Narrative Discourse after Closed Head Injury in Children and Adolescents

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This study examined narrative discourse in 20 children and adolescents at least 1 year after sustaining a head injury. Narratives were analyzed along the dimensions of language structure, information structure, and flow of information. Severity of impaired consciousness was associated with a significant reduction in the amount of language and information. The most important finding which emerged was the disruption in information structure. This pattern confirms the impression of disorganized discourse in severely injured children. Explanations for the disruption in information structure are explored in terms of the role of vocabulary, memory, and localization of lesion according to magnetic resonance imaging. In view of recent evidence that frontal lobe damage is associated with discourse formulation deficits in adults and is the most common site of focal lesion in closed head injury, we examined discourse patterns in individual patients with frontal lobe lesions. Preliminary data from our single-case studies suggest discourse patterns similar to those reported for adults with frontal lobe injuries. © 1992 Academic Press, Inc.

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INTRODUCTION

During the past decade, investigators have administered quantitative aphasia tests to assess language function in children and adolescents following closed head injury (CHI) (Ewing-Cobbs, Levin, Eisenberg, & Fletcher, 1987; Levin & Eisenberg, 1979; Sarno, Buonagura, & Levita, 1986). Notwithstanding atypical cases of focal lesions in classical language areas, language disturbance subsequent to CHI does not typically conform to conventional types of aphasia. In recognition of this distinction, Sarno et al. (1986) classified the linguistic processing deficits (e.g., problems in naming and word fluency) in adolescents and adults following severe CHI as a "subclinical aphasia disorder." The findings reported by Sarno and her colleagues confirmed earlier reports of subtle language disturbances after CHI even in the absence of aphasia (Levin, Grossman, & Kelly, 1976; Thomsen, 1975, 1976). Studies of language function after pediatric CHI have demonstrated dysgraphia and impaired expressive oral language abilities (i.e., verbal fluency and naming to confrontation), whereas receptive language tends to recover earlier after injury (Ewing-Cobbs et al., 1987; Levin & Eisenberg, 1979).

Notwithstanding the evidence of subtle linguistic disturbances, even quantitative tests seem to provide an incomplete characterization of the language difficulties observed in CHI patients. Case reports of children (Ylvisaker, 1986) and studies of adults sustaining CHI (Ehrlich, 1988; Mentis & Prutting, 1987; Wyckoff, 1984) have suggested that language deficits at the discourse level persist despite recovery of performance on structured language measures. Indeed, numerous researchers have proposed that discourse studies may provide the neurolinguistic sophistication necessary to clarify the scope of the communicative problems frequently described in CHI patients and elusive to traditional language measures of word and sentential level abilities (Dennis & Barnes, 1988; Dennis & Lovett, 1990; Ehrlich, 1988; Ewing-Cobbs, Fletcher, & Levin, 1985; Ewing-Cobbs et al., 1987; Jordan, Ozanne, & Murdoch, 1988; Mentis & Prutting, 1987; Wyckoff, 1984; Ylvisaker, 1986).

Discourse in CHI adults has been characterized as reduced in information content, fewer cohesive ties, increased hesitational phenomena, and decreased efficiency (Ehrlich, 1988; Wyckoff, 1984). Discourse deficits identified in CHI children and adolescents include problems in interpreting both ambiguous sentences and metaphors, drawing inferences, and formulating sentences from key words (Dennis and Barnes, 1990). Additionally, sentential complexity within discourse is reportedly simplified (Campbell & Dollaghan, 1990).

Discourse studies have also reported preliminary data on localized cerebral lesions, particularly discourse formulation deficits in patients with frontal lobe damage (Alexander, Benson, & Stuss, 1989; Kaczmarek,
In fact, separate discourse deficits have been postulated for different regions within the frontal lobes, i.e., dorsolateral and orbitofrontal (Kaczmarek, 1984). Although the frontal region is the most commonly identified site of focal lesion after CHI (Adams, Graham, Scott, Parker, & Doyle, 1980), the relationship between discourse formulation ability and frontal lobe injury in adults awaits confirmation in children.

It is a common belief that discourse representation is impaired in pediatric populations after sustaining a CHI (Dennis & Lovett, 1990). However, the nature of this discourse impairment is not well understood nor are the underlying mechanisms contributing to the disruption clear. Little evidence exists as to whether the discourse disruptions observed in CHI children and adolescents are associated with changes in measures of language and/or information. At a theoretical level, it has been postulated that deficits in language structures (e.g., lexical/semantic or syntactic abilities) will impact discourse abilities (Caplan & Evans, 1990; Dennis & Barnes, 1990; Ulatowska & Chapman, 1991). Since naming deficits and syntactic simplification have been identified in CHI children (Campbell & Dollaghan, 1990; Ewing-Cobbs et al., 1987), studies which examine the association between these deficits and discourse abilities are needed.

