NBI group was predicted to have results representing the opposite of each of these findings (most cohesive and detailed discourse, highest word count, etc.), with the mTBI-only group falling in between these groups for each measure.

The discourse outcome measures selected for this study include global coherence and story completeness, which have been found to be sensitive to discourse deficits following TBI (Galetto et al., 2013; Lê, Coelho, et al., 2011). In addition, measures found to be sensitive to PTSD from analyses of trauma narratives include word count, negative emotion, cognitive process, and nonfluencies based on their associations with PTSD symptomology and narratives (Jaeger et al., 2014; O'Kearney & Perrott, 2006; Papini et al., 2015).

Method

Participants

This prospective, descriptive study was part of a larger ongoing Defense and Veterans Brain Injury/Traumatic Brain Injury Center of Excellence 15-Year Longitudinal Study (Sec721 NDAA FY2007). The overall purpose of the study is to examine the natural history of TBI recovery through physical, cognitive, and behavioral health measures and was approved by the Walter Reed National Military Medical Center Institutional Review Board. Participants are enrolled on a rolling basis and complete a multiday initial baseline evaluation and up to 15 annual follow-up evaluations. General inclusion criteria include an age requirement of at least 18 years old and the ability to read and understand English. General exclusion criteria include a medical history of neurological or psychiatric conditions (other than mTBI and PTSD) and lack of proficiency in conversational English.

Participants were selected from 314 SMVs enrolled in the larger study; each completed the informed consent process prior to enrollment. Of these, 291 were initially identified as those who passed performance validity tests (PVTs) and symptom validity tests (SVTs; see below for further details). Women were removed from the analysis due to their extremely small representation in the sample ($n = 5$) and because narrative performance is known to differ between genders (Buckner & Fivush, 1998). The remaining 286 participants were categorized into one of three groups: mTBI + PTSD ($n = 63$), mTBI ($n = 97$), and NBI (n = 101). Of these, discourse samples were ineligible for analysis from 34 participants with mTBI + PTSD, 59 participants with mTBI, and 63 participants with NBI because they were given a story prompt that differed from the targeted story for this study (the larger study included three story options that were randomly assigned). An additional 14 participants with mTBI + PTSD, 13 participants with mTBI, and 12 NBI controls were excluded for saying fewer than 100 words in their discourse samples; stories this short were deemed by the authors as insufficient for reliable exploration of multiple discourse variables prior to data analysis. The final analyses included discourse samples from 15 participants with mTBI + PTSD, 26 participants with mTBI, and 25 NBI controls without PTSD.

Group Classification

Evidence of a history of TBI was determined via a comprehensive interview according to the Ohio State University TBI identification method (Corrigan & Bogner, 2007), a medical file review by trained master's level clinical research personnel, and a final determination by agreement among the interviewers and PhD-level clinicians and scientists during case conferencing. Uncomplicated mTBI was defined as a Glasgow Coma Scale (Teasdale & Jennett, 1974) score of 13–15, posttraumatic amnesia for less than 24 hr, loss of consciousness for less than 30 min, and/or alteration of consciousness present, as well as no trauma-related intracranial abnormality detected on computed tomography scan or magnetic resonance imaging.

The most common etiology of TBI in the study sample was motor vehicle accident, followed by fall, assault or gunshot wound, sports, and being struck by an object, respectively. Half of the participants in the mTBI group also endorsed a history of blast exposure (n = 13) compared to five participants in the mTBI + PTSD group. Mean scores on the Alcohol Use Disorders Identification Test (Saunders et al., 1993) did not suggest substance abuse in any of the three groups: NBI, M = 4.24, SD = 4.36; mTBI, M = 3.46, SD = 3.43; mTBI + PTSD, M = 3.27, SD = 2.65).

Neuropsychological Testing

As part of the parent study, participants completed an extensive range of objective and subjective neuropsychological measures. For the purpose of this study, a subset of those measures was selected given their relevancy to group classification, as well as their well-established utility for cognitive function, and validity testing. Symptoms of PTSD were assessed with the PTSD Checklist for Civilians (PCL-C; Blanchard et al., 1996). The PCL-C is a questionnaire based on the symptom criteria for PTSD from the *Diagnostic and Statistical Manual of Mental Disorders* (4th ed., Text Rev.; American Psychiatric Association, 2000). A participant was classified as having symptoms consistent with PTSD based on the endorsement of moderate or higher symptoms for one or more Criterion B symptoms, three or more Criterion C symptoms, and two or more Criterion D symptoms.

