Discourse after Closed Head Injury in Young Children

Sandra Bond Chapman,* Harvey S. Levin,† Alicia Wanek,* Julie Weyrauch,* and Joseph Kufera†

*Callier Center for Communication Disorders, University of Texas, Dallas, Texas; and †Division of Neurological Surgery, University of Maryland Medical System, Baltimore, Maryland

This study examined narrative discourse in 23 children, ages 6 to 8 years, who sustained a severe closed head injury (CHI) at least 1 year prior to assessment. Narratives were analyzed at multiple levels using language and information structure measures. Results revealed significant discourse impairments in the CHI group on all measures of information structure, whereas differences in the linguistic domain failed to reach significance. In addition, effects of age at injury and lateralization of lesion on discourse were considered. Although no significant differences were found according to age at injury, a consistent pattern of generally poorer discourse scores was found for the early injured group (<5 years). With regard to lesion focus, the group findings were unimpressive. However, preliminary examination of individual CHI cases with relatively large lateralized lesions suggested that the late injured children may show the language–brain patterns reported in brain-injured adults, whereas early injured children may not.

INTRODUCTION

Problems in discourse following closed head injury (CHI) in children have recently been documented using a number of different methodologies and discourse measures. Dennis and Barnes (1990) found persistent discourse deficits in head-injured children and adolescents 1 to 9 years postinjury. Ambiguous sentence interpretation, figurative language understanding, and inferencing were all impaired after head injury. In a study of conversational discourse in children and adolescents 1 year after CHI, Campbell and Dallaghan (1990) found that sentences comprising the discourse sample to be impaired in amount and complexity.

This work was supported by Grant NS-21889 and by a grant from The Greenery. We are indebted to Cathy Smiley and Gail Ober for manuscript preparation and to Lori Kusnerik for assistance in data management.

Address correspondence and reprint requests to Sandra Bond Chapman, Ph.D., Callier Center for Communication Disorders, University of Texas at Dallas, 1966 Inwood Road, Dallas, TX 75235. Fax: (214) 905-3026.

Copyright © 1998 by Academic Press
All rights of reproduction in any form reserved.
Our group corroborated the presence of discourse problems in children and adolescents at least 1 year after a severe CHI (Chapman, Culhane, Levin, Harward, Mendelsohn, Ewing-Cobbs, Fletcher, & Bruce, 1992). The CHI patients’ narrative discourse was impaired on some language measures (e.g., amount of language) and on all information structure measures (e.g., amount and organization of information), whereas the flow of information (e.g., repetitions and revisions of information) did not differ from a noninjured control group. Although the head-injured group used significantly less language (i.e., number of words and sentences) than the normal children, sentential complexity (i.e., amount of clausal embedding) was essentially the same for both groups. The importance of this latter study lies in the application of a discourse processing framework delineating abstract constructs of information structure to evaluate information organization in the CHI pediatric population. Using discourse constructs, impairments in information organization were quantified in terms of structure and content. Similar discourse processing models have been utilized extensively to characterize discourse abilities and disabilities in adult neurogenic populations (Ehrlich, 1994; Frederiksen, Bracewell, Breuleux, & Renaud, 1990; Joanette & Goulet, 1990; Ulatowska & Chapman, 1994). Discourse processing involves a complex interaction between cognition and language and may be a better indicator of communicative ability than structured tasks of isolated linguistic ability (Dennis, Jacenik, & Barnes, 1994).

Although recent findings suggest that discourse may be impaired after severe head injury in the pediatric population, little is known about injury effects on discourse in early grade-school-age children, the effects of age at injury, or lesion foci effects. The earlier studies either addressed discourse abilities in older children, i.e., 9 to 18 years (Chapman et al., 1992), or included a wide age range without consideration of age effects (Campbell & Dollaghan, 1990; Dennis & Barnes, 1990). It is important to examine the effects of head injury on discourse from a developmental perspective to determine whether the impairments and preservations differ qualitatively or quantitatively as a function of age.

Discourse abilities are likely to be affected by age variables including age at evaluation and age at the time of injury since discourse evolves through various developmental stages. With regard to narrative discourse, linguistic precursors appear in the early developmental language stages with continuing development of well-formed narratives increasing in complexity into adolescence (Applebee, 1978; Botvin & Sutton-Smith, 1977; Westby, 1984). Specifically, discourse abilities emerge as early as age two when a child learns to refer to a past event, followed by an ability to sequence two actions at 3½ years and to produce more than two events (not necessarily in sequence) by age four. By 5 years of age, basic narrative structure emerges as manifested by a story with a beginning (setting), action sequence, and a resolution or final outcome. Narrative conceptual and linguistic development
continues with the emergence of causal relations and the production of coherent stories developed around a central theme by 8 to 9 years of age. By 11 to 12 years of age, children show proficiency in embedding stories or episodes within a longer story. Thus, discourse abilities are likely to be affected by the child’s age or stage of discourse development at the time of assessment.

With regard to age at the time of injury, studies have sought to sort out whether younger children show preferential recovery of cognitive and linguistic abilities compared to older children in a variety of brain disorders. Until recently, the prognosis for recovery from brain injury was regarded as more favorable in younger brain-injured children than in older children and adults based on evidence from language, cognitive, and motor recovery (Chadwick, Rutter, Brown, Shaffer, & Traub, 1981; Lenneberg, 1967; Smith, 1984). However, these conclusions may overestimate long-term recovery in young children. Whereas the immature brain may show considerable neural plasticity, earlier injury does not necessarily imply a more favorable outcome with regard to later development. Acquisition of later emerging skills may be impaired despite the relative recovery of previously acquired abilities, suggesting that “recovery” cannot be considered a one-time phenomenon. Instead, the possibility exists that recovery may be an issue at each new stage of development. Moreover, the measures previously used to assess recovery may have been insensitive to the specific nature or complexity of the residual deficits (Fletcher, Miner, & Ewing-Cobbs, 1987; Smith, 1984; St. James-Roberts, 1979).