In regard to information structure, preliminary evidence suggests that information is reduced in pediatric CHI patients (Szekeres, Ylvisaker, & Holland, 1985). However, the nature of the information reduction is not clear. The primary issue to be addressed is whether the reduction of information reflects a loss of essential information, simply a loss of supporting details (or less important information), or both. Studies of other brain-injured populations (i.e., aphasic patients) have shown that information may be selectively reduced such that the important information is preserved whereas the less important information tends to be omitted (Ulatowska, Freedman-Stern, Doyel, & Macaluso-Haynes, 1983). Discourse representation is also reflected in the flow of information, as manifested by the amount of language relative to the amount of information conveyed, as well as the frequency of revisions and repetitions of information. Disruptions in informational flow have been reported for adult CHI (Ehrlich, 1988; Wyckoff, 1984) and for pediatric CHI patients (Campbell & Dollaghan, 1990). At present, no studies exist which have systematically examined the representation of discourse according to language structures, information structures, and informational flow in CHI children at follow-up intervals of 1 year or more.

The mechanisms most commonly held responsible for difficulties in discourse formulation for CHI patients are cognitive deficits, particularly memory deficits. Although memory deficits are pervasive in CHI populations (Levin, 1990), their role in producing discourse deficits is unclear.
The relationship between memory and discourse formulation in children who sustain CHI has not been carefully examined.

Thus, the primary purpose of the present study was to examine narrative discourse abilities in children and adolescents at least 1 year postinjury. Specifically, we investigated the relationship between severity of impaired consciousness and discourse representation for three domains, i.e., language structures, information structures, and information flow, in discourse formulation. Additionally, performance on traditional measures of vocabulary and verbal memory was analyzed in order to consider the potential influence on discourse. Assessment of working memory was of particular relevance to our study because the experimental task involved story recall. Finally, case descriptions are presented for four brain-injured children with focal frontal lesions (including three CHI patients and one case with a traumatic aneurysm) to examine whether frontal lesions in children are associated with patterns of discourse disruption similar to those described in adult populations.

METHODS

Subjects

Twenty head-injured patients, including 19 who had sustained CHI and 1 patient with a gunshot wound, were selected from consecutive admissions to the neurosurgery services at Parkland Hospital, Dallas and John Sealy Hospital, Galveston. All subjects were part of a larger study investigating long-term recovery of cognition related to frontal lobe function. Criteria for admission in the study were: (1) current age between 9 and 18 years; (2) a postinjury interval of 1 to 5 years; (3) no prior diagnosis of learning disability or other neuropsychiatric disorder; and (4) no evidence of child abuse. All but 2 CHI patients underwent magnetic resonance imaging (MRI) which was performed within 1 month of the neurolinguistic assessment (MRI was declined by the families of 2 patients). Injury severity was assessed using the lowest postresuscitation Glasgow Coma Scale (GCS) score (Teasdale & Jennett, 1974). CHI was classified as mild/moderate (n = 11) if the GCS score was greater than 8. A GCS score of 8 or less was indicative of a severe head injury producing coma (n = 9). Impairment of consciousness was minimal for the patient sustaining the gunshot wound (see Table 1, Patient 19), thus this patient was included in the mild/moderate group.

Table 1 summarizes demographic and clinical features of individual patients including computed tomography (CT) findings obtained during the initial hospitalization, as well as MRI findings and academic status at the time of study. Twenty normal children were selected for comparison with the CHI patients. A control child was individually matched to each head-injured patient according to age, gender, and parental socioeconomic level as reflected by education and employment.

Materials

The experimental tasks involved two complex adventure stories (Appendix), Buried Alive and Shipwrecked, taken from the Xerox Education Publication and modified by Merritt and Liles (1987) for the purposes of examining discourse ability in language disordered children. The stories were of similar length and complexity in terms of the amount of language (number of clauses, 45; and number of sentences, 28) and the amount of infor-
<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Age at injury (years)</th>
<th>Age at testing (years)</th>
<th>Injury-test interval (years)</th>
<th>Sex</th>
<th>GCS</th>
<th>Time until obeyed commands (days)</th>
<th>Cause of injury</th>
<th>Early CT findings</th>
<th>MRI findings</th>
<th>Size (cc)</th>
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<tr>
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<td>L. inferior and rectal frontal encephalomalacia</td>
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</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>L. BGH</td>
<td>L. temporal atrophy</td>
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<tr>
<td>2</td>
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<td>11.21</td>
<td>3.14</td>
<td>M</td>
<td>4</td>
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<td>R superior and orbital frontal gliosis;</td>
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<td></td>
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<td></td>
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<td>R temporal SDH</td>
<td>R temporal atrophy</td>
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<td>M</td>
<td>6</td>
<td>0.125</td>
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<td>R temporal fracture and contusion</td>
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<td>Regular classes</td>
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<td>2.42</td>
<td>M</td>
<td>6</td>
<td>3.000</td>
<td>Auto</td>
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<td>MVA</td>
<td>L temporal contusion</td>
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<td>M</td>
<td>9</td>
<td>15.000</td>
<td>MVA</td>
<td>L SAH; L BGH</td>
<td>R middle frontal gliosis; splenial hemorrhage</td>
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<td>R temporal fracture and SDH</td>
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<td>MVA</td>
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<td>Regular classes</td>
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<td>Normal</td>
<td>—</td>
<td>Regular classes</td>
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<td>1.98</td>
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<td>Hit by object</td>
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<td>—</td>
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<td>Aneurysm</td>
<td>Bifrontal IH</td>
<td>Not available</td>
<td>—</td>
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</tbody>
</table>

* BGH, basal ganglia hematoma; bilat, bilateral; EPH, epidural hematoma; GCS, Glasgow Coma Scale; GSW, gunshot wound; III, intracerebral hematoma; IVH, intraventricular hematoma; MVA, motor/vehicle accident; SAH, subarachnoid hemorrhage; SDH, subdural hematoma.