Executive function and memory were assessed due to their known influence on discourse production (Coelho et al., 2013; Mozeiko et al., 2011). Executive function assessment was based on a theoretically derived score using the Similarities subtest from the Wechsler Adult Intelligence Scale–Fourth Edition (Wechsler, 2008), Color–Word Inhibition and Verbal Fluency–Category Switching subtests from the Delis–Kaplan Executive Function System (D-KEFS; Delis & Kaplan, 2001), and the Categories subtest from the Neuropsychological Assessment Battery (Stern & White, 2003). These measures were chosen as they are well-known and well-accepted measures of executive function. Scores were converted to a common metric (e.g., scaled scores) with the mean of the scores calculated. Immediate and delayed memory were evaluated using the Immediate and Delayed Memory Indexes from The Wechsler Memory Scale–Fourth Edition (Wechsler, 2009). Lastly, as verbal fluency is considered to be a measure of both language and executive function (Henry & Crawford, 2004; Whiteside et al., 2016), scores were included from two of the D-KEFS Verbal Fluency subtests: Letter Fluency and Category Fluency. The D-KEFS Verbal Fluency–Category Switching subtest, a predominately executive function measure, was not included to ensure a purer assessment of verbal fluency ability.

The Minnesota Multiphasic Personality Inventory-2-Restructured Form validity scales were used as SVTs to evaluate possible symptom exaggeration. Based on recommended cutoff scores, participants were considered to have failed SVTs if they met one or more of the following criteria: Infrequent Somatic Responses ≥ 100 T; Infrequent Psychopathology Responses ≥ 90 T; Infrequent Responses ≥ 100 T; Response Bias Scale (Gervais et al., 2010) ≥ 100 T; and Symptom Validity ≥ 100 T. Participants were excluded from the study if they failed SVTs. In addition, a number of PVTs were used to evaluate cognitive effort; these included three embedded measures (Advanced Clinical Solutions [ACS]; Holdnack & Drozdick, 2009)—Visual Reproduction Recognition, Reliable Digit Span, and Logical Memory Recognition—and one of three stand-alone measures—ACS Word Choice, Medical Symptom Validity Test (Green, 2004), or Test of Memory Malingering (Tombaugh, 1996). PVT failure was defined as failure on one stand-alone PVT and/or failure on at least two embedded PVTs. Participants were excluded from the study if they failed PVTs.

Procedure and Analyses

Participants sat in a double-walled sound-attenuating booth and watched 26 story panels on a computer screen with no audio and the words removed from the book *Old McDonald Had an Apartment House* (Barrett, 1998). They proceeded through the story at a self-selected pace. The story follows Old McDonald as he becomes a superintendent in an apartment building. During the story, Old McDonald begins to turn the apartment house into a farm to the displeasure of other tenants and the landlord. Participants were instructed to retell the story in detail. Their narratives were recorded digitally on a laboratory computer. Recordings were audio only based on the design of the larger parent study; thus, only verbal information was captured. The transcriber of all the discourse samples for this analysis was a research assistant with 3 years of experience transcribing and analyzing audio recordings from this and similar tasks in the senior author's laboratory. The transcriber listened to the recordings of the discourse samples through earphones and typed each word, interjection, and partial words exactly as spoken. The recording was periodically stopped and replayed to be sure each word was captured. Once each story was transcribed, the transcriber listened to the recording again to confirm the written transcript was accurate. Sample partial transcripts from each group are located in Appendix A.

Global Coherence

Global coherence is a macrostructural aspect of discourse production and refers to how each utterance relates to the target topic. Mean global coherence was calculated for each discourse sample using a 4-point rating scale adapted by Wright et al. (2010) from Glosser and Deser's (1991) original scoring procedure. Scoring criteria are outlined in Appendix B.

All global coherence ratings were completed by one examiner who was blinded to participant group. To assess intrarater reliability, 13 story transcripts were randomly selected and rated again, approximately 3 weeks after completing the initial ratings. The two sets of ratings were then compared yielding intrarater agreement of 95.8%. Interjudge reliability between the primary rater and one of the co-authors who initially trained that rater on 13 story transcripts was 92.3%. The primary rater was trained by that co-author using similar story transcripts from a variety of individuals who were not included in this study. Training consisted of a review of the global coherence scoring procedures described by Wright et al. (2010) and practice scoring approximately 25–30 story transcripts. Training ceased once the rater achieved independent scoring accuracy of greater than 90% as compared to the co-author. Intraclass correlations (ICC) and their 95% confident intervals were calculated based on a mean rating, absolute agreement, two-way random model, ICC (2, 2) = .987.

Linguistic Categories

Linguistic content was analyzed using the Linguistic Inquiry and Word Count (LIWC; Pennebaker et al., 2015). The LIWC is a computerized text analysis program that has been used extensively in research to explore emotional (e.g., negative emotion words), cognitive (e.g., cognitive process words), and structural components (e.g., word count and nonfluencies) of discourse samples, including trauma narratives of individuals with PTSD (Tausczik & Pennebaker, 2010). The software computes the frequency of words in each category as a percentage of the raw word count within a text.

Story Completeness

Story completeness has been shown to be a sensitive parameter for discriminating discourse production by individuals with TBI and NBI (Coelho et al., 2013). Story completeness is the number of critical story components noted within a discourse sample. For this study, a modified version of story completeness was created by increasing the number of original critical components described by Lê, Coelho, et al. (2011) from five to nine. Appendix C includes a full description of the rationale for and development of the modified scoring scheme. Interrater agreement between two raters for the modified version was 84.6% within one component on 13 discourse samples. Using the same calculation parameters as global coherence, the ICC (2, 2) was .973.