Recent evidence suggests that sparing of function may be the exception rather than the rule in young brain-injured children. Indeed, children injured at a young age may manifest impairment similar to or even greater than that of children injured at later developmental stages. Levin, Eisenberg, Wigg, and Kobayashi (1982) found more global intellectual deficits in children injured before 13 years of age. With regard to language, head-injured children (ages 5–10 years) showed greater difficulty than adolescents (11–16 years) on written language tasks scaled for age regardless of injury severity (Ewing-Cobbs, Fletcher, Landry, & Levin, 1985). Age effects have also been documented in other neurological conditions with regard to the preferred treatment regimens. For example, caution is taken in treating childhood brain tumors with radiation (when medically possible) due to possible deleterious effects on later cognitive development (Fletcher & Copeland, 1988). While these studies suggest that prognosis from early injury may be less favorable than previously thought, no definitive studies exist that examine age at injury effects after CHI on discourse ability.

In addition to consideration of variables of age, consideration of the effects of lesion localization are motivated by the evidence that focal regions of abnormality are common neurological sequelae in CHI and that lateralized lesions may alter the language outcome. In contrast to focal vascular lesions,
focal lesions after CHI result from hematomas, contusions, and diffuse axonal injuries. Recent evidence suggests that a majority of CHI patients have areas of increased signal density identified by magnetic resonance imaging (MRI) in frontal and temporal regions (Levin, Culhane, Mendelsohn, Lilly, Bruce, Fletcher, Chapman, Harward, & Eisenberg, 1993; Mendelsohn, Levin, Bruce, Lilly, Harward, Culhane, & Eisenberg, 1992). Studies of language disturbances in diverse neurologically impaired children have suggested that laterality of brain damage affects language recovery and development. Aram, Ekelman, Rose, and Whitaker (1985) and Aram, Ekelman, and Whitaker (1986) reported greater impairment of syntactic ability in children with left-hemisphere vascular lesions than in those with right-hemisphere lesions. Dennis (1980a) described simplified syntax and story structure in a 9;9-year-old having suffered a stroke to the left temporoparietal region.

Additionally, an interaction between laterality and age effects may exist, but the findings are equivocal. Some studies report impairment in the initial stages of language acquisition irrespective of the lateralization of lesion. Feldman, Holland, Kemp, and Janosky (1992) found language acquisition to be impaired regardless of lesion lateralization in children with unilateral antepartum or perinatal results. Moreover, early unilateral insult reportedly did not alter subsequent development of language by the toddler–preschool years. Similarly, Dennis (1980b) reported minimal differences on various measures of referential naming of objects between children who underwent left or right hemidecortication in the early months of life. Woods and Carey (1979) suggested that 1 year of age may represent the upper limit for age at time of brain injury without lateralization effects. In their study, children with left-hemisphere lesions performed more poorly on object naming than controls only if the lesion occurred after 1 year of age. However, Dennis (1980b) suggested that differences associated with laterality after early brain damage were evident on more complex language measures involving identification of the topic of a sentence, in which the children with early right hemidecortication performed better than those with early left hemidecortication. In another study, children with early left decortication were found to have more difficulty than those with right decortication in using pronouns and nouns appropriately in narrative discourse (Newman, Lovett, & Dennis, 1986).

In the present study, we investigated the effects of severe CHI on discourse in children who were 6 to 8 years of age at the time of the language assessment. To consider age at injury effects, we compared the discourse of children who sustained a CHI before 5 years of age to the findings obtained in children who sustained comparable injuries at 5 years or older, since 5 years appears to be a critical age for basic story development. Additionally, we examined whether a relation exists between lesion focus and discourse findings in the CHI group as a whole or in individual case studies.
## METHODS

### Subjects

Twenty-three severely head-injured children, including 12 boys and 11 girls, were selected for study from the consecutive admissions to the neurosurgery service at Parkland Hospital, Dallas. All of these children were participating in a larger research project examining cognitive recovery following CHI and were 6 to 8 years of age at the time of assessment. Selection criteria included a severe CHI sustained at least 1 year prior to assessment of discourse. Injury severity was assessed using the lowest postresuscitation Glasgow Coma Scale (GCS) score (Teasdale & Jennett, 1974). Table 1 summarizes demographic and clinical features of the individual CHI patients, including the external cause of injury. Exclusion criteria for the study included: (1) a prior history of neurologic or psychiatric disorder; (2) grade failure or previous

### Table 1

Demographic Features and Severity of Injury According to the Postresuscitation Glasgow Coma Scale Score

