Impairments of discourse abilities and executive functions in traumatically brain-injured adults

CARL A. COELHO, BETTY Z. LILES† and
ROBERT J. DUFFY†

Southern Connecticut State University, New Haven and Gaylord Hospital,
Wallingford, CT, USA,
†University of Connecticut, Storrs, CT, USA

Preliminary findings from an ongoing investigation of the potential relationship between narrative discourse performance and executive functions in adults with traumatic brain injuries (TBI) are reported. Narrative stories were elicited from 32 adults with TBI. Stories were analysed at three levels: sentence production, intersentential cohesive adequacy, and story episode structure. These measures were then correlated with scores from the Wisconsin Card Sorting Test (WCST), the primary measure of executive function. A significant correlation was noted between a factor score from the WCST and the measure of story structure, but not sentence production or cohesive adequacy. These results suggest that executive functions may be a promising avenue to pursue in the search for underlying causal factors of narrative discourse dysfunction and, therefore to better delineate the nature of communicative deficits secondary to TBI.

Introduction

The purpose of this paper is to provide a brief overview of the literature on narrative discourse deficits in adults with traumatic brain injury (TBI) and to discuss the findings of these studies, in the context of Ylvisaker and Szekeres' [1] conceptualization, as evidence of impairments in executive functions. Preliminary findings from an ongoing investigation of the potential relationship between narrative discourse performance and various cognitive measures in mildly impaired TBI adults will then be presented in support of the conclusion of a relationship between discourse performance and impairments in executive function.

According to Lezak [2]: 'executive functions comprise those mental capacities necessary for formulating goals, planning how to achieve them, and carrying out the plans effectively'. Ylvisaker and Szekeres note that following severe TBI most individuals demonstrate communicative deficits directly attributable to disruption of executive functions. They list a number of dimensions of executive functioning in which this dysfunction may occur, including: (a) self-awareness and goal setting, (b) planning, (c) self-direction and initiation, (d) self-inhibition, (e) self-evaluation, and (f) flexible problem solving.

Recent investigators of verbal communication deficits in TBI adults have utilized narrative discourse analyses [3–9]. Such analyses are well suited for this population, in that accurate production and comprehension of a narrative requires a complex interaction of linguistic, cognitive, and social abilities, which is typically disrupted following even mild brain injuries.

Correspondence to: Carl A. Coelho, PhD, Communication Disorders Department, Southern Connecticut State University, 501 Crescent Street, New Haven, CT 06515, USA.

Narrative discourse deficits in TBI adults

Two aspects of discourse performance will be reviewed: intersentential cohesive adequacy and story structure.

Intersentential cohesion

Cohesion is defined as structural coherence among the parts of a text [10]. Sentences are conjoined by various meaning relations described as cohesive ties. Words are tied across sentences because one provides the source of the interpretation for the other. Cohesion is generally considered to be a rule-based semantic organization across sentences. Analysis of intersentential cohesion may involve the frequency of occurrence of specific linguistic devices (e.g. Reference, Lexical, Conjunctive). Each occurrence of a cohesive tie is then judged as to its adequacy. The Liles [11] procedure includes three categories of cohesive adequacy:

(1) Complete—a tie is judged complete if the information referred to by the cohesive marker is easily found and defined with no ambiguity.
(2) Incomplete—a tie is judged incomplete if the information referred to by the cohesive marker is not provided in the text.
(3) Error—a tie is judged to be an error if the cohesive marker refers the listener to ambiguous or erroneous information elsewhere in the text.

With regard to the TBI literature Hartley and Jensen [6] noted that their TBI subjects used significantly fewer cohesive ties per communication unit than the normal controls in both narrative and procedural discourse tasks. This finding was felt to provide evidence that their discourse lacked continuity. Mentis and Prutting [8] also noted that their TBI subjects used fewer cohesive ties than normal subjects in a variety of narrative tasks. Liles *et al.* [7] reported that the number of cohesive ties per T unit (independent, plus any dependent clauses) produced by their TBI subjects was the same as the normal subjects for both story retelling and story generation tasks. Mentis and Prutting further note that their TBI subjects used incomplete ties, which was not characteristic of the normal subjects. Liles *et al.* observed that, like the normal subjects, the TBI subjects showed greater cohesive adequacy in a story-retelling task, in which they demonstrated a higher percentage of Complete ties and a lower percentage of Incomplete ties than in the story-generation task. However, in story generation, half of the subjects exhibited a much lower percentage of Complete ties than normal subjects. Error ties were rare in both groups of subjects.