* Patient data not included in group b-analyses.
FIG. 1. A conceptual model of discourse processing depicting the interdependency of cognitive information handling processes and discourse representation at multiple levels in the linguistic and informational structure domains.

mation (number of units of information/propositions, approximately 66; and number of episodes, 4). Relatively long stories were chosen to preclude verbatim recall. We were interested in how well the CHI children were able to structure language and information in retelling the story.

Procedure

One of the two experimental stories was read individually to each child by the examiner in a quiet testing room. Before reading the story, the examiner instructed the child that he/she was to listen carefully to a story which he/she would be asked to retell in as much detail as possible. No prompting was given during the retelling unless it was unclear if the child's story had ended. The stories were audio recorded and transcribed verbatim including repetitions and revisions of information.

Discourse Measures

The stories produced by the CHI and control children were analyzed according to three domains, i.e., language structure, information structure, and flow of information. Each of these domains represents theoretical constructs underlying discourse processing (Chafe, 1980; Frederiksen, Bracewell, Breleux, & Renaud, 1990; Halliday & Hasan, 1976; Kintsch & van Dijk, 1978; Labov, 1972; Levelt, 1989). According to the conceptual model illustrated in Fig. 1, discourse representation is realized through both language structures (Domain I) and information structures (Domain II), each of which is composed of multiple variables. Detailed descriptions of measures of discourse representation are presented in Cannito,
Hayashi, and Ulatowska (1988) and in Ulatowska, Allard, and Chapman (1990). The processes related to information handling depicted in the Discourse Processing Model (Fig. 1) are not addressed in the present study. The third domain, i.e., flow of information, reflects the balance between linguistic and information structure (e.g., the relationship between amount of language used to express a similar amount of information). The variables composing each domain are described in the next section.

Domain I: Language structure. Language structure was assessed during four measures (Table 2): (1) total number of words (excluding repetition and revisions), (2) total number of T-units (roughly equivalent to a sentence) defined as one independent clause and all dependent clauses that modify it (Hunt, 1965); (3) mean number of words per T-unit, and (4) a measure of sentential complexity. Sentential complexity was assessed by the percentage of T-units containing dependent clauses (complex sentences) relative to the total number of T-units produced (simple + complex).

Domain II: Information structure. The composition of Information structure (Table 2) included analyses of propositions (units of information), story structure (episodic structure), and global story content (“gist”/macrostructure). A proposition is defined as a unit of meaning (information) and consists of a predicate (e.g., verbs, modifiers, and connectors) with one or more arguments (Kintsch & van Dijk, 1978). Propositional analyses entailed segmenting the original story information (a priori propositions) as well as segmenting the stories of individual patients into propositions. The a priori propositions were used as a template against which the children's story productions were compared.

Additionally, a story component analysis was completed on the two original stories using the method described by Labov (1972). Each unit of information (proposition) was classified to which story component it belonged (Table 2). According to Labov, story components include essential and optional components. The essential components include setting (identification of characters, time, and place), complicating action (event sequence), and resolution (final outcome). Optional components are evaluation (qualifies or modifies the event sequence, typically marked linguistically by adverbs and adjectives), abstract (initial summary of story content), and coda (literary closure at the end of the story). For this study, we examined the amount of information (measured by number of propositions) expressed for the story components of setting, complicating action, resolution, and evaluation. The components of abstract and coda were not evaluated, since they typically consisted of only a single statement.

In addition to amount of information, information structure was tapped by measures of story structure and global story content (Table 2). Story structure was analyzed in terms of number of complete episodes. An episode is the basic building block of narrative structure and is defined as a temporal sequence of events (Roth & Spekman, 1986). Episodic boundaries are demarcated by closings/resolution of one episode with the new episode beginning with a change in setting (e.g., change in time, place, or participants).

Global story content (macrostructure) is parallel to a skeletal outline containing the most important information or the “gist” of the story (van Dijk, 1985). In order to evaluate intactness of story macrostructure, a set of 10 propositions (from the approximate 66 original propositions) was established a priori based on the major setting, event, and resolution information for the episodes, which preserved the gist of the story. These “gist” propositions provided a way to examine the selective nature of information reduction, i.e., to address whether the gist of the story is preserved regardless of the amount of information produced.

Domain III: Flow of information. Flow of information was composed of two measures, both related to efficiency of expression (Table 2). One variable assessed hesitational phenomena as manifested by number of repetitions and revisions per T-unit. This factor was used to examine whether CHI children exhibit increased disruptions in the flow of information as described for CHI adults (Wyckoff, 1984). The second measure evaluated the ratio of the amount of language to the amount of information, i.e., the total number of
words divided by the total number of informational units or a priori propositions. This ratio was included to address whether CHI children use more language to express the same amount of information as normal control subjects, a pattern found in CHI adults (Ehrlich, 1988).