Statistical Analyses

Appropriate statistical analyses were selected after testing for assumptions. Shapiro–Wilk test for normality and a visual inspection of box plots were used to detect nonnormal distributions and outliers. In instances where assumptions were violated, a Kruskal–Wallis H test or Mann–Whitney U test was performed. Post hoc pairwise comparisons of nonparametric tests were examined using Mann–Whitney U tests. A one-way analysis of variance or independent-samples t test was conducted for parametric variables. Analyses were conducted using SPSS (Version 26). Significance level for this exploratory study was set at $\alpha = .05$.

Results

Groups were compared on demographic, TBI history, sensory, and cognitive variables known to influence cognitive communication skills (see Table 1). In comparison to the NBI and mTBI groups, the mTBI + PTSD group endorsed more neurobehavioral symptoms, $F(2, 63) = 26.725$, $p < .0005$, across cognitive, $F(2, 63) = 11.069$, $p < .0005$; affective, $F(2, 63) = 28.200$, $p < .0005$; vestibular, $F(2, 63) = 10.901$, $p = .008$; and somatic, $F(2, 63) = 16.552$, $p = .001$, subscales. A post hoc analysis using a series of Mann–Whitney U tests was conducted to compare level of symptoms on discourse production among the participants with mTBI regardless of PTSD

Table 1. Demographics and group comparisons of neurobehavioral, sensory, and cognitive profiles.

Variable	mTBI + PTSD *n* = 15		mTBI *n* = 26		NBI *n* = 25	
Ethnicity (total)						
White, Non-Hispanic	11		18		18	
Black	1		4		3	
Hispanic	2		2		3	
Other	1		2		1	
Military status						
Active-duty	8		18		22	
Veteran	7		8		3	
	M	***SD***	***M***	***SD***	***M***	***SD***
Age (years)	40.00	5.71	38.80	7.69	34.68	8.49
Education (years)	15.47	1.96	15.04	2.03	15.12	2.22
NSI total score[a]	30.87	12.75	10.39	7.01	8.2	10.28
Cognitive[a]	6.93	3.41	2.53	2.93	2.44	3.38
Affective[a]	10.93	4.33	3.77	3.14	2.64	3.41
Vestibular[a]	3.00	2.59	0.62	1.24	0.68	1.49
Somatic[a]	8.20	5.44	2.78	2.84	1.88	2.59
PCL-C scores[a]	39.60	8.91	21.73	4.32	21.00	5.83
	Mdn	**Range**	**Mdn**	**Range**	**Mdn**	**Range**
Time since brain injury (months)	113.4	171.48	60.30	403.68		
No. of brain injuries	1	2	1	6		
PTA, worse ear (0.5k, 1k, 2k)	11.67	11.67	10.00	33.33	8.33	14.38
HFPTA, worse ear (3k, 4k, 6k, 8k)	20	37.50	16.25	77.50	16.25	66.25
	M	***SD***	***M***	***SD***	***M***	***SD***
Memory, immediate	107.57	12.36	109.81	12.42	106.40	11.93
Memory, delayed	111.07	13.75	113.19	14.33	109.76	14.33
Executive function[a]	9.65	1.47	11.40	1.92	11.50	1.27
	Mdn	**Range**	***Mdn***	**Range**	***Mdn***	**Range**
VF–letter	9.5	13	11.5	14	10	19
VF–category[a]	8	14	12	17	12	18

Note. N = 66. p values of group differences for demographic variables outlined below. Age: p = .063; Education: p = .324; NSI total score: $p < .0005$, significant pairwise comparisons, mTBI + PTSD > mTBI, $p < .0005$, mTBI + PTSD > NBI, $p < .0005$; NSI Cognitive subscale, $p < .0005$, significant pairwise comparisons, mTBI + PTSD > mTBI, $p < .0005$, mTBI + PTSD > NBI, $p < .0005$; NSI Affective subscale, $p < .0005$, significant pairwise comparisons, mTBI + PTSD > mTBI, $p < .0005$, mTBI + PTSD > NBI, $p < .0005$; NSI Vestibular subscale, p = .001, significant pairwise comparisons, mTBI + PTSD > mTBI, $p < .0005$, mTBI + PTSD > NBI, $p < .0005$; NSI Somatic subscale, p = .008, significant pairwise comparisons, mTBI + PTSD > mTBI, $p < .0005$, mTBI + PTSD > NBI, $p < .0005$; PCL-C scores: p = .001, significant pairwise comparisons, mTBI + PTSD > mTBI, $p < .0005$, mTBI + PTSD > NBI, $p < .0005$; Time since injury: p = .490; Number of head injuries: p = .833; PTA, worse ear: p = .692; HFPTA, worse ear, p = .230; Memory, immediate: p = .604; Memory, delayed: p = .687; Executive function: p = .001, significant pairwise comparisons, mTBI + PTSD > mTBI, p = .004, mTBI + PTSD > NBI, p = .002; Verbal fluency–Letter: p = .313; Verbal fluency–Category: p = .021, significant pairwise comparisons, mTBI > mTBI + PTSD, p = .022, NBI > mTBI + PTSD, p = .072. mTBI = mild traumatic brain injury; PTSD = posttraumatic stress disorder; NBI = controls with no brain injury; NSI = Neurobehavioral Symptom Inventory; PCL-C = PTSD Checklist–Civilian Version; PTA = pure-tone threshold average; HFPTA = high-frequency pure-tone average; VF = verbal fluency.