<table>
<thead>
<tr>
<th>Patient no.</th>
<th>Age at injury (years)</th>
<th>Injury–test interval (days)</th>
<th>Age at study (years)</th>
<th>Sex</th>
<th>GCS score</th>
<th>Coma duration* (days)</th>
<th>External cause of injury</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6.5</td>
<td>409</td>
<td>7.6</td>
<td>M</td>
<td>3</td>
<td>17.0</td>
<td>MPA^</td>
</tr>
<tr>
<td>2</td>
<td>5.0</td>
<td>1199</td>
<td>8.3</td>
<td>M</td>
<td>3</td>
<td>13.0</td>
<td>MVA'</td>
</tr>
<tr>
<td>3</td>
<td>6.5</td>
<td>335</td>
<td>7.4</td>
<td>M</td>
<td>3</td>
<td>17.0</td>
<td>MPA</td>
</tr>
<tr>
<td>4</td>
<td>2.1</td>
<td>1637</td>
<td>6.6</td>
<td>F</td>
<td>4</td>
<td>20.0</td>
<td>MPA</td>
</tr>
<tr>
<td>5</td>
<td>1.6</td>
<td>1878</td>
<td>6.8</td>
<td>M</td>
<td>4</td>
<td>2.0</td>
<td>MVA</td>
</tr>
<tr>
<td>6</td>
<td>6.6</td>
<td>573</td>
<td>8.1</td>
<td>M</td>
<td>4</td>
<td>29.0</td>
<td>MVA-Train</td>
</tr>
<tr>
<td>7</td>
<td>5.8</td>
<td>469</td>
<td>7.1</td>
<td>F</td>
<td>5</td>
<td>3.0</td>
<td>MPA</td>
</tr>
<tr>
<td>8</td>
<td>4.4</td>
<td>1162</td>
<td>7.5</td>
<td>M</td>
<td>6</td>
<td>15.0</td>
<td>MPA</td>
</tr>
<tr>
<td>9</td>
<td>3.4</td>
<td>1651</td>
<td>7.9</td>
<td>M</td>
<td>6</td>
<td>7.0</td>
<td>MPA</td>
</tr>
<tr>
<td>10</td>
<td>7.4</td>
<td>415</td>
<td>8.5</td>
<td>F</td>
<td>6</td>
<td>13.0</td>
<td>MPA</td>
</tr>
<tr>
<td>11</td>
<td>5.3</td>
<td>1002</td>
<td>8.0</td>
<td>F</td>
<td>6</td>
<td>16.0</td>
<td>Fall</td>
</tr>
<tr>
<td>12</td>
<td>1.7</td>
<td>1804</td>
<td>6.6</td>
<td>F</td>
<td>6</td>
<td>21.0</td>
<td>MPA</td>
</tr>
<tr>
<td>13</td>
<td>6.8</td>
<td>353</td>
<td>7.8</td>
<td>F</td>
<td>7</td>
<td>4.0</td>
<td>MPA</td>
</tr>
<tr>
<td>14</td>
<td>7.2</td>
<td>352</td>
<td>8.2</td>
<td>M</td>
<td>7</td>
<td>7.0</td>
<td>MVA</td>
</tr>
<tr>
<td>15</td>
<td>5.5</td>
<td>1064</td>
<td>8.5</td>
<td>M</td>
<td>7</td>
<td>16.0</td>
<td>MVA</td>
</tr>
<tr>
<td>16</td>
<td>4.8</td>
<td>1347</td>
<td>8.5</td>
<td>F</td>
<td>7</td>
<td>13.0</td>
<td>MVA</td>
</tr>
<tr>
<td>17</td>
<td>7.8</td>
<td>420</td>
<td>8.9</td>
<td>M</td>
<td>7</td>
<td>45.0</td>
<td>MPA</td>
</tr>
<tr>
<td>18</td>
<td>4.8</td>
<td>423</td>
<td>6.0</td>
<td>F</td>
<td>7</td>
<td>14.0</td>
<td>MPA</td>
</tr>
<tr>
<td>19</td>
<td>5.3</td>
<td>848</td>
<td>7.6</td>
<td>M</td>
<td>7</td>
<td>5.0</td>
<td>MPA</td>
</tr>
<tr>
<td>20</td>
<td>5.6</td>
<td>350</td>
<td>6.5</td>
<td>F</td>
<td>7</td>
<td>2.0</td>
<td>MVA</td>
</tr>
<tr>
<td>21</td>
<td>2.6</td>
<td>1829</td>
<td>7.6</td>
<td>F</td>
<td>8</td>
<td>3.0</td>
<td>MPA</td>
</tr>
<tr>
<td>22</td>
<td>4.5</td>
<td>1044</td>
<td>7.4</td>
<td>M</td>
<td>8</td>
<td>0.1</td>
<td>MVA</td>
</tr>
<tr>
<td>23</td>
<td>1.7</td>
<td>1869</td>
<td>6.8</td>
<td>F</td>
<td>8</td>
<td>0.0</td>
<td>MPA</td>
</tr>
</tbody>
</table>

*Defined as the number of days until the child could follow motor commands.
^MPA, Motor–pedestrian accident.
'MVA, Motor vehicle accident.
^Child entered the project prior to the addition of the cat story; data limited to the rooster story.
^Excluded from comparison of early versus late injury because of a brief duration of coma, which was shorter than that suffered by any of the children in the late injury group.
diagnosis of learning disability or mental deficiency; and (3) evidence of child abuse. The control group consisted of 26 children within the same age range. The head-injured and control groups did not differ significantly in age, gender, or parental socioeconomic level as reflected by the parent’s education and employment status.

Materials

The experimental discourse tasks involved elicitation of the two stories shown in Appendix A. One story involved an auditory retell task of an Aesop’s fable subsequently referred to as the “Rooster Story.” The second story was elicited using five picture sequence cards and is referred to as the “Cat Story.”

The stories were similar in length and conceptual complexity. Each story contained a core of 16 informational units or propositions, consisting of verbal elements and their associated nouns (arguments) using a modification of the framework delineated by Kintsch and van Dijk (1978). The story information units depicted in verbal form for the “Rooster Story” and in pictorial form for the “Cat Story” were established a priori (Appendix A). Both stories had a well-structured organization represented by distinct episodes. Moreover, the stories were similar in the global semantic meaning (macrostructure) in that the gist of both stories was realized through a role-reversal situation for the main characters. For example, the “winning” rooster in the “Rooster Story” ending up losing because of his bragging, whereas in the “Cat Story” the man rescuing the cat had to be rescued himself from the tree at the end of the story. To comprehend the central meaning or gist for both stories, it is important to appreciate the role-reversal situations.

