Introduction

Subtle communication impairments have been documented in the discourse of individuals following closed head injury (CHI) (Coelho, 1995). It has been suggested that the most useful measures of discourse performance following CHI are the super-structural measures of discourse, namely story grammar (Coelho, 2002). Good use of story grammar requires content organization and an ability to structure a narrative, providing logical relationships between people and events.

Story grammar impairment is thought to reflect dysfunction of executive control over cognitive and linguistic organizational processes (Ylvisaker, Szekeres, & Feeney, 2001). Significant correlations have been observed with measures of story grammar and on scores from the Wisconsin Card Sorting Test (WCST, Grant & Berg, 1948), a measure of executive functioning with CHI (Coelho, 2002).

Focal and diffuse frontal lesions disrupt activities of daily living (ADL) and executive impairment may represent a main component of failure to carry out ADLs. Executive abilities of planning, self-monitoring and self-correction, decision-making and judgment are considered critical for independent, adaptive functioning in the real world. Impact of such impairments can be viewed as damaging a complex cognitive-emotional macrostructure or managerial knowledge unit (including strategic planning, procedural memory, and working memory) that underlies most multi-step routines of real life. (Eslinger, Zappala, Chakara, & Barrett, 2007; Fortin, Godbout, Braun, 2003; Grafman, 1995).

Strategic planning, procedural memory, and working memory are also required to formulate a narrative and participate in other forms of discourse. In terms of cognitive demands, discourse is not different from any other complex, goal-directed activity (Alexander, 2006) and requires at least equal executive and attention resources (Chapman, Gamino, McGlothlin, & Cliff 2003; Chapman & Ulatowska, 1989). It follows that executive function impairment will result in discourse impairment, specifically a decrease in the ability to use story grammar.

It is important to note that impairments of executive function may be related not only to focal traumatic lesions of the prefrontal cortex but also to white matter disconnection (DAI) of prefrontal-related networks that link to the thalamus and other important cortical and subcortical regions (Goldenberg, Oder, Spatt, & Podreka, 1992).

The purpose of the present study was to examine the story grammar and executive functions of a large group of individuals who had survived severe and diverse penetrating head injuries. It was hypothesized that story grammar ability would be significantly correlated with measures of executive functioning.

Methods

Participants

All individuals are participants in the Vietnam Head Injury Study (VHIS), a longitudinal investigation of the long term consequences of penetrating head injury incurred during the Vietnam War (see Mohr, Weiss, Caveness, et al., 1980). Each of these participants was followed for over 30 years and received extensive cognitive evaluations on at least two occasions. Data for the present study were acquired during phase III of VHIS.

PHI group. 167 participants with diverse PHI characterized by cortical lesions and white matter damage were included in this analysis. Participants were 52-70 years of age. 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).

NBI group. 46 individuals, 55-76 years of age with no history of neurologic disease or injury also were studied. Years of education ranged from 12-20. Scores ranged from 14-95 on the AFQT, 46-60 on the BNT, and 94-100 on the TT.

Discourse Analysis Procedure

Participants were shown a picture story (Old McDonald had an apartment house) without a sound track on a computer screen. Upon completion of the story, participants were instructed to retell the story they had just watched. Each story was digitally video-recorded. The recordings were then transcribed verbatim, segmented into T-units and analyzed for story grammar. In a previous study story grammar measures were noted to be sensitive to deficits of individuals with closed head injuries (Coelho, 2002). Two story grammar measures were analyzed in this study. 1) The *total number of episodes* and 2) *the proportion of T-units within episodic structure*. An *episode* is considered to be the central element in most models of story grammar. Episode components are defined as statements bearing information about stated goals, attempts at solutions, and the consequences of these attempts (Liles, Coelho, Duffy, Rigdon, & Zalagans, 1989). The relationships among the components of episodes are considered to be logical, not bound by specific content and the organization of an episode is thought to involve processes that are not exclusively linguistic. The second measure, *proportion of T-units within episode structure,* is the number of T-units that contribute to episodic structure (i.e., T-units in episode structure/total number of T-units in story narrative). This measure is considered to be an indication of participants' ability to use story grammar as an organizational plan for language (Coelho, 2002). Comments not contributing to the story are not counted in this number.

The first and second authors independently completed all story grammar measures. Intra-judge reliability was 90%. Inter-judge reliability was 84%.

Distinguishing PHI and NBI groups

An ANOVA was run to confirm story grammar measures as useful in distinguishing the PHI and NBI groups.

Measures of Executive Function

Two measures of executive functioning from the Delis-Kaplan Executive Function System (D-KEFS), (Delis, D.C., Kaplan, E., Kramer, J.H., 2001) the card sort test and the Tower Test were selected as the indices of EF in the present study. These measures are both considered to be nonverbal measures of problem solving.

Results

Distinguishing PHI and NBI groups

Means for the PHI group and NBI group were .604 and .701, respectively. ANOVA confirmed that PHI participants had significantly lower story grammar scores for *proportion of T-units within episode structure* than the NBI group, as expected (p=.018). (See Table 1).

Measures of Executive Function

Pearson product-moment correlations were calculated for the Card Sorting and Tower Test scores and the two story grammar measures described above: *total number of episodes* and *proportion of T-units within episode structure*. (See Table 2). For the measure *total number of episodes*, significant correlations were noted on both the Tower Test (.153, $p \leq .05$) and the Card Sorting Test (.327, $p \leq .01$). For the measure *proportion of T-units within episode structure,* significant correlations were noted only for the Card Sorting Test (.338, $p \leq .01$).

Discussion

The following issues will be discussed:

1) The story grammar measure, proportion of T-units within episode structure, effectively distinguishes the PHI and NBI groups as it has in studies of adults with CHI (Coelho, 2002; Coelho, Youse, Le, & Fein, 2003)
2) Findings of significant correlations between SG and EF are consistent with those seen in adults with CHI (Coelho, 2002;Coelho et al 1995; Tucker & Hanlon, 1998).
3) Production of story narratives appears to be related to executive functioning which is associated with prefrontal cortical regions. The PHI participant group studied had diverse cortical and white matter damage, suggesting that prefrontal functions may be disrupted by lesions some distance from the prefrontal cortex.
4) Intervention for discourse deficits secondary to acquired brain injuries should be focused on story grammar impairments.

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Table 1: Descriptive statistics				
	PHI Group		*NBI Group*	
Measure	Mean	Standard Deviation	Mean	Standard Deviation
Story grammar (proportion of T-units in episodic structure)	.60	.25	.70	.21

Table 2: Pearson product-moment correlation coefficients for PHI group		
	Tower Test	*Card Sort*
Total Episodes		
Pearson Correlation	.153*	.327**
Sig (2-tailed)	.048	.000
N	167	167
Proportion of T-units in episode structure		
Pearson Correlation	.123	.338**
Sig (2-tailed)	.113	.000
N	167	167

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).