[a]Variables with significant group differences for analysis of variance/t tests (M, SD) and Kruskal–Wallis tests (Mdn, range).

symptoms. Groups were separated by reported low symptoms (n = 28) and high symptoms (n = 13) using a midpoint cutoff score of 26 on the NSI (participants' scores ranged from 0 to 53, with one participant [mTBI only] reporting no symptoms). Results showed no statistically significant differences between the two groups on any of the discourse variables: global coherence, U = 184.5, Z = −0.284, p = .776; story completeness, U = 193, Z = −0.055, p = .956; word count, U = 143.5, Z = −1.394, p = .163; negative emotion words, U = 163.5, Z = −0.854, p = .393; cognitive process words, U = 1482, Z = −0.352, p = .725; nonfluencies, U = 141, Z = −1.462, p = .144. The mTBI + PTSD group had poorer executive function (p = .001) and category fluency (p = .021) than the other two groups. The mTBI + PTSD group also reported more postconcussive symptoms than the mTBI group (p = .001). No other statistically significant between-groups differences were observed.

Table 2 lists the mean ranks and significance levels for the discourse variable with pairwise comparisons noted for significant differences. Figures 1 and 2 show box plots for statistically significant group differences. Significant group differences were observed for global coherence scores, $\chi^2(2)$ = 6.044, p = .049, and word count, $\chi^2(2)$ = 7.698, p = .021, such that both were lower for the two TBI groups compared to the NBI group. The effect sizes were low–moderate for word count and small for global

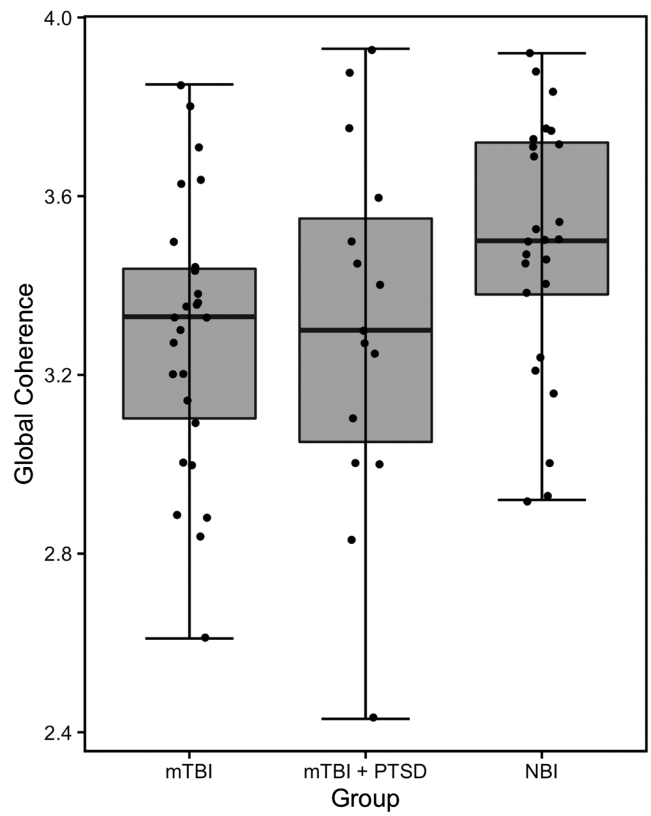
Table 2. Mean ranks for discourse variables.

Discourse variable	χ^2	*df*	Mean rank	*p*	ε^2
Story completeness	0.971	2		.615	
mTBI + PTSD			32.1		
mTBI			31.5		
NBI			36.4		
Global coherence	6.044	2		.049*	.03
mTBI + PTSD			31.0		
mTBI			27.9		
NBI			40.8		
Word count	7.698	2		.021*	.06
mTBI + PTSD			22.9		
mTBI			33.1		
NBI			40.3		
Negative emotion words	0.875	2		.646	
mTBI + PTSD			36.0		
mTBI			30.8		
NBI			34.8		
Cognitive process words	1.681	2		.432	
mTBI + PTSD			32.7		
mTBI			30.4		
NBI			37.3		
Nonfluencies	3.281	2		.194	
mTBI + PTSD			30.1		
mTBI			38.8		
NBI			30.0		

Note. N = 66. Kruskal–Wallis *H* Test. Significant pairwise comparisons (Mann–Whitney *U* tests). Global coherence: NBI > mTBI, p = .017; Word count: NBI > mTBI + PTSD, p = .006. mTBI = mild traumatic brain injury; PTSD = posttraumatic stress disorder; NBI = controls with no brain injury.