Procedures

Both story tasks were administered as part of a larger neuropsychological battery consisting of standardized and experimental tests. For the auditory “Rooster Story,” the examiner instructed the child to listen carefully to a story so that he/she could immediately retell the story in as much detail as possible. No prompting was given during the child’s retelling unless it was unclear whether the child’s story had ended. For the “Cat Story,” the examiner presented the five picture sequence cards placed in the same incorrect order for each child and asked the child to rearrange the pictures in the correct order by selecting the first pictured event of the story, then the second, until all the cards were sequenced. If the child placed a card out of sequence, he/she was told immediately that the card was out of place and to select again. The number of trials required to sequence the cards correctly was noted. Using this procedure, the child’s pictures were in the correct order before he/she was asked to tell a story based on the sequence of pictured events. All stories were audiotaped and transcribed verbatim.

Discourse Measures

The stories produced by the CHI and control children were analyzed using a modification of an approach developed by Ulatowska, North, and Macaluso-Haynes (1981). The method is based on a theoretical framework using discourse grammar to define the organization of information for narratives (Kintsch & van Dijk, 1978; Labov, 1972). Discourse representation is realized through language structures (i.e., the lexicon, the syntactic structures, and the type of clauses used to express the story) and through information structures (i.e., units of meaning referred to as propositions, the story structure, and the global semantic meaning or gist).

The children’s stories were analyzed according to three domains of Language Structure, Information Structure, and Flow of Information, defined in Appendix B. The Language Structure domain focuses on the lexical and sentential levels of language. Despite some evidence
that sentential abilities often recover to relatively normal levels in CHI populations (Chapman et al., 1992), it is felt that sentential analysis should be retained because little is known about language recovery in young children. The pattern of preserved sentential abilities may not generalize to younger pediatric populations. Further, it is important to document either associations or dissociations between sentential and discourse levels of language.

The Information Structure domain is of particular interest in CHI populations because it takes into account the complex interaction between cognition and language. Information Structure measures tap one’s ability to use the language system to select, organize, and integrate information. Thus, information measures may be more revealing than measures of isolated specific linguistic abilities in illuminating the deleterious effects of head injury on communication processes. Head-injured individuals frequently demonstrate marked communicative difficulties in spite of relatively normal performance on traditional language measures (Campbell & Dollaghan, 1990; Jordan, Murdoch, & Buttsworth, 1991). These communicative deficits may result from difficulties in manipulating information at a discourse level.

Flow of Information measures the balance between linguistic and information structures by assessing the amount of language used to convey a specified core of information. Discourse in CHI adult patients is commonly characterized as inefficient, manifested by a reduction of information despite excessive amounts of language, partially due to repetitions and revisions of information (Ehrlich, 1988; Hartley & Jensen, 1991). The Flow of Information measures examine whether inefficient discourse is apparent in CHI children.

Cohesive Measures

In addition to the above measures, the use of selected cohesive devices was considered, specifically the use of reference and connectives. Cohesive devices operate in the language system to enable the speaker to produce a text that functions as a coherent whole (Halliday & Hasan, 1976). Analysis of reference was selected because this cohesive device has been found to contribute significantly to the clarity of stories across sentences (Bond, 1986; Chapman & Ulatowska, 1989; Ulatowska, Freedman-Stern, Doyel, Macaluso-Haynes, & North, 1983). Identification of referential errors included: (1) failure to introduce characters with a noun, e.g., first mention of characters with pronoun; (2) several possible referents for a pronoun, e.g., for the “Rooster Story”: “he” was carried off is ambiguous; or (3) unclear substitution of referents, e.g., for the “Cat Story”: use of the “man” and later the “boy.”

Connectives have also been described as important cohesive devices for well-formed discourse (Ulatowska et al., 1981; Ulatowska et al., 1983). Moreover, connectives reflect developmental patterns, in terms of both linguistic and cognitive abilities. Use of temporal connectors (e.g., then, after, until, while) and causal connectors (because, since) were examined in the present study. Certain temporal connectors, particularly “then,” appear developmentally before particular causal connectors (i.e., because, since). The early developmental causal relations are cognitively more complex than certain temporal relations. Therefore, examining the use of connectives at early developmental stages may help to elucidate neurodevelopmental aspects of language that interfere with ability to produce well-formed discourse.

Discourse Analyses Reliability

The narratives were analyzed by author AW, who was trained by author SBC. Training involved analyzing both narratives for 10 children, resulting in consistency of analyses at a 90% level between the two authors. AW then analyzed all the stories for this study with questionable responses resolved by discussion. Five samples for each story were randomly selected and analyzed independently by the first author. Interjudge reliability was 89% for propositions and 95% for gist across both stories.
DISCOURSE AFTER CLOSED HEAD INJURY 427

Vocabulary and Verbal Memory Measures

**Vocabulary test.** The Vocabulary subtest of the *Wechsler Intelligence Scale for Children–Revised (WISC-R)* (Wechsler, 1974) was administered and a standard score was computed. This test requires the child to define a number of words increasing in complexity from concrete to more abstract. The child’s responses are scored according to whether or not certain predetermined features of the word are represented in his/her definition.

**Verbal memory test.** To address the potential role of memory deficits on recalling a story (‘‘Rooster Story’’), a test of verbal recall, the *California Verbal Learning Test (CVLT)–Children’s Version* (Delis, Kramer, Kaplan, & Ober, 1987), was given. The CVLT measures free recall of a 15-word list given in five consecutive trials with only the first trial analyzed here. The list contains items that can be grouped into three semantic categories (fruit, clothing, and toys). The score represented the number of items correctly recalled.

RESULTS

The effects of severe head injury on discourse performance were analyzed within the domains of Language Structure, Information Structure, and Flow of Information. A multivariate analysis of variance (MANOVA) was performed on the scores of each domain to compare the discourse measures at $\alpha = .05$ for the severely head-injured and control groups for both the Rooster and the Cat Stories. MANOVA was chosen due to the similarity of structures within each domain, the independence of scores between patients, and the robustness of the $F$ test to scores with moderate departures from normality.