Story structure

Story structure knowledge refers to the purported regularities in the internal structure of stories which guide an individual's comprehension and production of the logical relationships between people and events, both temporal and causal. Descriptions of story structures differ, but the episode unit is central to virtually all models proposed by recent investigators. Because the relationships among components of the episode are considered to be logical, and not bound by specific content, researchers describe episode organization as being in the cognitive domain. According to Stein and Glenn [12] an episode must consist of: (a) an initiating event that causes

a character to formulate a goal-directed behavioural sequence, (b) an attempt at solving the goal, and (c) a direct consequence marking attainment or non-attainment of the goal. In addition, these three components must be logically related. An episode is judged complete only if contains all three components.

At the level of story structure organization, Liles *et al.* [7] noted that their TBI and normal subjects produced a comparable number of episodes in story retelling. In story generation, however, several of the TBI subjects produced no episodes. In order for the TBI subjects to produce a story containing complete episodes, in the story-generation task, they had to specify the relationships of the characters and events, either depicted or implied, in the stimulus picture as causal and/or temporal information. In other words they were required to transpose a static representation (i.e. the picture) into a dynamic representation of the events (i.e. story development). Blank, Rose and Berlin [13] have termed such dissonance between the context and the required language use as cognitive 'reordering'.

Narrative discourse impairments and executive functions

The inadequacies in discourse performance that have been noted in TBI adults may be interpreted in terms of what Ylvisaker and Szerkeres [1] have described as deficits in executive functions; specifically, to a reduced ability to formulate goals, to plan how such goals are to be achieved, and to carry out the plan.

Preliminary findings on the relationship between discourse abilities and executive functions

In an effort to better delineate the hypothesized relationship between discourse performance and executive functioning in TBI adults, an investigation is currently under way in which dimensions of each area are being measured and correlated. A brief review of the methodology and some preliminary results follows.

Methods

Subjects. Thirty-two adults with the diagnosis of TBI have been studied to date. This group is made up of eight females and 24 males, ranging in age from 17 to 49 years with a mean age of 26·2 years. Mean time post-onset is 5·6 months with a range of 2–19 months. Subjects studied all met the following criteria:

(1) Non-aphasic, the group had a mean Aphasia Quotient, from the Western Aphasia Battery [14] of 95·7 (range 94·2–100).
(2) No significant motor speech disorder as determined by two certified speech–language pathologists.
(3) Pass screens of visual acuity and perception as well as hearing acuity.
(4) Rancho Los Amigos Level VII or above [15].
(5) Score of 75 or above on the Galveston Orientation and Amnesia Test [16].
(6) Score of 125 or above on the Dementia Rating Scale [17], a general screen of cognitive processing.

Discourse elicitation task. Although a variety of elicitation tasks is being utilized in this study only the results from the story-generation task will be reviewed. In the generation task subjects are shown a copy of a Norman Rockwell painting and instructed to tell a story about what they think is happening in the picture. Each story is audiotaped and transcribed verbatim. The transcriptions are distributed into T units prior to analysis. Measurement of story narrative performance is then made at three levels: sentence production, intersentential cohesive adequacy, and story episode structure.

Discourse analysis procedures

Sentence production. A T unit is defined as an independent clause plus any dependent clauses associated with it. The primary measure of sentence production to be reported on here is number of subordinate clauses per T unit. This ratio is obtained in order to permit comparisons across stories that varied in length. The frequency of clause use may be considered a measure of the complexity of sentence-level grammar.

Intersentential cohesive adequacy. Each occurrence of a cohesive tie is judged as to its adequacy, that is, Complete, Incomplete, or Error (as previously defined). The measure of intersentential cohesive adequacy selected for analysis is the percentage of complete ties relative to the total number of cohesive ties used within each narrative. The percentage of complete ties represents the total use of ties minus incomplete or error ties, and is considered to be a general indicator of cohesive adequacy.

Story structure. The number of complete episodes in each story is counted, and used as the measure of story structure performance. As discussed above, an episode is considered complete only if it contains all three components (an initiating event, an action, and a direct consequence). An episode is judged to be incomplete if it contains only two of the three components, incomplete episodes are counted as well.

Measure of executive function

The primary measure of executive function used in this study is the Wisconsin Card Sorting Test (WCST) [18]. According to Spreen and Strauss [19] the purpose of the WCST is to assess the ability to form abstract concepts, and shift and maintain the set. There is a variety of scores which can be derived from the WCST, such as number of categories completed, number of cards used, number of errors, number of perseverative responses and number of perseverative errors.