*$p < .05$.

Figure 1. Box plots representing global coherence ratings separated by group. Boxes represent the interquartile range, and the vertical line represents the median value. mTBI = mild traumatic brain injury; PTSD = posttraumatic stress disorder; NBI = controls with no brain injury. N = 66.



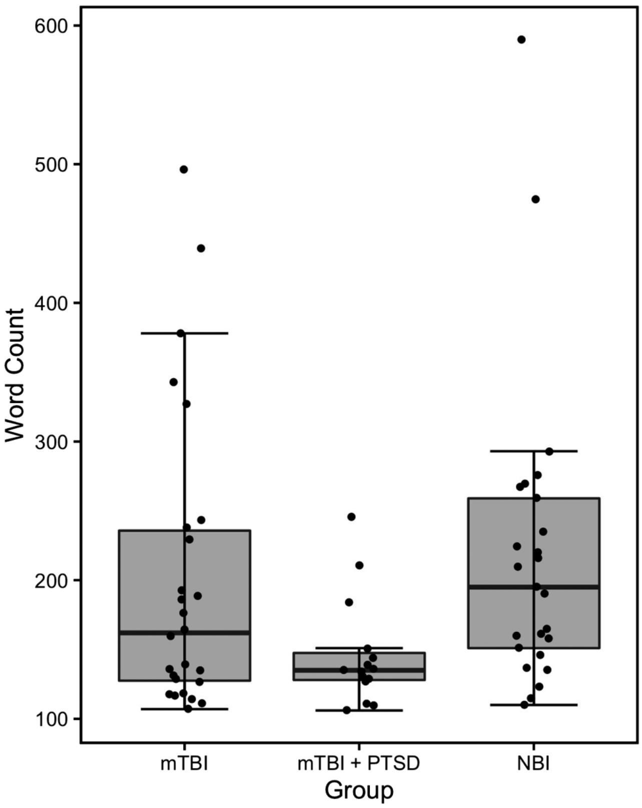
coherence, which accounted for 6% and 3% of the variance for each main effect, respectively. Examination of ranked data reveals that the mTBI group ranked lowest for global coherence and the mTBI + PTSD ranked lowest for word count; NBI ranked highest for both variables. These differences between the lowest and highest ranking groups were significant for each variable according to post hoc comparisons. No statistically significant differences were noted across groups for story completeness scores, $\chi^2(2) = 0.971$, $p = .615$; use of negative emotion words, $\chi^2(2) = 0.875$, $p = .646$; use of cognitive process words, $\chi^2(2) = 1.681$, $p = .432$; or number of nonfluencies, $\chi^2(2) = 3.281$, $p = .194$. Overall, only structural aspects of discourse production (i.e., global coherence and word count) differed significantly between groups.

Discussion

This study sought to identify differences in the discourse production performance between individuals with a history of TBI with and without significant PTSD symptoms and individuals with NBI. As predicted, group differences were observed in global coherence scores and word count. Global coherence appears to be a sensitive measure for distinguishing mTBI from NBI, but the statistically significant difference was not maintained when mTBI was comorbid with significant PTSD symptoms. Alternatively, word count, as a function of verbal fluency, appeared to be a characterizing factor in the discourse production ability of SMVs with concurrent mTBI + PTSD.

Lower global coherence scores in the mTBI group as compared to the NBI group and the lack of differences regarding discourse content mirrors previous research. For example, Galetto et al. (2013) found that individuals with mTBI had adequate lexical and grammatical skills but produced more errors of global coherence, making their discourse samples less informative than those of the control group. Reduced global coherence is likely the result of cognitive dysfunction and may account for some of the difficulty many of these individuals experience with topic maintenance during conversation. Executive function, memory (immediate and delayed), and language were examined in this study, but other cognitive processes that

Figure 2. Box plots representing the total number of words in discourse samples (word count) separated by group. Boxes represent the interquartile range, and the vertical line represents the median value. mTBI = mild traumatic brain injury; PTSD = posttraumatic stress disorder; NBI = controls with no brain injury. N = 66.



have been studied to a much lesser extent have been shown to play a significant role in global coherence. In particular, Kurczek and Duff (2011) found that participants with selective and severe declarative memory deficits had less cohesive and coherent discourse than demographically matched participants without declarative memory deficits.