The MANOVA for Language Structures testing the effects of group (i.e., head-injured versus control) approached but failed to reach significance for the ‘‘Rooster Story’’: Wilks = .8484, approximate $F(3, 44) = 2.62, p = .0626$, and for the ‘‘Cat Story’’: Wilks = .8576, approximate $F(3, 43) = 2.38, p = .0828$. For Information Structure (Domain II), however, there was a significant group for both the ‘‘Rooster Story’’: Wilks = .7475, approximate $F(3, 44) = 4.95, p = .0048$, and the ‘‘Cat Story’’: Wilks = .7505, approximate $F(3, 43) = 4.77, p = .0059$. The MANOVA for the Flow of Information domain failed to reach significance for the ‘‘Rooster Story’’: Wilks = .9228, approximate $F(2, 41) = 1.71, p = .1928$ and for the ‘‘Cat Story’’: Wilks = .9887, approximate $F(2, 43) = .25, p = .7841$. Tables 2 and 3 summarize the results for the univariate analyses of variance performed on the component variables comprising each of the three domains for the ‘‘Rooster Story’’ and the ‘‘Cat Story,’’ respectively.

**Domain I (Linguistic Structure).** Although the difference between the groups for the linguistic domain approached but failed to reach significance on the MANOVA, the univariate analysis of variance on the component measures suggests that the normal control group tended to use more words and sentences (T-units) than did the severely head-injured children on both stories. Sentential complexity did not differ significantly between groups for either story. Sample stories for a normal child and for a CHI child (Appendix
TABLE 2
Summary of Performance on “Rooster Story” and Neuropsychological Measures for Severely Head-Injured Group and Normal Control Group

<table>
<thead>
<tr>
<th>Measures</th>
<th>Severe</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td>SD</td>
</tr>
<tr>
<td>Discourse measures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linguistic structure</td>
<td>2.62</td>
<td>.0626</td>
</tr>
<tr>
<td>Number of words (unedited)</td>
<td>43.52</td>
<td>32.15</td>
</tr>
<tr>
<td>Number of T-units</td>
<td>4.57</td>
<td>2.57</td>
</tr>
<tr>
<td>Number of dependent clauses</td>
<td>.16</td>
<td>.18</td>
</tr>
<tr>
<td>Information structure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of propositions</td>
<td>4.09</td>
<td>3.60</td>
</tr>
<tr>
<td>Story structure</td>
<td>1.83</td>
<td>1.19</td>
</tr>
<tr>
<td>Percentage of gist</td>
<td>.41</td>
<td>.32</td>
</tr>
<tr>
<td>Flow of information</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of mazes</td>
<td>2.11</td>
<td>1.67</td>
</tr>
<tr>
<td>Number of words/propositions</td>
<td>11.26</td>
<td>5.24</td>
</tr>
<tr>
<td>Cohesion measures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of reference errors</td>
<td>1.22</td>
<td>1.57</td>
</tr>
<tr>
<td>Connectives</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temporal</td>
<td>.74</td>
<td>1.25</td>
</tr>
<tr>
<td>Causal</td>
<td>.13</td>
<td>.34</td>
</tr>
<tr>
<td>CVLT Trial 1 recall</td>
<td>4.55</td>
<td>2.14</td>
</tr>
<tr>
<td>WISC-R vocabulary (scaled score)</td>
<td>7.00</td>
<td>3.11</td>
</tr>
</tbody>
</table>

C.1) illustrate the Language findings and the findings on Information measures as described below.

**Domain II (Information Structure).** Differences were examined between the two groups on information structure measures. As indicated in Tables 2 and 3, the differences between the head-injured and the noninjured control groups were highly significant ($\alpha = .05/3 = .017$ for multiple comparisons) on all measures of information structure, including amount of information, story structure, and global story content for both stories. The head-injured group produced significantly less information than the normal controls. On the average, the normal control individuals produced approximately one-half of the core propositions for both stories, whereas the head-injured averaged one-third of the core propositions on the “Cat Story” and only one-fourth of the core propositions on the “Rooster Story.” For the story structure measure, the head-injured group tended to omit an essential story component, resulting in incomplete episodic structure. The “Rooster Story” appeared to be more difficult than the “Cat Story” as reflected in lower mean performance levels for both groups on the component variables of information structure.
### TABLE 3
Summary of ‘Cat Story’ Performance for Severely Head-injured Group and Normal Control Group

<table>
<thead>
<tr>
<th>Measures</th>
<th>Severe</th>
<th>Control</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td>SD</td>
<td>X</td>
<td>SD</td>
</tr>
<tr>
<td>Discourse measures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Linguistic structure</td>
<td>2.38</td>
<td>.0828</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of words (unedited)</td>
<td>56.00</td>
<td>28.49</td>
<td>78.44</td>
<td>32.33</td>
</tr>
<tr>
<td>Number of T-units</td>
<td>7.23</td>
<td>3.54</td>
<td>9.36</td>
<td>3.98</td>
</tr>
<tr>
<td>Number of dependent clauses</td>
<td>.18</td>
<td>.12</td>
<td>.17</td>
<td>.12</td>
</tr>
<tr>
<td>Information structure</td>
<td>.477</td>
<td>.0059</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of propositions</td>
<td>6.50</td>
<td>2.09</td>
<td>8.80</td>
<td>2.29</td>
</tr>
<tr>
<td>Story structure</td>
<td>2.55</td>
<td>.60</td>
<td>2.92</td>
<td>.28</td>
</tr>
<tr>
<td>Percentage of gist</td>
<td>.84</td>
<td>.20</td>
<td>.95</td>
<td>.09</td>
</tr>
<tr>
<td>Flow of information</td>
<td>.25</td>
<td>.7841</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of mazes</td>
<td>2.18</td>
<td>3.17</td>
<td>2.71</td>
<td>2.37</td>
</tr>
<tr>
<td>Number of words/propositions</td>
<td>8.49</td>
<td>2.25</td>
<td>8.92</td>
<td>2.17</td>
</tr>
<tr>
<td>Cohesion measures</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of reference errors</td>
<td>1.19</td>
<td>1.50</td>
<td>1.17</td>
<td>1.49</td>
</tr>
<tr>
<td>Connectives</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temporal</td>
<td>1.50</td>
<td>1.34</td>
<td>2.24</td>
<td>1.88</td>
</tr>
<tr>
<td>Causal</td>
<td>.18</td>
<td>.50</td>
<td>.28</td>
<td>.54</td>
</tr>
<tr>
<td>Number of trials to sequence pictures</td>
<td>2.64</td>
<td>1.99</td>
<td>1.44</td>
<td>.92</td>
</tr>
</tbody>
</table>

