Microlinguistic deficits in the narrative discourse of adults with traumatic brain injury

Article *in* Brain Injury · January 2006

DOI: 10.1080/02699050500110678 · Source: PubMed

Carl A Coelho
University of Connecticut

Richard Feinn
Quinnipiac University

Brain Injury, December 2005; 19(13): 1139–1145

Taylor & Francis
Taylor & Francis Group

ORIGINAL ARTICLE

Microlinguistic deficits in the narrative discourse of adults with traumatic brain injury

C. A. COELHO[1], B. GRELA[1], M. CORSO[1], A. GAMBLE[1], & R. FEINN[2]

[1]*University of Connecticut, Storrs, CT, USA and* [2]*University of Connecticut Health Center, Farmington, CT, USA*

(Received 9 August 2004; accepted 14 February 2005)

Abstract

Background: Recent studies of microlinguistic impairments in the narrative discourse of adults with traumatic brain injury (TBI) have applied syntactic analyses, with some noting no deficits and others specific problems with sentence formulation. An alternative approach to examining the microlinguistic dysfunction in the discourse of individuals with TBI is through the use of propositional analysis. The advantage of propositional analysis is that it enables one to assess semantic complexity of utterances apart from sentence structure and grammaticality.

Aims: The present study applied propositional analysis to the story narratives of participants with TBI and participants with no brain injury (NBI). Specifically, the mean number of propositions within a sentence was tallied, in other words the participants' ability to insert multiple ideas into single surface sentences. It was hypothesized that the participants with TBI would produce fewer propositions per sentence because of organizational problems than the participants with NBI, regardless of level of education.

Methods and procedures: Two story narratives (retelling and generation) previously elicited from the two participant groups (TBI ($n = 53$) and NBI ($n = 42$)) were analysed. For each language sample, the number of propositions was tallied and divided by the number of T-units. The resulting number, the propositional complexity index (PCI), was the average number of predicates per sentence.

Outcomes and results: Results indicated that the group with TBI produced significantly fewer propositions per T-unit.

Conclusions: The present findings are in harmony with the notion that the participants with TBI studied presented with impairments of both micro- and macrolinguistic processes involved with the organization of semantic information in discourse. Clinical implications are discussed.

Keywords: *Traumatic brain injury, discovery, linguistic*

Introduction

Recent studies of the narrative discourse of adults with traumatic brain injuries (TBI) have noted a variety of impairments at both the micro- and macrolinguistic levels [1–9]. Macrolinguistic organization of a text crosses sentential boundaries and is felt to involve non-specific, higher-order, diffusely represented cognitive processes. Examples of macrolinguistic measures include: inter-sentential cohesion, local and global coherence and story grammar. By contrast, microlinguistic or within-sentence analyses involve measures of lexical, syntactic and lexical-syntactic processes and are generally considered to be language-specific. Discourse deficiencies following TBI have been reported to be most pronounced at macrolinguistic levels and least apparent at the levels of lexical and sentential organization [10, 11]. The presence of discourse deficits secondary to disrupted macrolinguistic processes is consistent with the diffuse brain pathology which characterizes TBI. However, the discourse deficits associated with microlinguistic disruptions are more difficult to understand in light of the relatively low incidence of focal left

Correspondence: Carl A. Coelho, PhD, Communication Sciences Department, University of Connecticut, Unit-1085, Storrs, CT 06269-1085, USA. Tel: (860) 486-4482. Fax: (860) 486-5422. E-mail: coelho@uconn.edu

ISSN 0269–9052 print/ISSN 1362–301X online
DOI: 10.1080/02699050500110678

hemisphere lesions and aphasia noted in TBI. Adding to the confusion surrounding the notion of microlinguistic impairments is the inconsistent findings which have been reported. For example, it has been concluded that individuals with TBI demonstrate relatively preserved syntax and syntactic complexity comparable to normal controls in their discourse [1, 5, 12]. Conversely, Glosser and Deser [3] found nine individuals with TBI to be impaired in measures of syntactic completeness and complexity and on a measure of lexical errors. These individuals, however, were diagnosed as having fluent aphasias. In a related study, Peach and Schaude [13] examined the clausal structure in the descriptive narratives of 20 individuals with TBI. Results indicated that, although the syntactic complexity was comparable for the groups with TBI and NBI, the group with TBI produced more syntactic errors including word order transpositions, verb tense and agreement errors and complex alterations.

