Introduction

Situated at the nexus of cognition and communication, discourse abilities are common and persistent sequelae of traumatic brain injury (TBI). In particular, individuals with TBI consistently demonstrate difficulty with global measures of content and organization (Body & Perkins, 2004; Coelho, 2002; Moran & Gillon, 2010). A recent index of story goodness combined the two measures and demonstrated sensitivity in examining narrative discourse following TBI. Content and organization were assessed using story completeness and story grammar respectively (Lê et al, in press). Germane to understanding story goodness performance is the examination of potential cognitive substrates of story completeness and story grammar.

Emerging evidence points to executive functions (EFs), working memory (WM), and immediate memory as potentially fruitful avenues to elucidating the relationship between narrative discourse and cognition. Performance on the Wisconsin Card Sorting Task (WCST), a commonly used measure of EF, has correlated moderately with story grammar measures (e.g., total episodes) in studies of TBI (Coelho, 2002; Coelho, Liles, & Duffy, 1995). Another study identified low-to-moderate correlations between WCST scores and measures of content and organization (e.g., gist, story grammar; Brookshire et al., 2000). Overall, the TBI literature provides support for a relationship between narrative discourse production and EF.

The relationship between memory and discourse continues to be defined. In one study, story grammar measures correlated moderately with associate learning performance, a measure of declarative memory, but did not correlate significantly with WM scores (e.g., digit span) (Youse & Coelho, 2005). Another study indicated that "n-back" task performance, tapping WM, varied with content measures, including summarization ability (Chapman et al., 2006). However, there was no correlation between immediate declarative memory measures and discourse content. Conflicting results, such as those within these studies, suggest a tentative relationship between particular memory processes and discourse content and organization that warrants further examination.

Much of the research on discourse and cognition is correlational but no study to date has examined how well potential cognitive substrates predict discourse performance. The present study of 167 individuals with TBI investigated the contribution of measures of EF, WM, and immediate declarative memory in predicting outcomes on story goodness measures of story completeness and story grammar. This study is an initial attempt to model discourse performance based on cognitive measures. It is hypothesized that all three cognitive factors will be significant predictors for both story completeness and story grammar in separate multiple regression analyses.

Methods

Participants

All 167 participants were native English-speaking male Vietnam War veterans, 52-70 years of age, who sustained severe penetrating head wounds during the Vietnam War. Education ranged from 8-22 years. Scores ranged from 1-99 on the Armed Forces Qualification Test (AFQT), 25-60 on the Boston Naming Test (BNT), and 87-100 on the Token Test (TT).

Discourse Analysis Procedure

Task. Participants were shown a multi-frame picture story with no soundtrack on a computer screen. Upon completion each participant was instructed to "tell me that story you just watched." Each retelling was digitally video-recorded. Recordings were transcribed verbatim and segmented into T-units.

Analyses. Story narratives were analyzed along for content and organization. Story completeness, the content measure, involved tallying the number of critical story components (events and characters) mentioned by the storyteller out of five.

Story grammar analysis was to quantify organization. Story grammar guides comprehension and expression of logical relationships (temporal & causal) between people and events. The analysis yielded the proportion of T-units within episode structure (T-units within episodes/total T-units in retelling), reflecting the percentage of utterances framed within episodes.

Intra-rater and inter-rater reliability for the proportion of T-units within episode structure was 90% and 84%, respectively. Intra-rater reliability and inter-rater reliability for the completeness measure were both 100%.

Cognitive Measures

EF was indexed using the Sorting Test composite score from the Delis-Kaplan Executive Function System (D-KEFS; Delis, Kaplan, & Kramer, 2001). The Sorting Test is analogous to the WCST and requires multiple skills, including concept formation, problem-solving, and mental flexibility.

The Working Memory Primary Index Score from the Wechsler Memory Scale – Third Edition provided the WM metric (WMS-III; Wechsler, 1997). The WM score reflects performance on both letter-number sequencing and spatial span tasks.

The Immediate Memory Primary Index Score, also from the WMS-III, served as a measure of immediate declarative memory. The immediate memory score reflects the ability to remember verbal and non-verbal information.