**Domain III (Flow of Information).** No significant differences were found for flow of information measures on either story.

**Number of Trials to Sequence Pictures**

For the ‘Cat Story,’ Table 3 shows that the head-injured group needed significantly more trials to sequence the pictures than the controls ($p = .0097$).

**Cohesion Measures**

As reported in Tables 2 and 3, no significant differences were found between the group with severe head injury and the normal control group on number of referential errors for either the Rooster or the Cat Stories. Moreover, these two groups showed similar patterns in spontaneous use of temporal and causal connectives in their narratives. Both groups tended to use more temporal connectors than causal connectors.

**Vocabulary and Verbal Memory Measures**

Mean performance levels on the vocabulary subtest (WISC-R) and the Verbal Memory Test (CVLT) are reported in Table 2. The overall group
effect was significant for the verbal memory measure and highly significant for the vocabulary subtest. To address the contribution of vocabulary and verbal memory ability to discourse performance, an analysis of covariance (ANOVA) was performed. The selected discourse performance variable was the Information Structure variable of propositions, reflecting the amount of information in the “Rooster Story” retell because amount of information recalled is sensitive to both memory and vocabulary deficits. The results revealed a significant effect of head injury on amount of information recalled even after controlling for vocabulary and verbal memory \( F(3, 41) = 14.12; p = .0005 \).

**COMPARISON OF EARLY VERSUS LATE HEAD INJURY**

In addition to examining discourse differences between normal control and CHI children with a severe head injury, this study compared discourse performance within the head-injured group according to age at injury. Specifically, do children who sustain injuries before the age of 5 perform differently on the discourse measures from children injured after 5 years of age?

**Group Specifications**

Early versus late injury was dichotomized at 5 years of age based on empirical evidence that this age represents a critical developmental stage. The early injury group consisted of the severely head-injured children (GCS < 8) who were younger than 5 at the time of injury and the late injury group consisted of children 5 and older at time of injury. As stated previously, all the children were 6 to 8 years of age at time of testing. To control for initial severity, children with brief coma duration (i.e., ≤3 h) were excluded from the study (Patients 22 and 23 in Table 1). Applying this exclusionary criterion, there were 9 children in the early injury group and 12 in the late injury group.

In view of the small sample size, the comparison of early versus late injury is regarded as preliminary. One child in the early injury group was studied before the “Cat Story” was added to the protocol. As shown in Table 4, no significant differences were found between the early and the late injury groups on demographics including age at test, gender, and socioeconomic status as reflected by parental education and occupation levels. Moreover, the two groups did not differ significantly on coma duration and GCS score. As expected, the groups differed on the time interval between injury and time of evaluation with the early injury children having a longer injury–test interval than the late injury children. Nonetheless, all the children were at least 1 year postinjury.

**Results**

The same three domains described above (i.e., the domains of Linguistic Structure, Information Structure, and Flow of Information) were utilized
to compare the early versus late injury groups of head-injured children. MANOVA was also applied according to the assumptions described earlier. Due to the variability in number of words to generate the story in these small samples of children, a square root transformation of the number of unedited words was used for analysis. Although the overall MANOVAs for the three domains were not significant at $\alpha = .05$ for either story, there was a pattern of generally poorer scores for the group injured early than for those injured late across most measures on the “Rooster Story” (Table 5).

Since this is an exploratory analysis based on modest sample sizes, the findings are reported to document the consistent pattern of poorer performance for the early injured group. The early injured group tended to use fewer words and sentences than the late injured group. Also, the mean performance level for the early injured group was lower on all information structure measures, including amount of information, episodic structure, and gist. No significant differences were found between the early and the late injury groups on the vocabulary test, on the memory test (CVLT), or on the number of trials necessary to sequence the pictures (“Cat Story”), although the mean performance levels were lower for the early injured group.
### TABLE 5
Comparison of Early Versus Late Injury Groups on Discourse Domains for Rooster Story and Other Tests