A different approach to examining microlinguistic dysfunction in the discourse of individuals with TBI is through the analysis of semantics, specifically propositional analysis. An advantage of propositional analysis is that it enables one to examine the semantic complexity of utterances apart from sentence structure and grammaticality [14]. Propositions are meaning units which consist of a predicate (verb, modifier) and its arguments (agent, instrument). A single sentence may contain several propositions [15]. Chapman et al. [16] specified information units in a similar fashion in a study of adolescents with TBI. Using a measure of words per proposition, Chapman et al. did not find deficiencies in information flow. McDonald [17] tallied unspecified propositions in explanations of a board game by two individuals with TBI and found that one individual provided less detail than the non-brain-injured controls.

The present study analysed story narratives from two groups of participants (TBI and normal controls) and calculated the mean number of propositions within a T-unit. A T-unit is similar to a sentence and consists of an independent clause plus any sub-ordinate clauses associated with it [18]. The number of propositions per T-unit is considered an indication of an individual's ability to insert multiple ideas into single surface sentences. It was hypothesized that the participants with TBI would produce fewer propositions per T-unit than the normal controls because of organizational problems that are common sequelae of TBI. In addition, it was predicted that this group difference would not be influenced by level of education or socio-economic status.

Methods

Participants

TBI. Fifty-three native speakers of English who had sustained a TBI were studied. Participants were selected because they had recovered a high level of functional language—that is, they had achieved fluent conversation and did not demonstrate any significant deficits on traditional clinical language tests. In addition, participants were recruited to represent a range of socioeconomic backgrounds.

All participants with TBI met the following criteria: (a) no reported history of substance abuse or psychiatric illness; (b) passing scores on screens for hearing acuity, visual acuity and visual perceptual deficits; (c) an aphasia quotient above 93 on the Western Aphasia Battery [19]; (d) no substantial motor speech disorder as determined by an experienced speech-language pathologist; (e) Rancho Los Amigos Level of Cognitive Functioning [20] of VII (automatic-appropriate) or above; (f) *Galveston Orientation and Amnesia Test* [21] score of 75 or above; and (g) a score of 120 or above on the *Dementia Rating Scale* [22], a general screen of cognitive processing. The group with TBI consisted of 18 females and 35 males with a mean age of 31.7 years (ranging from 16–69 years old). The participants with TBI were also assigned to one of three socioeconomic groups: Professional, Skilled Worker or Unskilled Worker on the basis of the Hollingshead rating [23] (see Coelho [1] for a description). Level of education ranged from 9–21 years ($M = 13.0$ years). All of the participants with TBI had injuries which were rated as either moderate or severe on the basis of criterion established by Lezak [24]. Mean time post-onset was 12.8 months (range = 1–99 months).

NBI. Forty-two hospital employees, working in a variety of capacities, who were native speakers of English served as the control group. No individual in this group reported a history of neurologic disease or injury, psychiatric condition or substance abuse. These individuals also passed screens for hearing and visual acuity. Participants with no brain injury (NBI) were selected on the basis of SES and also assigned to one of three groups: Professional, Skilled Worker or Unskilled Worker on the basis of the Hollingshead rating. Attempts were made to match these individuals as closely as possible with individuals from the group with TBI on the basis of age and gender. There were 30 males and 12 females studied, mean age was 31.9 years (ranging from 16–63 years old). Level of education ranged from 11–22 years ($M = 14.2$ years).