Because of the variety of possible scores which could be derived from the WCST a principal-components factor analysis was conducted in an attempt to identify a single construct underlying performance on this test. The analysis resulted in two factors being extracted with an eigenvalue greater than 1 (which accounted for 85% of the variance in WCST performance). The results of this analysis are presented in Table 1. Of the six possible scores derived from the WCST, five (perseverative responses, number of categories achieved, ratio of categories achieved to total cards, perseverative errors, and total cards) loaded on factor 1, with factor loadings ranging from 0·70 to 0·93. These factor loadings imply high communalities among the five WCST scores; that is, the proportion of variance in the WCST performance that each score has with the other four scores. One of the six possible WCST scores (percentage of perseverative responses which were errors) loaded on factor 2, with a high loading factor of 0·97.

Table 1. *Rotated factor matrix for Wisconsin Card Sorting Test scores*

WCST Scores	Factor 1	Factor 2
Perseverative responses	0·93	
Categories achieved	− 0·92	
Categories/cards	− 0·92	
Perseverative errors	0·86	
Total cards	0·70	
Percentage perseverative errors		0·97

In summary, the results of the factor analysis demonstrate that two factors were extracted that account for a major proportion of the variance in overall WCST performance. Our interpretation of these factors is that factor 1 represents a group of general test-taking abilities such as attention, concentration, and efficiency. Factor 2, on the other hand, which was made up of only the percentage of perseverative responses which were also errors score, represents a more specific indicator of executive functioning.

Results

Although data have been collected from normal controls their performance will not be compared with that of the TBI adults within the context of this paper. Rather, results noted to date pertaining to the relationships of discourse performance and executive function for the TBI subjects will be reviewed.

Narrative discourse performance

Sentence production. Pearson product–moment correlations between the number of subordinate clauses per T unit and executive function (factors 1 and 2 from the WCST) were not significant (see Table 2).

Intersentential cohesive adequacy. The TBI subjects' overall cohesive adequacy was noted to be poorer than the performance of a group of normal controls reported on by Liles *et al.* [7]. Correlations between intersentential cohesive adequacy and executive function revealed no significant correlations (see Table 2).

Story structure. Many of the TBI subjects produced few complete episodes, but did produce a higher frequency of incomplete episodes. Correlations between measures of

Table 2. *Correlation coefficients for measures of story narrative performance and factors generated from the Wisconsin Card Sorting Test scores*

	Factor 1	Factor 2
Sentence production	0·13	0·11
Cohesion	0·23	0·26
Story structure	0·18	0·51★

★$p < 0.05$.

story structure and executive function revealed a significant correlation of 0.51 ($p < 0.05$) for the percentage of incomplete episodes and WCST factor 2.

Discussion

The intent of the ongoing project from which these results were taken is to further delineate the clinical utility of discourse analyses with mildly impaired adults with TBI. In addition, we are seeking to identify potential causal factors for these deficits, and therefore to better define the nature of communicative deficits secondary to TBI. The results from this investigation reported here, while preliminary, suggest that the rather broad and poorly defined constellation of cognitive abilities known as executive functions may be a promising avenue to pursue in this search for underlying factors of discourse deficits. The following observations are made on these preliminary data:

(1) These results appear to support Ylvisaker and Szekeres' [1] contention that deficits in executive functions may be a significant contributor to the communicative deficits in higher-level TBI individuals.

(2) It is interesting that the only significant correlation noted between our measures of discourse performance and executive function was with story structure, and not sentence production or intersentential cohesive adequacy. This is consistent with the notion that sentence production, as well as the organization of meaning across sentences, or cohesion, while semantic in nature, are more linguistically based than story structure, which appears to be more cognitive in nature. Such a finding emphasizes the importance of using a discourse analysis procedure which allows for analyses to be made at multiple levels. The multilevel analyses of story narratives employed in the present study permits an examination, not only of sentence production and cohesive adequacy, but also of the abilities underlying the organization and production of a story text. The interactions among levels of sentence grammar, cohesion, and knowledge of story structure required for the production of a story may place a communicative load on the TBI individual's performance that may reveal problems not observable in other forms of discourse.