Scoring Reliability for Discourse Measures

The information structure for all the narratives produced by the children was independently analyzed by two examiners in terms of number of propositions, gist information, and complete episodic structure. Interjudge reliabilities of 88% for total propositions and 89% agreement for both episodic structure and macrostructure (gist) were obtained. When disagreements in coding occurred, they were resolved by discussion so that point by point agreement in scoring was achieved. Independent analysis of amount and complexity of language for 50% of the stories disclosed 89% agreement.

Lexical and Verbal Memory Measures

Lexical test. The vocabulary subtest from the Wechsler Intelligence Scale for Children—Revised (WISC-R) (Wechsler, 1974) was utilized to evaluate knowledge of both concrete and abstract words. The vocabulary test data were analyzed to determine whether groups were comparable on structured language at a lexical level.

Test of verbal memory. To address the potential role of working memory deficits on discourse retelling, a test of verbal recall, i.e., the California Verbal Learning Test—Children's Version (CVLT) (Delis, Kramer, Kaplan, & Ober, 1987), was administered. The test consists of a list of 15 words presented orally over five immediate-recall trials. The list consists of five semantically related words from three categories with adjacent words from different categories. The test also contains a second “interference” list which is given following the five trials of the first list. For this investigation, scores from only the first trial were used to evaluate differences across the three groups, since the experimental story recall task involved immediate recall after only one telling of the story.

RESULTS

Discourse Measures

The effects of severity of head injury on discourse performance were analyzed for the domains of language structure, information structure, and information flow. A multivariate analysis of variance (MANOVA) was performed on the scores of each domain for the mild/moderate CHI, severe CHI, and normal control groups. There was a significant group effect for Domain I (Linguistic structure), Wilks $\lambda = 0.596$, approximate $F(8, 68) = 2.52$, $p = 0.019$, and for Domain II (Information structure), Wilks $\lambda = 0.456$, approximate $F(12, 64) = 2.57$, $p = 0.008$, but not for Domain III (Flow of Information), Wilks $\lambda = 0.873$, approximate $F(4, 72) = 1.27$, $p = 0.29$.

To explore the vulnerability of individual parameters of linguistic structure and information structure, univariate analyses of variance were performed on the component variables comprising each of these domains. In view of the nonsignificant group effect for Flow of Information, the component measures were not analyzed further. Table 2 displays the results of the comparisons across the three experimental groups, i.e.,
TABLE 2: DISCOURSE AND NEUROPSYCHOLOGICAL FINDINGS FOR PATIENTS GROUPED BY INJURY SEVERITY

<table>
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<tr>
<th>Measures</th>
<th>Severe (n = 9)</th>
<th>MILD/MOD (n = 11)</th>
<th>Control (n = 20)</th>
<th>F(2, 37)</th>
<th>p</th>
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<td>X</td>
<td>SD</td>
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<tr>
<td>Amount</td>
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<tr>
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<td>53</td>
<td>172&lt;sup&gt;b&lt;/sup&gt;</td>
<td>41</td>
<td>173&lt;sup&gt;a&lt;/sup&gt;</td>
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<tr>
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Note. Significant (p < .05) pairwise differences using Tukey's test are indicated by matching superscript letters.
mild/moderate CHI, severe CHI, and normal control groups on the discourse measures. Pairwise comparisons were performed using Tukey's test.

*Domain I (Linguistic structure).* As indicated in Table 2, the severe CHI group produced significantly less language in retelling a story than either the mild/moderate CHI or the control groups. The reduction of language was observed in the number of words and the number of sentences. No significant differences in sentential length (words/T-units) or complexity (percentage complex T-units) were found across the three groups.

*Domain II (Information structure).* Differences across the three groups on measures related to information structure were examined. As depicted in Table 2, the severely injured group differed from the control group on measures of amount of information, whereas no other pairwise comparisons were significant on this variable. The severely injured group showed a significant reduction in the essential story components of setting and complicating action compared to the control group. No significant differences were found for the story components of resolution and evaluation.

On measures of information organization, the severely injured patients differed significantly from both the control and the mild/moderately injured CHI patients on episodic structure and macrostructure (global content). The pattern of impairment in episodic structure was characterized by failure to signal a new episode with setting information and omission of essential action information for the severely injured group. Impairment in story macrostructure for the severely injured group was manifested by significant loss of the core information (10 core propositions condensed from the approximate 66 original propositions). Little difference was found between the mild/moderately injured CHI group and the control group.

*Lexical and Verbal Measures*

Scores for the head-injured and control groups on the vocabulary (WISC-R, vocabulary subtest) and the verbal memory (CVLT) measures were analyzed using analysis of variance. Pairwise comparisons using Tukey's test were performed. Although the overall group effect on the vocabulary test approached significance, the group differences in verbal memory (first trial of the CVLT) were less impressive (Table 2). Additionally, an analysis of covariance revealed a significant effect of injury severity on story recall while controlling for verbal memory (number of words recalled on trial 1 of the CVLT) \((F(2, 35) = 6.03; p = 0.006)\).