Discourse elicitation procedures

Two story narrative discourse samples were elicited from all participants:

Story retelling task. Participants were presented the picture story, The Bear and the Fly [25], by filmstrip projector on a 23×30.5 cm screen. The picture story has 19 frames with no sound track. Each frame was displayed for $\sim$5 seconds. After viewing the filmstrip, the participants were given the following instruction: 'Tell me that story'. When a participant stopped retelling the story, the examiner would wait 10 seconds then ask, 'Is that the end of the story?' If the participant answered affirmatively, the task was ended.

Story generation task. Participants were presented with a copy of the Norman Rockwell painting, The Runaway. The participants were given the following instruction: 'Tell me a story about what you think is happening in this picture'. The picture remained in view of the examiner and participant until the task was completed. When a participant stopped telling the story, the examiner would wait 10 seconds then ask, 'Is that the end of the story?' If the participant answered affirmatively, the task was ended.

All narrative samples elicited from the individuals with TBI and NBI displayed characteristics of narratives, that is a temporal sequence of events and not simply elaborate descriptions of individual frames from the filmstrip or the Rockwell picture.

Data collection

Each story was audiotaped and later transcribed verbatim. Transcriptions of the stories were distributed into T-units (i.e. an independent clause plus any subordinate clauses associated with it [18]) prior to analysis, following the conventions described by Liles et al. [5]. A T-unit is similar to a sentence but is more reliably identified [26]. Segmenting narratives into sentences can be problematic because of the tendency of some speakers to link sentences of a narrative with conjunctions such as *and*, *or*, and *then*, making it difficult to identify sentence boundaries. Use of T-units, which are objectively defined, solves the problem of continuous conjoining of clauses.

Propositional analysis of story narratives

The propositional analysis, as described by Kamhi and Johnston [14], involved the following steps:

(1) Identify the propositions in each sentence. To identify propositions, each predicate and all its inherent arguments were identified. Predicates involve different numbers of arguments depending on their meanings. Once one proposition was designated as the focal point or 'nucleus', other predicates (i.e. 'non-nuclear') were defined according to their hierarchical relationship to the nuclear proposition. Three 'non-nuclear' propositions are possible:
    (a) Adverbial—proposition that has a nuclear proposition as one of its arguments. For example, 'They washed the car *in* the garage'.
    (b) Embedded—proposition that functions as an argument of the nuclear proposition. For example, 'I asked Alex to *wash* dishes'.
    (c) Associated—proposition with an argument that is also an argument of some other argument network. For example, 'The *commuter* train is arriving'.
(2) The number of nuclear and non-nuclear predicates were tallied and divided by the number of T-units; and
(3) The resulting number, the propositional complexity index (PCI), was the average number of predicates per sentence.

The propositional analysis for each participant was based on the total number of propositions and surface sentences (T-units) from both story narrative samples (generation and re-telling) combined to increase the length of language sample analysed. The total number of words for the combined narrative samples of the group with TBI ($M = 228.6$, $SD = 90.8$) and group with NBI ($M = 252.4$, $SD = 101.4$) were comparable.

Reliability of propositional analyses

Two authors performed all of the propositional analyses. Ten per cent of the narratives were re-analysed by a third author to assess inter-examiner reliability. An additional 10% of the story narratives were re-analysed by the original two authors $\sim$2 weeks after the initial analyses were completed to assess intra-examiner reliability. Reliability measures were based on point-to-point scoring. Inter-examiner reliability was 86% and intra-examiner reliability was 92%.

Results

In order to compare the PCI of the two participant groups across SES levels, an analysis of variance (ANOVA) was applied. An α-level of 0.01 was adopted to control for type I errors. Results revealed no evidence of an interaction between group

Table I. Propositional complexity index scores of participant groups with TBI and NBI across SES levels.