Channon and Watts (2003) have suggested that cognitive processes such as executive function do not fully explain problems observed in social communication. Therefore, it is possible that other variables may better explain the findings observed regarding global coherence in the present population, especially given the small effect size from the current data. For example, given the number of SMVs with a history of blast exposure in the mTBI group (50%) as compared to the mTBI + PTSD group (33%), blast exposure may account for some of the variance observed and may partially explain why significance was not maintained with the mTBI + PTSD group. The impact of blast exposure on cognitive communication skills is equivocal based on recent literature. Palombo et al. (2015) provided evidence of less coherent narratives in individuals with probable mTBI related to blast exposure than in individuals with probable mTBI not associated with blast exposure. However, Norman et al. (2019) found that TBI severity was more strongly associated with cognitive communication disorders than blast exposure based on diagnostic codes from Veterans Health Administration records. Future studies should explore blast exposure as a comparison group while controlling for TBI severity level and should also include additional cognitive processes to determine the most robust factors that contribute to difficulties with discourse production.

Individuals in the mTBI + PTSD group had shorter narratives (lower word count) than the mTBI and NBI groups, although there was a low–moderate effect size. Longer trauma narratives have been attributed to better psychological adjustment in individuals with PTSD as they demonstrate an individual's ability to provide more details in an organized and cohesive manner (Beaudreau, 2007). As the mTBI + PTSD group endorsed more neurobehavioral symptoms than both the mTBI and NBI groups, this may account for their significantly shorter narratives and suggests a lack of adequate psychological adjustment post trauma. The results also indicate that the presence of significant PTSD symptoms, in conjunction with mTBI, can impact a non–trauma-related narrative task. As such, it adds to the very limited knowledge regarding PTSD and non–trauma-related discourse. The poorer score on the category verbal fluency task in the mTBI + PTSD group further emphasizes the role PTSD may have in cognitive communication function.

In addition to overall verbal fluency, the differences observed in letter (phonemic) and category (semantic) fluency indicate specific challenges for the mTBI + PTSD group that may be explained by differences in neural localization. Specifically, letter fluency has been associated primarily with the frontal region of the brain, whereas category fluency has been associated with frontal and temporal–parietal regions (Sheldon & Moscovitch, 2012; Vonk et al., 2019). Regions linked to category fluency have also been shown to play an important role in PTSD (Bremner, 2006), possibly explaining why the mTBI + PTSD group had poorer scores for category but not letter fluency. The overlap in brain regions associated with category fluency and PTSD is also supported by research that found that individuals with PTSD have difficulty generating semantic details about their personal past events (Moradi et al., 2008). Conversely, content-related word features (e.g., negative emotion words and cognitive process words) rather than structural-related word features (e.g., word count and nonfluencies) have been reported to be associated with indices of PTSD narratives (Jaeger et al., 2014). These findings may have differed from the existing literature in this regard since the narrative task was non–trauma related. Nevertheless, the assessment of the potential impact of PTSD is important given that concurrent mTBI + PTSD has been shown to negatively impact neurobehavioral functioning more than mTBI alone (Lange et al., 2020).

Contrary to our hypothesis, the mTBI group did not demonstrate significantly reduced verbal fluency compared to the NBI group. The literature is equivocal regarding the presence of verbal fluency impairment in individuals with mTBI, apparently due to inconsistencies across studies (Henry & Crawford, 2004) and the heterogeneity of individuals with mTBI (Rosenbaum & Lipton, 2012). In this study, it is possible that reduced verbal fluency was not detected due to the mTBI group's high variability for some individual characteristics (e.g., time since injury). Future studies should aim to use more homogenous groups when investigating the impact of TBI on verbal fluency.

There were no group differences for negative emotion words, cognitive process words, nonfluencies, or story completeness. The use of negative emotion and cognitive process words has been associated with emotional processing during trauma narratives (O'Kearney & Perrott, 2006) and is likely not pertinent to a non–trauma-related task. A study investigating conversational assessment following TBI revealed that linguistic nonfluency did not distinguish severely injured TBI speakers from non-TBI orthopedic patients and a group of neurotypical university students (Snow et al., 1997). Similarly, nonfluencies did not differ in another study between individuals with and without TBI (Gordon et al., 2015). It seems that nonfluencies may not be a salient parameter for discourse errors in TBI in general regardless of the presence of PTSD. Lastly, current literature supports story completeness as a good marker of discourse deficits in moderate–severe TBI populations (Coelho et al., 2013; Lê, Coelho, et al., 2011). Thus, story completeness, even with an increase in the number of critical components, may not be sensitive enough for an uncomplicated mTBI population.