<table>
<thead>
<tr>
<th>Domain</th>
<th>Variable</th>
<th>Early Injury (n = 9)</th>
<th>Late Injury (n = 12)</th>
<th>F</th>
<th>p</th>
<th>Wilks’ λ</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rooster Story</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Language structure</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unedited words</td>
<td>29.56 (21.06)</td>
<td>55.50 (37.39)</td>
<td>3.34</td>
<td>.083</td>
<td>.78</td>
<td>.230</td>
</tr>
<tr>
<td></td>
<td>Sentences (T-units)</td>
<td>3.33 (2.06)</td>
<td>5.58 (2.78)</td>
<td>4.16</td>
<td>.056</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sentential complexity (clauses)</td>
<td>.18 (.21)</td>
<td>.15 (.15)</td>
<td>.14</td>
<td>.710</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Information structure</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Propositions</td>
<td>2.67 (2.18)</td>
<td>5.42 (4.17)</td>
<td>3.23</td>
<td>.088</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Percent gist</td>
<td>.31 (.25)</td>
<td>.50 (.34)</td>
<td>2.02</td>
<td>.172</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Episodes</td>
<td>1.56 (1.01)</td>
<td>2.08 (1.24)</td>
<td>1.08</td>
<td>.311</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Flow of information</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.93</td>
<td>.568</td>
</tr>
<tr>
<td></td>
<td>Mazes</td>
<td>1.63 (1.19)</td>
<td>2.40 (2.17)</td>
<td>.82</td>
<td>.380</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Language/information</td>
<td>12.41 (7.36)</td>
<td>10.58 (3.25)</td>
<td>.50</td>
<td>.489</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Additional tests</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number of trials to sequence</td>
<td>3.50 (2.33)</td>
<td>2.17 (1.75)</td>
<td>2.14</td>
<td>.160</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Cat Story)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vocabulary scaled score</td>
<td>5.78 (3.23)</td>
<td>7.60 (2.91)</td>
<td>1.67</td>
<td>.213</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(WISC-R)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number correct on Trial 1</td>
<td>4.11 (2.42)</td>
<td>5.25 (2.18)</td>
<td>1.28</td>
<td>.272</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(California Verbal Learning</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Test)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
We also considered the potential role of focal brain lesions (i.e., areas of abnormal signal) on language abilities in this CHI population since previous evidence has suggested that specific lesion localizations may be associated with differential language patterns (Aram et al., 1985; Chapman et al., 1992; Dennis & Whitaker, 1976). A disproportionate neuroanatomic distribution of lesions between the two age at injury groups may contribute to the discourse differences. Table 6 lists the location and volume of each area of abnormal signal found on MRI for children in the early and late injury groups. An anterocaudal gradient is present in both groups as most areas of abnormal signal are situated in the frontal lobes. Ten of the 12 children injured at 5 years of age or older sustained a left frontal lesion compared to 2 of the 9 children who had early injuries, a difference in proportions that was statistically significant according to Fisher’s exact method, \( p = .009 \). The relative frequency of right frontal lesions in the late injury group (7/12) and in the children injured before 5 years (5/9) was nonsignificant. Wilcoxon rank sum comparisons disclosed no significant group difference in lesion volume (Table 6) for the left hemisphere (\( p = .97 \)) and right hemisphere (\( p = .53 \)).

To explore the potential effects of lesion focus on language ability in CHI, we examined whether there was a correlation between size of focal lesions (identified by MRI at time of test) and language abilities. As shown in Table 6, many children had lesions which were widely distributed in multiple regions. With regard to amount of language, there were no significant Spearman rank order correlations between the number of words for the story retell task and the size of lesion in the left frontal (\( r = .07 \)), total left hemisphere (\( r = .05 \)), right frontal (\( r = .09 \)), or total right hemisphere (\( r = -.01 \)). The correlation coefficients were of similar magnitudes for syntactic complexity and number of propositions.

When four individual children with primarily left and right lesions (two in the late injury group and two in the early injury group) were examined, however, some interesting patterns emerged, possibly related to age of injury. The two late injury children (Nos. 13 and 19 in Table 6) had relatively large frontal lesions (>6.0 cc) with little or no identifiable lesions in other brain regions. As shown in Table 6, CHI Child No. 13 had a right frontal lesion (6.6 cc) and Child No. 19 had a large left frontal lesion (11.7 cc). Both children were in the late injury group and were comparable in initial severity (GCS = 7) and age at test (7.77 and 7.65 years, respectively), yet they differed in hemispheric lesion focus. Stories for these children appear in Appendix C.3. The most striking difference between their stories is the amount and complexity of language. The language in the left frontal patient was reduced in amount and length of sentences compared to the mean for the other severely head-injured children. In contrast, the child with a right frontal lesion performed similarly to the normal control children in amount and complexity.
<table>
<thead>
<tr>
<th>Age at study (years)</th>
<th>GCS Score</th>
<th>Lesion Volume (cc) Listed for Individual Children in Early and Late Injury Groups</th>
<th>Right hemisphere</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>8.3</td>
<td>3</td>
<td>2.8</td>
<td>3.4</td>
</tr>
<tr>
<td>4</td>
<td>6.6</td>
<td>4</td>
<td>2.0</td>
<td>0.6</td>
</tr>
<tr>
<td>6</td>
<td>6.8</td>
<td>6</td>
<td>8.5</td>
<td>0.4</td>
</tr>
<tr>
<td>8</td>
<td>7.5</td>
<td>6</td>
<td>8.2</td>
<td>0.4</td>
</tr>
<tr>
<td>10</td>
<td>7.5</td>
<td>7</td>
<td>8.0</td>
<td>0.1</td>
</tr>
<tr>
<td>12</td>
<td>8.0</td>
<td>6</td>
<td>8.5</td>
<td>0.1</td>
</tr>
<tr>
<td>14</td>
<td>8.5</td>
<td>6</td>
<td>8.0</td>
<td>0.1</td>
</tr>
<tr>
<td>16</td>
<td>8.5</td>
<td>7</td>
<td>7.8</td>
<td>0.6</td>
</tr>
<tr>
<td>18</td>
<td>8.9</td>
<td>7</td>
<td>8.5</td>
<td>0.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Late:</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>7.6</td>
<td>8</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>3</td>
<td>7.4</td>
<td>7</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>4</td>
<td>8.0</td>
<td>8</td>
<td>0.0</td>
<td>0.1</td>
</tr>
<tr>
<td>5</td>
<td>8.3</td>
<td>6</td>
<td>0.4</td>
<td>0.6</td>
</tr>
<tr>
<td>6</td>
<td>8.1</td>
<td>6</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>7</td>
<td>8.2</td>
<td>7</td>
<td>8.5</td>
<td>0.1</td>
</tr>
<tr>
<td>8</td>
<td>8.3</td>
<td>7</td>
<td>11.7</td>
<td>0.6</td>
</tr>
<tr>
<td>9</td>
<td>8.6</td>
<td>7</td>
<td>11.7</td>
<td>0.6</td>
</tr>
<tr>
<td>10</td>
<td>8.1</td>
<td>7</td>
<td>8.5</td>
<td>0.1</td>
</tr>
<tr>
<td>11</td>
<td>8.4</td>
<td>7</td>
<td>8.5</td>
<td>0.1</td>
</tr>
</tbody>
</table>