SES	PCI
TBI ($n=53$)	
Professional ($n=18$)	
M	3.25
SD	0.57
Skilled worker ($n=17$)	
M	3.20
SD	0.73
Unskilled worker ($n=18$)	
M	2.84
SD	0.53
Group ($n=53$)	
M	3.10[a]
SD	0.63
NBI ($n=42$)	
Professional ($n=15$)	
M	4.42
SD	1.54
Skilled worker ($n=14$)	
M	3.53
SD	0.79
Unskilled worker ($n=13$)	
M	3.93
SD	0.98
Group ($n=42$)	
M	4.00[a]
SD	1.20

Notes: SES = Hollingshead rating, PCI = propositional complexity index, TBI = traumatic brain injured, NBI = non-brain injured. Means with same superscripts are significantly different at the $p<0.001$ level.

(TBI and NBI) and SES (professional, skilled worker, unskilled worker) for the PCI [$F(2, 94) = 1.97, p = 0.15$], nor main effect for SES [$F(2, 94) = 2.85, p = 0.06$]. A main effect for group was noted [$F(1, 94) = 21.50$, $p < 0.001$] (see Table I). An ε^2 value of 0.19 indicated that the effect size for the group difference was large [27].

Discussion

The present findings support the hypothesis that the participants with TBI would generate fewer propositions per T-unit than the NBI adults. Further, the findings indicated that the PCI for the group with TBI was smaller than the group with NBI, regardless of SES. These results will be discussed from the perspective of what the propositional complexity index represents, whether or not this finding is consistent with what is known regarding other discourse deficits following TBI and how TBI may disrupt discourse production.

Propositional complexity index

Once again, propositions are idea units or semantic information specifically encoded in language structures. In any given narrative, the task of the speaker is to formulate utterances that make his or her communicative intent clear and pertinent to the listener. The extent to which a speaker can produce propositionally complex sentences directly influences the organization and clarity of their spoken discourse [14]. In the present study, the group with NBI demonstrated a higher PCI or 'propositional density' than the participants with TBI. This chunking of information may be considered as a mechanism for linking propositions together and increasing the likelihood that the listener might understand multiple ideas as a connected semantic unit [28]. On the basis of these findings it appears that the participants with TBI were less adept at applying this strategy to facilitate discourse organization.

Levels of discourse processing

Kintsch and van Dijk [29] have proposed that semantic information may be represented at multiple levels. These levels include: the surface structure or microstructure (i.e. meaning contained in words and phrases of a text), the macrostructure (i.e. topic- or gist-level information) and the mental model where the listener constructs a representation of the situation described (i.e. comprehends the text). The notion that a text's representations occur at a number of levels implies that discourse analysis must be performed at multiple levels as well. The primary division in such structural analyses occurs between the analysis of linguistic and of conceptual (semantic) representations [28]. Several types of specific analyses under each of these headings can be undertaken. For example, under the general level of the linguistic structure of the text are lexical analyses, syntactic analyses and analyses which examine the structure of text across sentences as in the assessment of cohesion. The analyses of the conceptual or semantic structure occur at the propositional and frame (i.e. higher level of semantic structure specifying constituents and relations among constituents) levels. Two broad types of cognitive functions assumed to be involved in discourse processing further characterize these levels of analysis, that is whether an analysis is micro- or macrolinguistic in nature. Microlinguistic functions are language-specific procedures for processing phonological and syntactic aspects of single words and sentences in the absence of context. Macrolinguistic functions involve cognitive procedures for integrating linguistic and non-linguistic knowledge for the purposes of maintaining the conceptual, semantic and pragmatic organization of discourse. The critical distinction between these two categories is that the macrolinguistic processes involve analyses of language units as contextual events [30].