Limitations and Future Directions

Limitations of this research include the limited availability of medical information during the acute phase of the TBI and reliance on a self-report checklist to assess PTSD symptoms. Diagnosis of mTBI was based on historical reports of symptomatology at the time of injury, whether or not participants had persisting overt signs of brain injury at the time of data collection, whereas PTSD symptoms were based on evaluation during the same study time point as the discourse task. Although these common limitations affect almost all studies conducted with these populations (Troyanskaya et al., 2015), we employed a rigorous diagnostic process to minimize risk of inaccuracies and misclassification of TBI and PTSD. In addition, we conducted supplemental analyses to minimize risk of misattribution of mTBI and PTSD symptomatology regarding our findings. Our attempt to study a relatively homogenous population led to the decision to exclude women from the study. Therefore, these results cannot be extended to women. Given that women are one of the fastest growing groups in the military and among eligible VA health care users (Meehan, 2006) and there are known gender differences regarding TBI (Cogan et al., 2020), PTSD (Breslau, 2002; Olff et al., 2007), and discourse (Buckner & Fivush, 1998), future research is warranted to compare the sensitivity of discourse analysis between men and women with mTBI and mTBI + PTSD. The inclusion of a PTSD-only condition would have also allowed for a more comprehensive comparison of linguistic elements across groups and provided a stronger insight of the magnitude of our findings. Moreover, subsequent studies should examine the presence of other psychological disorders such as depression and anxiety as potential confounding variables. Other factors that merit consideration in future studies are potential differences between active-duty SMVs, such as years of military experience, number of deployments, and current living circumstances.

Despite drawing from a large group of potential candidates, the small sample size makes the conclusions from this study preliminary. Given the small and low moderate effect sizes observed, a larger sample is needed to achieve sufficient power to support statistical significance, to determine the generalizability of our findings, and to assess additional variables that may be more sensitive to subtle discourse deficits in the mTBI population. In addition, the procedures employed did not allow the authors to examine potential contributions of nonverbal signals such as hand or facial gestures to discourse performance. Future research should investigate how nonverbal signals may affect discourse production. One method that may be promising for further exploration is the administration of multiple discourse elicitation tasks. In a study comparing three discourse elicitation methods between individuals with and without aphasia, Stark (2019) found that, although individuals with aphasia produced notably shorter narratives, each method impacted language differently for both groups. Specifically, the story-retell task elicited the most complex language, followed by the descriptive and procedural tasks, respectively. Similar findings were observed in another study comparing discourse production in individuals with moderate to severe TBI to a healthy control group using a multipicture wordless story and a single Norman Rockwell picture (Coelho, 2002). Therefore, the use of multiple discourse tasks may prove beneficial in detecting subtle deficits in persons with mTBI and mTBI + PTSD, providing a dynamic opportunity to elicit useful discourse for assessment regardless of length or complexity.

Clinical Relevance

Findings from this study provide relevant information for clinicians both in the fields of speech-language pathology and psychology. Clinicians from both disciplines may benefit from the use of discourse analysis for determining subtle cognitive communication deficits in patients with mTBI and mTBI + PTSD that are not detected from traditional language and psychological assessments. The methods used for discourse analysis may be appealing since typical assessment methods fail to translate well in the real-world environment. Furthermore, as discourse production ability can impact various treatments used in psychotherapy, such as narrative writing, it is important to be able to assess potential discourse impairment. Exploration of the clinical utility of discourse analysis is not only warranted within the general population; it is also highly relevant in the military population given the high prevalence of both disorders. Having tools that provide clinicians with diagnostic insight into active-duty service members' discourse production abilities could result in better return-to-duty outcomes. Regardless of the discipline or setting, the use of discourse analysis as a measure of cognitive communication function for persons with a history of mTBI may be instrumental in enhancing current clinical assessment practices.

Conclusions

This exploratory study focused on individuals with a history of mTBI and expanded upon previous work that has used discourse analysis to assess cognitive communication deficits in TBI. It also included the concomitant feature of PTSD in one of the mTBI groups. The results suggest that structural features of discourse may be a better index of cognitive communication impairment in mTBI than content features. Equally important, PTSD may contribute to discourse deficits, particularly verbal fluency, in individuals with history of mTBI. Additional factors such as blast exposure and inclusion of women warrant further exploration. This novel investigation demonstrates the need for future research to assess discourse-related TBI measures, especially those pertaining to narrative structure, since they may be sensitive to the subtle complexities of the effects of mTBI and PTSD on cognitive communication abilities.

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Appendix A

Sample of Partial Transcripts From Participants in Each Group

Participant With NBI

"…old MacDonald started moving livestock in there…this upset the residents even further…they moved their animals out…this really upset what I'm assuming was the apartment owner…um as old MacDonald took over the new empty rooms to uh to expand the…the farm…however eventually the uh owner decided to build a produce stand out front and sell meat and produce and uh milk from old MacDonald's apartment farm and everybody was very happy… and old MacDonald was happy because he and his wife had uh basically a produce stand to take their produce from their apartment farm to and everybody was happy with him."

Participant With mTBI

"…um they started moving plants inside and turned the apartment building into a farm…uh carrots were growing through the roof which made the tenants unhappy at which point they moved out…um after growing a bunch of vegetables and having farm animals in the house a businessman set up a fruit stand at which point old MacDonald was able to sell his fruits and vegetables to the townspeople."

Participant With mTBI + PTSD

"…And uh…uh…uh…they…they were uh given a test to plant some vegetables and uh…they did a wonderful job and uh…and the…and the man was um given an award from the landlord or from the managers of the farm and uh…after the job was done the man and woman left."