*Individual Case Reports*

In this section, individual cases are presented as preliminary data regarding the discourse performance of patients with frontal lobe damage.
documented by MRI. Of the nine patients with focal abnormalities on MRI, seven had frontal lobe involvement and five had temporal lobe lesions or atrophy (See Table 1). At the present stage of our research, the distribution of GCS scores in our frontal lobe patients reflects more severe acute injury compared to the extra-frontal lobe lesion group (Table 1). Although this disparity in severity of injury precluded an analysis of localization of lesion, we selected three head-injured patients with frontal lobe lesions to examine the potential effects of frontal lobe damage on discourse (See Table 1, Patients 1, 2, and 5). For comparative purposes, an additional case (Patient 21, in Table 1; not included in the previous group analyses) who sustained bilateral frontal lobe lesions subsequent to a traumatic aneurysm is presented. This traumatic aneurysm patient is included to characterize the effects of well-defined frontal lesions without the contribution of diffuse cerebral insult.

As shown in Table 1, Patients 1 and 5 were similar in age at testing, initial severity of injury, and the presence of left frontal lesions. As illustrated in Figs. 2 and 3, the lesion focus for Patient 1 involved primarily the left gyrus rectus, with primary involvement of the left middle and
Fig. 3. T2 weighted (3000/60/2) coronal image through the frontal lobes of Patient 5 shows abnormal increased signal intensity involving both the white matter and the adjacent cortex of the left middle and superior frontal gyri secondary to post-traumatic encephalomalacia. There has been an overlying craniectomy performed. See Table 1 for demographic and clinical information.

Stories for Patients 1 and 5 appear in the Appendix. The most striking feature of their stories was the sparse amount of detail. Both head-injured children exhibited a marked reduction in the amount of language compared to normal, mild/moderate CHI, and even the severe CHI group (4 T-units to retell the entire story). Sentential length and complexity were decreased for Patient 1, whereas sentential abilities for Patient 5 were comparable to performance of normal children. The severe reduction in language for both patients was paralleled by reductions in gist information and essential story component units (e.g., setting, action) as shown in Fig. 4. It is interesting to note that both subjects retold information solely from the first episode and completely omitted information from the subsequent three episodes. Patient 1 produced an inaccurate resolution according to the story stimulus. Patient 5 had difficulties in formulating and sequencing information as evidenced by repetition of information.
The cost of the dramatic reduction of information was the loss of essential information necessary for maintaining story structure and for preserving the core content (gist). This pattern raises the question as to whether the impairment of discourse reflects a more global impairment involving other cognitive domains. The results from these two patients do not support such a view. Both patients had average to at least low average performance on vocabulary scores. Verbal fluency measures were within normal limits for both patients. Patient 1 showed impaired memory function on the CVLT—trial 1, whereas Patient 5 performed within normal limits.

The third case with a frontal lesion, Patient 2, was 11 years old at time of testing and 8 years old when he sustained a CHI similar in severity to those of Patients 1 and 5 (Table 1). Patient 2 had parenchymal involvement restricted to the right superior and orbital frontal gyri. As indicated in Table 1, nonparenchymal involvement of the right temporal region was also noted. He is currently in resource classes at school. This patient’s story (see Appendix) was not reduced relative to controls in amount and complexity of language. However, the amount of story information in Patient 2’s story was reduced. Moreover, his story contained inaccurate information and the relation between the temporal sequence of events was disrupted (Fig. 4). This child had difficulty moving from one part of the story to the next. While it appeared that he attempted to produce a
number of episodes, episodic boundaries were not marked by resolutions or explicit setting information. The most interesting aspect of this patient's story was the disruption in information structure similar to that of the previous cases, despite a relative preservation in the amount of language. On cognitive measures, Patient 2 showed average performance on the vocabulary subtest with reduced performance on the memory measure.

The fourth case, Patient 21, suffered a traumatic aneurysm with well-defined frontal lesions depicted by computed tomography (MRI was not performed because of his aneurysm clips). He was 16 years old at testing and 11 years old at injury. Although this patient had a reduction in amount of language compared to controls, sentential complexity and length were preserved. As illustrated in Fig. 4, Patient 21 did not show the degree of impairment in setting and resolution information compared to the severely injured group or the three frontal patients presented above. However, the reduction of action information was marked and disrupted the story structure. In fact, this patient only produced one complete episode. While Patient 21's performance was less impaired than that of the other three patients, he clearly showed omission of action information and disruption in episodic structure compared to the mild/moderate CHI group and normal controls. It is unclear whether the somewhat better performance of Patient 21 was due to his older age, differences at either test or injury, stimulus differences, or injury mechanism.

In sum, the three CHI patients with frontal lobe injuries (Patients 1, 2, and 5) showed marked impairment in information structure as measured by story structure (episodic structure) and macrostructure (global story content/gist) even compared to the mean performance levels for the severely injured group (Fig. 4). The patient with bifrontal lobe lesions due to traumatic aneurysm displayed similar, although not quite as severe, discourse disruptions in reduction of the “gist” information and disruption of episodic structure (1/4 complete) compared to the other frontal lobe patients.

**DISCUSSION**

Our findings indicate that narrative discourse on a story retell task was impaired in children at least 1 year after sustaining a severe CHI. The discourse of the severe CHI group differed from that of the control group on both language and information structures and from that of children who sustained mild/moderate CHI on information structure measures of narratives. No significant differences, however, were found for flow of information measures.