At this point, it may be useful to examine the present findings within the context of what is currently known about deficits associated with discourse production following TBI. Toward that end, we will briefly summarize the results of discourse analyses, which have been performed at a variety of levels, on this same set of discourse samples (i.e. two stories each from 53 participants with TBI and 42 participants with NBI). With regard to microlinguistic analyses, the participants with TBI were noted to have comparable scores to the group with NBI on a measure of syntactic complexity (subordinate clauses per T-unit). For measures of macrolinguistic processes, no differences between the groups for cohesive adequacy (proportion of total ties which were complete) were noted; however, the participants with TBI had lower scores on a measure of story grammar performance (proportion of T-units within episode structure) than the group with NBI [1]. The findings from Coelho [1] would seem to indicate that the participants with TBI as a group demonstrated relatively preserved microlinguistic functioning in discourse. The impairments noted in their discourse production were associated with problems in macrolinguistic functions, that is with the interaction between linguistic and conceptual structures. However, the results of the present study, that the TBI group demonstrated lower propositional density scores than the participants with NBI, is not felt to be consistent with that conclusion. An interpretation that is more harmonious with the findings of both studies is that the individuals with TBI demonstrated relatively intact syntactic microlinguistic processes, but impairments were noted in lexical-semantic components. In other words, the findings for the microlinguistic analyses were mixed and a direct reflection of the focus of the analysis. The differences in the findings between the two studies highlight the need for multi-level analyses within each broad category of micro- and macrolinguistic discourse processes.

How does TBI disrupt both micro- and macrolinguistic processes?

Glosser and Deser [3] have specified that microlinguistic, language-specific, functions are dependent on the integrity of a specialized neural system within the left hemisphere. Conversely, macrolinguistic functions depend on different neural systems that are non-focal and bilaterally distributed. How then are both general levels of discourse processes compromised in TBI? One explanation is that the nature of diffuse pathology that characterizes TBI disrupts cognitive processes that sub-serve both linguistic and non-linguistic discourse functions. A variety of underlying cognitive components for discourse have been suggested, but organization is a common link in most. For example, discourse impairment following TBI has been interpreted as a breakdown of the executive control over cognitive and linguistic organizing processes [31]. Similarly, individuals who are proficient at discourse processing are able to integrate prior real-world knowledge to facilitate interpretation of the ongoing discourse. This integration of prior experiences is facilitated through the use of story schemas and script knowledge. Schemas and scripts are cognitive structures that generate expectations about the way a story might progress and organize the understanding of real-world events and their consequences. Both scripts and story schemas are attempts to characterize pre-requisite memory representations of contextual information. Inclusion of irrelevant information during the production of discourse may reflect attentional or memory problems [32].

Conclusion

Previous studies have reported the presence of syntactic impairments in the discourse of survivors of TBI [3, 13]. This apparent discrepancy may be ascribed to differences among the participants with TBI studied. For example, individuals with TBI who are aphasic or individuals who are in more acute stages of recovery may be disoriented and confused and produce disjointed utterances that could be characterized by both semantic and syntactic errors. However, the present finding that the group with TBI had a lower propositional density than the participants with NBI is consistent with the notion that the participants with TBI demonstrated difficulty at the microlinguistic level, specifically with lexical-semantics. These findings in conjunction with those from previous studies [1, 10] suggest that the discourse impairments observed following TBI are the result of disruptions of both micro- and macrolinguistic processes involved with the organization of semantic information in discourse.

Clinical implications

Although there is a growing body of literature on discourse impairments following TBI, there is little empirical evidence to guide the treatment of such deficits. A recent review of the discourse literature identified three data-based discourse treatment studies, with a total of four participants. In the first, a hierarchical technique referred to as 'Strategies of Observed Learning Outcomes' (SOLO) was applied to text management. Treatment focused on training two participants (one post-TBI and one post-CVA) to answer increasingly complex questions based on personally relevant discourse texts. The SOLO programme was based on five levels of abstraction ranging from 'pre-structural', in which there was no relation between the question and the answer, to 'extended abstract', in which there was extrapolation beyond the given situation. After 15 treatment sessions, gains were noted for the individual with TBI in her ability to organize and integrate information and to self-cue and self-monitor her productions. For the individual with CVA, gains were noted in text comprehension. The authors attributed improvements in discourse abilities to the individualized, hierarchical, meta-cognitive and meta-linguistic nature of the treatment programme [33]. In a second study, 'Communication Awareness Training' was applied to an individual with TBI. After an analysis of the individual's communicative performance, nine areas of breakdown were identified by a clinician and the participant's mother. One behaviour in particular was identified as the most disruptive—interruptions—and was selected for treatment. A three-step technique was introduced which involved: increasing awareness of the disruptive behaviour, developing strategies to improve discourse performance and practice in applying the strategies to novel situations. The authors reported a steady decrease in the number of interruptions from baseline levels, generalization to group and social contexts and maintenance of the improvements following termination of treatment [34]. Finally, a meta-cognitive/meta-linguistic approach was introduced in the treatment an individual with TBI noted to have marked difficulty with episode structure during a story generation task. The participant was instructed to first identify then to formulate story structure components. Over the 6-week treatment programme, the individual demonstrated steady gains in his ability to generate story components; however, this did not result in his producing stories which were judged to be qualitatively better or more interesting. Follow-up sessions at 1 and 3 months post-treatment indicated that treatment effects were not maintained. The poor carry-over and maintenance were attributed to the lack of relevance of the treatment materials to this individual's life situation [35]. The mixed findings from this review indicate there is a need for ongoing research pertaining to identifying effective treatment strategies for discourse deficit following TBI.