Data Analysis

Pearson correlation coefficients were calculated for the cognitive measures and each discourse measure, story completeness (number of critical components) and story grammar (proportion of T-units in episode structure). Two multiple regression analyses, one predicting story completeness and the other story grammar, were performed with Sorting Test, WM, and immediate memory scores entered as predictors in that order.

Results

Descriptive Statistics

Discourse Measures. For story completeness, the average was 3.59 of the five critical components referenced. For story grammar, the mean was a proportion of .61 T-units in episode structure (Table 1).

Cognitive Measures. The average Sorting Test score was 10.32. The mean WM score was 99.41. The mean immediate memory score was 96.02 (Table 1).

Correlations

The story completeness measure correlated moderately with the cognitive variables, $r = .43$ for the Sorting Test, $r = .32$ for WM, and $r = .51$ for immediate memory with $p < .001$ for all correlations. The story grammar measure had low-to-moderate correlations, $r = .32$, $p < .001$ for the Sorting Test, $r = .1$, $p < .05$ for WM, and $r = .32$, $p < .001$ for immediate memory.

There was a moderately-high correlation ($r = .55$, $p < .001$) between the Sorting Test and WM and moderate correlations between the Sorting Test and immediate memory ($r = .51$, $p < .001$) and WM and immediate memory ($r = .47$, $p < .001$).

Multiple regression analysis

The model significantly predicted about 30% of the variance in story completeness ($R^2 = .296$, $F(3, 163) = 22.81$, $p < .001$). Results indicated that only the Sorting Test ($\beta = .23$, $p < .01$) and immediate memory ($\beta = .39$, $p < .001$ were significant predictors. The Sorting Test predicted 18.4% of the variance while immediate memory contributed an additional 10.5% (see Table 2).

The model accounted for 14.2% of the variance in story grammar ($R^2 = .142$, $F(3, 163) = 8.99$, $p < .001$). Again, only the Sorting Test ($\beta = .26$, $p < .01$) and immediate memory ($\beta = .23$, $p = .01$ were significant predictors. The Sorting Test predicted 10.5% of the variance while immediate memory contributed an additional 3.6% (see Table 3).

Discussion

1) Cognitive measures significantly predicted performance on both discourse content and organizational measures, providing support for cognitive processes underlying discourse ability.
2) The moderate and modest amount of variance explained in the story completeness and story grammar models, respectively, suggest that discourse production draws upon a number of different processes not yet identified. A logical next step would be to delineate other potential predictors.
3) The finding that WM was not a significant predictor of the discourse measures may be explained by the notion that the Sorting Test subsumes disparate cognitive skills, including WM.
4) Utility of modeling discourse performance using cognitive measures.
5) Discrete cognitive tasks, rather than global cognitive indices, will likely provide a better understanding of the factors underlying discourse deficits following TBI.

References

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Table 1: Descriptive statistics		
Measure	Mean	Standard Deviation
Story completeness (# of critical components)	3.59	1.55
Story grammar (proportion of T-units in episodic structure)	.61	.25
Sorting Test (D-KEFS)	10.32	3.31
Working Memory Primary Index Score (WMS-III)	99.41	13.5
Immediate Memory Primary Index Score (WMS-III)	96.02	15.68

Table 2: Summary of Multiple Regression Analysis for Variables Predicting Story Completeness									
	Model 1			Model 2			Model 3		
Variable	*B*	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Constant	1.53	.36		.64	.82		-1.16	.85	
Sorting Test	.20	.03	.43*	.17	.04	.37*	.11	.04	.23*
Working Memory				.01	.01	.10	-.001	.01	-.01
Immediate Memory							.04	.01	.39*
R^2		.18			.19			.30	
F for change in R^2		37.17*			1.45			24.22*	

*p ≤ .01

Table 3: Summary of Multiple Regression Analysis for Variables Predicting Story Grammar									
	Model 1			Model 2			Model 3		
Variable	*B*	*SE B*	*β*	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Constant	.36	.06		.41	.14		.25	.15	
Sorting Test	.02	.01	.32*	.03	.01	.35*	.02	.01	.26*
Working Memory				-.001	.002	-.04	-.002	.002	-.10
Immediate Memory							.004	.001	.23*
R^2		.11			.11			.14	
F for change in R^2		19.34*			.20			6.84*	

*$p \leq .01$