The failure to find significant differences in flow of information for the severe CHI children in our study is inconsistent with evidence from studies of adult CHI patients (Ehrlich, 1988; Wyckoff, 1984). The disparity in findings may be consequent to different task demands or maturational
issues. Tasks involving a more spontaneous generation of discourse than required for a retell task may place increased cognitive demands on the patient resulting in greater use of hesitational phenomena. Another possibility is that the relatively intact flow of information in severe CHI children compared to normal children may be more apparent than real. The fact that the overall amount of language was reduced in the severe CHI children in this study may account for the seemingly normal ratio of flow of information.

It is not surprising that the severe CHI children produced less language and less information than the normal children in retelling a story. However, a more salient finding is the disruption in story structure which was manifested primarily by omission of critical setting and action information. This evidence for impaired story structure was not necessarily expected since story structure is developed early in life (Botvin & Sutton-Smith, 1977) and is more resistant to disruption than sentential language in aphasic patients (Ulatowska et al., 1983).

The disruption in story structure for recalled stories may contribute to the perception of disorganized discourse frequently alluded to in CHI patients' discourse (Ylvisaker, 1986). The disruption in story structure may reflect an underlying impairment in an internal story schema or perhaps a difficulty implementing a story schema during ongoing discourse formulation. The nature of our experimental tasks, however, does not allow us to determine the basis for disruption of story structure.

It is likely that subgroups of head-injured patients have impaired story structure for different reasons, including severity and mechanism of initial injury, localization of brain lesions, and age at injury, to mention a few. Our findings are relevant to both the severity of head injury and the localization of lesion. For severity, children with mild/moderate injuries did not exhibit significant differences from the controls on story structure for the story recall task in contrast to the differences observed for the severe CHI children. It is interesting to note that the discourse performance of our gunshot wound patient (Patient 19), who sustained posterior, frontal, and parietal damage with minimal impairment of consciousness was also unimpaired relative to that of controls. However, we can not rule out the possibility that children with milder injuries manifest deficits in information structure at some level.

Our findings are consistent with individual case studies of children with other neuropathologies involving the left hemisphere, including a 9-year-old stroke case involving the left hemisphere (Dennis, 1980) and two adolescents who underwent left hemidecortication in infancy (Dennis & Lovett, 1990; Lovett, Dennis, & Newman, 1986; Newman, Lovett, & Dennis, 1986). Similar to our two patients with left frontal lesions, the stroke case described by Dennis (1980) produced a simplified narrative at both sentential and discourse levels. Moreover, their patient did not
spontaneously produce any embedded episodes. In contrast to our single-case reports, narratives were reduced in informational content for the left hemidecorticate children compared to a right hemidecorticate child. In our study, informational content was reduced for CHI patients with both left and right frontal lesions. However, the amount of language was reduced for only the left frontal patients. It is unclear whether the quantitative differences in information are due to different injury mechanisms, extent of injury, age at injury, discourse measures, or other phenomena.

While the present results must be interpreted cautiously, the discourse profiles of the three CHI patients and one traumatic aneurysm with frontal lesions paralleled the profile of prefrontal patients summarized by Alexander et al. (1989). In their review of the literature, Alexander et al. characterized the discourse of patients with left prefrontal lesions as unelaborated and sparsely detailed narrative, whereas the discourse of right prefrontal patients was tangential. We postulate that frontal lesions may disrupt the organizational schema which guide discourse formulation. Individual differences in discourse observed among our frontal patients may be due, in part, to different lesion localization within the frontal lobes. Kaczmarek (1984) suggests that the functions of the frontal lobes are not unitary, at least for adults. In support of this view, he characterizes different discourse patterns for adult patients with left dorsolateral and left orbitofrontal lesions. Alternatively, the frontal cortex may be less modular in children than in adults. Investigations which compare children at various ages in development are needed to address this issue. It was not within the scope of the present study to examine age at injury; however, this factor presents a possible confound. The consequences of a severe head injury on discourse may differ depending on the developmental stage of story schema acquisition. The impact of an early versus late injury on discourse abilities in severe CHI children warrants further investigation.

Additional factors which may contribute to the discourse deficits observed in our severely injured CHI population include vocabulary deficits and working memory deficits. Concerning vocabulary, Dennis and Barnes (1990) recently reported a strong association between vocabulary and specific discourse abilities for interpreting ambiguous sentences and figurative language. For the present study, the effect of head injury severity on a measure of vocabulary approached but failed to reach significance.

In terms of working memory, it seems intuitive that memory capacities would be directly related to ability to recall and structure story information on an auditory retell task. The results from our study, however, indicate that the impairment of discourse ability after severe head injury cannot be accounted for entirely by a disturbance of working memory, at least as measured by word list recall. From a theoretical perspective, this finding is not unexpected since discourse theories have suggested that text recall
is not explained by working memory theories (Bartlett, 1932). Instead, text recall is better accounted for by hierarchical theories (e.g., Kintsch & van Dijk, 1978; Labov, 1972) which conceptualize the retention of certain information and the loss of other information. The pattern of results indicates that the discourse parameters were measuring some differences that were not apparent on the selected vocabulary and memory on discourse. Although the specific vocabulary and memory measures used in the present study did not show differences across groups, other language and cognitive measures may have revealed differential abilities. Indeed, the roles of vocabulary and memory in discourse remain important variables to consider.