The results of the present study support the notion that discourse impairments of individuals with TBI are symptomatic of generalized cognitive disruptions of, for example, conceptual knowledge and/or organizational skills, as opposed to linguistic-specific abilities. Various techniques have been suggested for improving organizational and conceptual skills which may have applications for treating discourse impairments following TBI [36]. The finding that such 'organizational impairments' may be manifested at micro- and macrolinguistic levels of discourse processing suggests that the effects of such intervention should be probed at multiple levels of discourse production.

References

1. Coelho CA. Story narratives of adults with closed head injury and non-brain-injured adults: Influence of socioeconomic status, elicitation task, and executive functioning. Journal of Speech, Language, and Hearing Research 2002;45: 1232–1248.
2. Coelho CA, Liles BZ, Duffy RJ. Discourse analyses with closed head injured adults: Evidence for differing patterns of deficits. Archives of Physical Medicine and Rehabilitation 1991;72:465–468.
3. Glosser G, Deser T. Patterns of discourse production among neurological patients with fluent language disorders. Brain and Language 1990;40:67–88.
4. Hartley LL, Jensen P. Narrative and procedural discourse after closed head injury. Brain Injury 1991;5:267–285.
5. Liles BZ, Coelho CA, Duffy RJ, et al. Effects of elicitation procedures on the narratives of normal and closed head-injured adults. Journal of Speech and Hearing Disorders 1989;54:356–366.
6. Snow P, Douglas J, Ponsford J. Discourse assessment following traumatic brain injury: A pilot study examining some demographic and methodological issues. Aphasiology 1995;9:365–380.
7. Stout CE, Yorkston KM, Pimental JI. Discourse production following mild, moderate, and severe traumatic brain injury: A comparison of two tasks. Journal of Medical Speech-Language Pathology 2000;8:15–25.
8. Tucker FM, Hanlon RE. Effects of mild traumatic brain injury on narrative discourse production. Brain Injury 1998;12:783–792.
9. Van Leer E, Turkstra L. The effect of elicitation task on discourse coherence and cohesion in adolescents with brain injury. Journal of Communication Disorders 1999;32: 327–349.
10. Ewing-Cobbs L, Brookshire B, Scott M, et al. Children's narratives following traumatic brain injury: Linguistic structure, cohesion, and thematic recall. Brain and Language 1998;61:395–419.
11. Wolfolk WB, Fucci D, Dutka FE, et al. Differences in narrative productions of closed head-injured adults. The Bulletin of the Psychonomic Society 1992;30:226–228.
12. Mentis M, Prutting CA. Cohesion in the discourse of normal and head-injured adults. Journal of Speech and Hearing Research 1987;30:583–595.
13. Peach RK, Schaude BA. Reformulating the notion of 'preserved' syntax following closed head injury. Paper presented at the annual convention of the American Speech-Language-Hearing Association, November 1986.
14. Kamhi AG, Johnston JR. Semantic assessment: Determining propositional complexity. In: Secord WE, Damico JS, editors. Best practices in school speech-language pathology: Descriptive/nonstandardized language assessment. New York: The Psychological Corp. Harcourt Brace Jovanovich, Inc.; 1992. pp 99–105.