Appendix B

Global Coherence Rating Scale (Wright et al., 2014)

Score	Description
4	The utterance is overtly related to the stimulus by the mention of actors and/or actions mentioned in the stimulus, which are of significant importance to the main details of the stimulus. In the case of procedural descriptions and reactions when a designated topic acts as the stimulus, overt relation is defined by the provision of substantive information related to the topic so that no inference is required by the listener.
3	The utterance is related to the stimulus or designated topic, but with some inclusion of suppositional or tangential information that is relevant to the main details of the stimulus, or substantive information is not provided so that the main topic must be inferred from the statement. In recounts,[a] appropriate elaborations that are not essential but are related to the main topic are given a score of 3.
2	The utterance is only remotely related to the stimulus or topic, with possible inclusion of inappropriate egocentric information: It may include tangential information or reference some element of the stimulus that is regarded as noncritical.
1	The utterance is totally unrelated to the stimulus or topic; it may be a comment on the discourse or tangential information is solely used.

Note.

[a]Recounts are verbal reiterations of an event.

Appendix C

Development of Nine-Component Version of the Story Completeness Index

Lê, Coelho, et al. (2011) constructed a scoring rubric for story completeness to assess the extent of content produced during the same storytelling task used in this study. Development was based on 46 Vietnam War veterans without penetrating head wounds. In total, those participants produced 50 different story elements. These were clustered into seven components that were mentioned by 65% of the participants (see Table C1) and further reduced to five components mentioned by 80% (all but Components 2 and 3 in bold font in Table C1). The resulting five-component scheme differentiated participants with and without severe penetrating TBI (Lê, Coelho, et al., 2011).

Table C1. Development of the original story measure (Lê, Coelho, et al., 2011; Karen Lê, personal communication, July 8, 2019).

1	The couple/farmer moving to city and/or finding an apartment and/or having an apartment building (i.e., statement regarding urban living).
2	**Couple/farmer/wife growing plant, not growing because of lack of light, farmer takes care of it.**
3	**The farmer starts planting outside, problems with outside garden.**
4	The farmer having a garden/farm indoors.
5	Tenants/neighbors becoming upset and/or moving out due to the farmer's indoor activities.
6	The owner/inspector arriving and attempting to resolve situation (e.g., couple is evicted and/or the owner has brainstorm).
7	Construction/buying of vegetable stand/greenhouse/market, business partnership between the farmer/owner.

Analysis of story completeness did not differentiate participants with NBI and participants with mTBI in this study. One potential reason for this was that the five-component scheme may not have provided adequate detail to differentiate subtle differences in performance between the groups. This prompted an effort to redefine story components into more discrete units. The goal was to develop a sensitive and reliable measure that would also be practical for data analysis so that it could eventually be translatable to clinical practice.

An initial attempt to expand the list to nine components was based on the author's (N. P. S.) review of the picture book. A preliminary analysis of these nine components with 50 participants who had mild to moderate TBI and 20 NBI controls revealed a trend toward significantly fewer components expressed by the TBI group, $F(1, 67) = 3.011$, $p = .087$. This encouraging finding motivated further development of a valid and reliable set of components to assess story completeness. Authors N. P. S. and J. N. identified 21 separate story elements, corresponding to each item listed in Table C2; each was counted as a single component that was equally weighted. This scheme was highly reliable, with intrarater agreement = 100% and interrater agreement = 93% within one component for re-analysis of 19% (15/78) of discourse samples.

Table C2. Current rubric for assessing story completeness.

Component	Story elements
1	McDonald/wife in an apartment house (urban living)
	McDonald was superintendent/janitor
2	(Mrs. McDonald) had a (tomato) plant (inside) (kitchen/apartment)
	Plant was dying/wilting (needs sun, not growing)
3	McDonald cut down shrubs
	Plant grows (after not growing before) *(consolidate with previous or next group)*
4	McDonald plants vegetables/garden outside
	Neighbors/tenants unhappy with outdoor vegetable garden
5	McDonald plants vegetables inside
	Plants growing everywhere
	Animals/birds (inside or inside implied)
6	Tenants unhappy (consolidate with previous or next group)
	Tenants move out
	Apartments fill up with more plants/animals (because tenants moved out or mention picture with different floors having different plants OR mention more plants after tenants move out)
7	Landlord/owner angry/displeased (or scolds them)
	Landlord/owner fires/evicts McD (or plans to evict them)
	McDonalds pack/move out /are very unhappy
8	Owner has dilemma/contemplates situation /has an idea
	Construction of vegetable stand
9	Vegetable stand is a functioning business/partnership (sell produce)
	Everyone is happy

For the purposes of this study and for the practical reason of simplifying data analysis, the 21 elements were grouped into nine components, each composed of two to three elements. The nine components closely correspond to those identified by Lê, Coelho, et al. (2011), but split Components 2 and 7 in half, resulting in a total of nine components that were judged by the authors to have comparable weight in terms of content. A component was awarded 1 point if participants mentioned at least one element from that section.