Our findings confirm recent evidence of discourse problems in pediatric CHI populations even though divergent methodologies and discourse types were utilized (Campbell & Dollaghan, 1990; Dennis & Barnes, 1990). Dennis and Barnes (1990) documented persistent discourse problems in head-injured children and adolescents between 1 and 9 years postinjury. Dennis and Barnes tapped component processes underlying discourse performance on separate measures, e.g., interpreting ambiguous sentences, figurative language, and inferences. In contrast, the ability to structure language and information at multiple levels for narrative story production was examined in the present study.

Campbell and Dollaghan (1990) investigated impairment of conversational discourse in CHI children and adolescents 1 year postinjury by examining language comprising a conversational sample at lexical and sentential levels. Patterns of discourse organization were not reported. Consequently, comparisons between information structure at a discourse level for narrative and conversational discourse are not possible. The Campbell and Dollaghan study of conversational discourse in CHI children provided important information that sentential level language necessary for building higher levels of language was impaired. Consistent with our findings, Campbell and Dollaghan’s patients produced significantly fewer sentences than the normal children. Counter to our findings, their children exhibited a reduction in sentential complexity. In our study, differences in sentential complexity failed to reach significance. The disparity in sentential performance between studies may be due to inherent differences between the two discourse genres or task differences. Our narrative task did not require spontaneous generation of ideas, but rather retelling a previously presented story. Perhaps the auditory model aided the patients in producing more complex utterances for our task. Moreover, narrative discourse may not require as complex or diverse sentential structure as conversational discourse.

For future investigations of discourse performance in CHI patients, verification of the present findings of impaired story structure is warranted.
In addition, further examination of the underlying mechanisms contributing to impaired story structure is necessary. Methodologies which probe conditions under which story structure is impaired and preserved will help illuminate the mechanisms contributing to any disruption in information structure. For example, comparisons of story structure for narrative elicited by using picture sequences (explicit depiction of story structure) with spontaneously generated narratives (implicit story structure) will clarify the extent of impaired story structure. It would be of interest to determine whether the present findings would be confirmed if simpler stories (e.g., reduced number of episodes) were used. Additionally, discourse genres other than narratives may be more sensitive to disruptions in CHI patients with milder degrees of impairment. Discourse genres such as procedural, conversational, and expository, differ in terms of characteristic components, unique organizational structure, elements of meaning, and sentential complexity demands. Narrative discourse may be more resistant to disruption since its structure represents a clear organization of information reflected in a chronologic sequence of events. Discourse genres with less conventional structure, e.g., expository, may be more impaired in CHI populations. Other discourse genres may require more complex syntax than stories, and thus may be more sensitive to linguistic differences in CHI populations. In addition to examining organization of discourse representation, probes which tap information handling processes underlying discourse formulation as illustrated in the Discourse Processing Model (Fig. 1) offer a promising direction for future research. It is possible that CHI patients may be able to isolate certain information (using probe questions) which they did not make explicit when generating a story. Moreover, the preliminary evidence of parallel discourse patterns in children and adults with frontal lesions encourages future studies to compare the relationship of discourse performance in CHI patients with frontal versus extrafrontal lesions.

The most important implication of the present study is the merit of using discourse measures to examine the communication problems in CHI populations. In particular, the application of conceptual models which examine both language and information structures in discourse formulation may provide insight into the disorganization of discourse so often alluded to in CHI populations, but elusive to objective documentation.

We acknowledge that our statistically significant results do not necessarily translate as functional incompetence as eloquently cautioned by Newcombe (1991). However, we believe that discourse studies provide a promising avenue for understanding communicative competence in CHI patients. Moreover, discourse studies may illuminate the impact of certain cognitive deficits (e.g., memory) on communicative abilities and subsequently provide functional rehabilitative strategies.
APPENDIX

I. Narrative Discourse Story Materials

A. "Shipwrecked." Once there were three brothers who fished together in the ocean. They were good sailors and usually were gone from home for only a short time. One day, they all fell asleep on their boat. While they slept, the anchor broke loose and the boat drifted away in the dark night. It finally crashed against some rocks. The boys woke up frightened but then saw an island about a mile from the wrecked boat. They swam for their lives and finally all reached the island. The boys were grateful to be alive but they knew they were lost.

In the beginning, life on the island was very hard. The boys could not find fresh water or food. But they knew they could survive if they worked together. First, they looked for coconuts. Then they caught birds with their bare hands and cooked them over an open fire. They always had enough to eat and drink and never felt hungry again.

The blazing sun was always hot on the island. But one day the rainy season began. The brothers knew they had to build a shelter. They searched the island and found parts of their wrecked boat. They tied the wood together and built a simple cabin and kept dry when the rain came.

The boys still dreamed every night of returning home to their family. One day, they spotted a ship. They became excited and set fire to some large bushes. The black smoke rose high in the sky and the ship's captain spotted it. He ordered his men to go ashore, where the sailors were welcomed by the three brothers. They shouted their thanks. After 15 long months on the island, they were finally going home.