15. Kintsch W. The psychology of discourse processing. In: Gernsbacher MA, editor. Handbook of psycholinguistics. San Diego: Academic Press; 1994. pp 721–740.
16. Chapman SB, Culhane KA, Levin HS, *et al.* Narrative discourse after closed head injury in children and adolescents. Brain and Language 1992;43:42–65.
17. McDonald S. Pragmatic language skills after closed head injury: Ability to meet the informational needs of the listener. Brain and Language 1993;44:28–46.
18. Hunt K. Syntactic maturity in school children and adults. Monographs of the Society for Research in Child Development 1970;35(Serial No. 134).
19. Kertesz A. Western aphasia battery. New York: Grune & Stratton; 1982.
20. Hagan C, Malkmus D, Durham P. Levels of cognitive functioning. In: Hagan C, editor. Rehabilitation of the head injured adult: Comprehensive physical management. Downey, CA: Professional Staff Association of Rancho Los Amigos Hospital; 1980.
21. Levin HS, O'Donnell VM, Grossman RG. The Galveston orientation and amnesia test: A practical scale to assess cognition after head injury. Journal of Nervous and Mental Disease 1979;167:675–684.
22. Mattis S. Mental status examination for organic mental syndrome in the elderly patient. In: Bellak L, Karasu TB, editors. Geriatric psychiatry. New York: Grune and Stratton; 1976.
23. Hollingshead A. Four factor index of social status. Unpublished manuscript, Department of Sociology, Yale University, New Haven; 1972.
24. Lezak M. Neuropsychological assessment. 3rd ed. New York: Oxford University Press; 1995.
25. Winter P. The bear and the fly. New York: Crown Publishers; 1976.
26. Hughes D, McGillvray L, Schmidek M. Guide to narrative language. Eau Claire, WI: Thinking Publications; 1997.
27. Cohen J. Statistical power analysis for the behavioral sciences. Revised ed. New York: Academic Press; 1977.
28. Frederiksen CH, Bracewell RJ, Breuleux A, et al. The cognitive representation and processing of discourse: Function and dysfunction. In: Joanette Y, Brownell HH, editors. Discourse ability and brain damage: Theoretical and empirical perspectives. New York: Springer-Verlag; 1990. pp 69–112.
29. Kintsch W, Van Dijk TA. Towards a model of text comprehension and production. Psychological Review 1978;85:363–394.
30. Glosser G. Discourse production patterns in neurologically impaired and aged populations. In: Brownell HH, Joanette Y, editors. Narrative discourse in neurologically impaired and normal aging adults. San Diego, CA: Singular; 1993. pp 191–212.
31. Ylvisaker M, Szekeres SF, Feeney T. Communication disorders associated with traumatic brain injury. In: Chapey R, editor. Language intervention strategies in aphasia and related neurogenic communication disorders. Philadelphia: Lippincott Williams and Wilkins; 2001. pp 745–800.
32. Ulatowska HK, Allard L, Chapman SB. Narrative and procedural discourse in aphasia. In: Joanette Y, Brownell HH, editors. Discourse ability and brain damage: Theoretical and empirical perspectives. New York: Springer-Verlag; 1990. pp 180–198.
33. Penn C, Jones D, Joffe V. Hierarchical discourse therapy: A method for the mild patient. Aphasiology 1997;11:601–632.
34. Snow PC, Douglas JM. Conceptual and methodological challenges in discourse assessment with TBI speakers: Towards an understanding. Brain Injury 2000;14:397–415.
35. Cannizzaro MS, Coelho CA. Treatment of story grammar following traumatic brain injury: A pilot study. Brain Injury 2000;14:397–415.
36. Parente R, Herrmann D. Retraining cognition: Techniques and applications. Gaithersburg, MD: Aspen Publishers; 1996.