(3) If one considers the components that make up an episode (our primary measure of story structure performance) along with Lezak's definition of executive function, there appears to be a logical basis for the significant correlation noted between the two. An episode consists of a goal, an attempt at achieving the goal, and some consequence marking attainment or non–attainment of the goal. Executive function involves those abilities needed for formulating a goal, as well as a plan necessary for its achievement, and effectively carrying out the plan. However, at this point in time we can only speculate as to why our story structure measure correlated with only one of the factors, factor 2, of our measure of executive function (WCST) and not the other. It may be that factor 2, which was made up of the percentage of perseverative responses which were also errors score, was more of true index of executive function than the more generic scores, such as total cards and categories, which loaded on factor 1. This explanation is supported in part by Heaton's [20] observation that degree of perseveration is the most useful diagnostic measure that is derived from the WCST.

(4) Finally, these findings also provide a logical rationale for addressing executive

functions in the remediation of certain discourse deficits (i.e. story structure) versus a more traditional language-based approach to therapy.

References

1. YLVISAKER, M. and SZEKERES, S. F.: Metacognitive and executive impairments in head-injured children and adults. *Topics in Language Disorders*, **9**: 34–49, 1989.
2. LEZAK, M. D.: The problem of assessing executive functions. *International Journal of Psychology*, **17**: 281–297, 1982.
3. COELHO, C. A., LILES, B. Z. and DUFFY, R. J.: Discourse analyses with closed head injured adults: evidence for differing patterns of deficits. *Archives of Physical Medicine and Rehabilitation*, **72**: 465–468, 1991.
4. COELHO, C. A., LILES, B. Z. and DUFFY, R. J.: Analysis of conversational discourse in head-injured adults. *Journal of Head Trauma Rehabilitation*, **6**: 92–99, 1991.
5. COELHO, C. A., LILES, B. Z. and DUFFY, R. J.: Conversational patterns of aphasic, closed head injured, and normal speakers. *Clinical Aphasiology*, **21**: 183–192, 1993.
6. HARTLEY, L. L. and JENSEN, P. J.: Narrative and procedural discourse after closed head injury. *Brain Injury*, **5**: 267–285, 1991.
7. LILES, B. Z., COELHO, C. A., DUFFY, R. J. *et al.*: Effects of elicitation procedures on the narratives of normal and closed head-injured adults. *Journal of Speech and Hearing Disorders*, **54**: 356–366, 1989.
8. MENTIS, M. and PRUTTING, C. A.: Cohesion in the discourse of normal and head-injured adults. *Journal of Speech and Hearing Research*, **30**: 88–98, 1987.
9. MENTIS, M. and PRUTTING, C. A.: Analysis of topic as illustrated in a head-injured and normal adult. *Journal of Speech and Hearing Research*, **34**: 583–595, 1991.
10. HALLIDAY, M. A. K. and HASAN, R.: *Language, Context and Text: Aspects of language in social-semiotic perspective* (Oxford University Press, Oxford), 1989.
11. LILES, B. Z.: Narrative ability in normal and language-disordered children. *Journal of Speech and Hearing Research*, **23**: 123–133, 1985.
12. STEIN, N. L. and GLENN, C. G.: An analysis of story comprehension in elementary school children. In: R. O. Freedle (editor) *New Directions in Discourse Processing* (Ablex, Norwood, NJ), 1979.
13. BLANK, M., ROSE, S. A. and BERLIN, L. J.: *Preschool Language Assessment Instrument: The assessment of learning in practice* (Grune & Stratton, New York), 1978.
14. KERTESZ, A.: *The Western Aphasia Battery* (Grune & Stratton, New York), 1982.
15. HAGAN, C., MALKMUS, D., and DURHAM, P.: Levels of cognitive functioning. In: *Rehabilitation of the Head Injured Adult: Comprehensive management* (Professional Staff Association of Rancho Los Amigos Hospital, Inc., Downey, CA), 1980.
16. LEVIN, H. S., O'DONNELL, V. M. and GROSSMAN, R. G.: The Galveston orientation and amnesia test: a practical scale to assess cognition after head injury. *Journal of Nervous and Mental Disease*, **167**: 675–684, 1979.
17. MATTIS, S.: Mental status examination for organic mental syndrome in the elderly patient. In: L. Bellak and T. B. Karasu (editors) *Geriatric Psychiatry* (Grune & Stratton, New York), pp. 148–159, 1976.
18. GRANT, D. A. and BERG, E. A.: *Wisconsin Card Sorting Test* (Psychological Assessment Resources, Odessa, FL), 1948.
19. SPREEN, O. and STRAUSS, E.: *A Compendium of Neuropsychological Tests* (Oxford University Press, New York), 1991.
20. HEATON, R. K.: *Wisconsin Card Sorting Test Manual* (Psychological Assessment Resources, Odessa, FL), 1981.