B. "Buried Alive." Jim had been a truck driver for 20 years. He was a very careful driver and he never took chances. One day it had been snowing for several hours. The roads were getting bad and Jim could hardly see where he was going. He wanted to get home safely, so he looked for a wide place at the side of the road, pulled over his eighteen-wheeler, and fell fast asleep. He was finally able to relax.

Jim woke up many hours later. It was dark inside the truck but his watch said it was morning. The snow on the truck was keeping the sun out. Jim knew he was trapped. First, he turned on the windshield wipers. Then he tried to push open the door. But the wipers and the door wouldn't budge. Jim started to worry.

By noontime, it was getting harder and harder to breathe. The air in the truck was running out. Jim remembered he had a blowtorch in the back of the truck. He lit it, cut a hole in the roof, and melted the snow above the hole. Sunlight and fresh air poured in. Jim was relieved but he knew it would take a long time for all that snow to melt. A whole week went by.
One day, two state police officers saw an exhaust pipe sticking out of the snow. They thought that the driver of the truck might be dead. The officers took shovels out of their car and started digging the snow. About 10 minutes later, they reached the door and pulled it open. Jim smiled at the officers. He was tired and he was hungry. But he was alive!

II. Example Stories from Controls

A. "Shipwrecked" discourse sample: 9-year-old male control subject. The following story shows a general reduction in story information, however, structure of all four episodes is intact:

Once there was three brothers who fished in the ocean. Once they fell asleep and the boat, and the anchor broke loose. The boat floated far away, finally hit a rock. And the brothers woke up. They were very scared. They saw an island and swam to it. They were very glad to be on the island but they knew it would be hard. First they looked for coconuts then birds and caught them with their hands. They built a little place with grass and leaves which kept them warm. In the morning they saw a boat go by and they started a fire in the bushes. They dreamed of being home every night. Then they saw a boat and the boat saw the fire. The captain sent some of his men out to find them. The boys were going to be off the island.

B. "Buried Alive" discourse sample: 15-year-old male control subject. Jim had been a truck driver for 20 years and he was real careful and didn't take any chances. One day, he was driving, he was driving home and then it started snowing and he wanted to get home safely so he found a wide spot on the side of the road. He pulled over and went to sleep. Jim was finally relaxing. Well, he woke up many hours later and he noticed the snow was keeping the sunlight in. Time went by. He tried the windshield wipers and he tried to open the door but neither would budge and he was starting to lose air. So he remembered that he had a blowtorch in the back of the truck. He carved a hole in the ceiling and melted the snow and fresh air and sunlight poured in. But he knew that it would take a long time for all the snow to melt. So about 1 week went by and some police officers saw an exhaust pipe out of the snow. They thought the driver might be dead, so they got the shovels out. They started digging. They finally got to the front door. They opened and Jim was smiling. He was hungry and tired, but he was alive.

III. Frontal Lobe Case Examples (see Table 1 for Details of Patients)

A. Patient 1—"Shipwrecked" story sample: Severe CHI patient with primarily left frontal damage. The following story shows disruption of story structure and loss of the most important content ("gist"). Only information from the first episode is produced and even this information is sparsely elaborated. The resolution is inaccurate:
Three little boys were sailing in their boat. They fell asleep in the water. The boat crashed. The little boys were killed.

B. Patient 2—"Shipwrecked" story sample: Severe CHI patient with primarily right frontal damage. The following story shows a disruption of story structure as manifested by omission of setting, action, and resolution for episodes attempted. Also evidence is confabulation of story content. Sequence of events is difficult to follow:

There were three boys camping in the woods . . . there were three boys camping in the woods. They got into a boat sail and sailed so they catch some fish. The boat started to flood, flooded the water. People started to fuss each other and say bad words and stuff. Also, they was trying to swim out the water they were trying to swim out the water and swim to shore. After that they fished on the shore and on the grass. They got ropes and stuff. They brought all their supplies off the boat and jumped out and got a little boat. And they split . . . a pet canary that talks.

C. Patient 5—"Shipwrecked" story sample: severe CHI patient with primarily left frontal damage. The following story shows a disruption of story structure. Setting is unclear in that identification of the story characters is ambiguous. The resolution is omitted for the only episode attempted. It is unclear what "hit the rocks," but it appears to be the anchor. Repetition of information interferes with the sequence of events. Story content is extremely sparse and the most important information is omitted:

First they were sailing and they fell asleep. And after that they got up they were frightened because the anchor broke and hit a bunch of rocks. And they woke up and got frightened.

D. Patient 21—"Buried Alive" story sample: Traumatic aneurysm with bifrontal damage. The following story shows a collapse of the four episodes into a single episode. The primary reason for the collapse of episodes is the omission of action information from the four episodes:

Jim was a very careful truck driver who never took any chances. But one day he was driving home from work and he was snowed under by an avalanche or some other cause and the air was running out. So in quick thinking, he took a blowtorch from the back of the cab and bore a hole in the top of the truck, allowing him to breathe. So by the time the cops got there to free him, he was tired but alive.

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