**Note:** Patients are identified by numbers used in Table 1. F, frontal; T, temporal; P, parietal; O, occipital; BG, basal ganglia. Two children (Patients 22 and 23 in Table 1) who sustained early injuries were excluded from the comparison of early versus late injury because their durations of coma were much briefer than those experienced by children in the late injury group. The MRI disclosed no areas of abnormal signal for either child.
of language and produced more information (propositions = 10) than the child with a left frontal lesion (propositions = 3). Story structure was also better preserved in the child with the right frontal lesion than in the child who had a left frontal lesion. Nonetheless, the global semantic structure/gist was impaired for both children. The child with a right frontal lesion exhibited difficulty conveying the role reversal because of referential errors and inadequate combining of ideas. In contrast, information was too sparse for the left frontal child to convey the gist.

In contrast to a pattern of differential language impairment in the older group according to lesion focus, the language of the two early injured CHI children did not differ according to localization of abnormal signal, i.e., predominantly left-hemisphere lesions in Child No. 9 or right-hemisphere lesions in Child No. 21. CHI Child No. 9 (GCS = 6) had a left frontal lesion (5.4 cc) and a left temporal lobe lesion (7.2 cc) and CHI Child No. 21 (GCS = 8) had a right frontal lesion (3.4 cc) and a right parietal lesion (.6 cc). Both children were comparable in age at test with each other (7.9 and 7.6 years, respectively) and with the two late injured children described above. For the ‘‘Rooster Story,’’ neither early injured child could produce the story information, despite their similarity in age at test to the two late injured children. For the ‘‘Cat Story’’ (Appendix C.2), both early injured children used simple sentences with minimal use of embedded clauses. However, the child with a right-hemisphere lesion produced slightly more information (propositions = 7) than the child with a left-hemisphere lesion (propositions = 4). It is of interest to note that the two CHI children with left-hemisphere lesions (whether early or late injury) had more difficulty sequencing the pictures for the ‘‘Cat Story’’ (late injury—3 trials; early injury—6 trials) than the two right-lesioned CHI children (both early and late injury) who both sequenced the pictures correctly on the first trial.

**DISCUSSION**

Severe closed head injury has a deleterious effect on discourse in young children. These early school-age children with severe head injuries showed marked reductions in the overall amount of information (propositions), in the structural completeness (as measured by episodic structure), and in the expression of the central semantic meaning (gist) of the story. Discourse-level impairments were apparent even at late stages of recovery ranging from 1 to 5 years postinjury. Moreover, the finding of significant problems for the severe head-injured children in sequencing the picture cards for the ‘‘Cat Story’’ suggests that the difficulties in organizing chunks of information may cross nonverbal and verbal modalities. In contrast, sentential aspects of language were not found to be significantly different between the severe CHI and the noninjured control groups. Moreover, the ability to manipulate certain cohesive devices (e.g., use of reference and connectors) appeared to be comparable for the head-injured and normal control groups.
Despite the somewhat pessimistic outcome of discourse after severe CHI in children, it is important to note that not all of the CHI children remained significantly impaired. Indeed, some produced well-structured stories that were comparable to those produced by the non-brain-injured controls. The individual factors that seemed to be important to consider include age at injury, size of lesion, and localization of lesion. Additionally, other variables need to be considered, including premorbid level of performance, psychosocial factors related to the family milieu, and educational support.

The documentation of discourse deficits in a group of young severely head-injured school age children is of particular interest for several reasons. This evidence supports the view that language abilities, particularly at a discourse level, are vulnerable in young children following a brain injury (Dennis & Barnes, 1990; Ewing-Cobbs et al., 1985; Ewing-Cobbs, Levin, Eisenberg, & Fletcher, 1987; Levin & Eisenberg, 1979). Moreover, the evidence of discourse impairment at long-term postinjury periods contradicts the once held view that recovery of language abilities (Alajouanine & Lhermitte, 1965; Guttmann, 1942) and even of discourse abilities (Jordan et al., 1991) has a favorable prognosis after head injury in children.

The findings of relative preservation of sentential abilities after CHI support the claim that surface-level aspects of language may recover to normal or near normal limits after CHI (Chapman et al., 1992). However, this finding should be interpreted cautiously for several reasons. For example, the relatively young age (6 to 8 years) of our children at the time of testing may account for failure to find differences in specific language structures. The possibility remains that the reductions in syntactic complexity may not appear until later developmental stages when narratives increase in conceptual complexity, requiring greater syntactic complexity. Additionally, although Chapman and colleagues (1992) did not find any differences in syntactic complexity of sentences in an older head-injured group (i.e., 9–18 years) or in the present younger group of CHI compared to control children during a narrative retell task, Campbell and Dollaghan (1990) reported simplified syntax in conversational discourse in a small sample of CHI children. Therefore, the findings with regard to syntactic complexity are equivocal and may depend on the age of the child and the type of discourse genre.

The failure to find differences in the use of temporal and causative connectors (cohesive devices) may be explained by age and stimulus factors. Conceptual understanding of causal relations emerges around 4 years (Byrnes & Duff, 1988), but may not be mastered linguistically until 9 years of age (Bamberg & Damrad-Frye, 1991). Our children were tested at an age when the conceptual basis for causal relations and the linguistic marking of causality are just being mastered. Alternatively, the limited expression of causality may be the consequence of the stimuli. Causal relations were not explicitly depicted in the pictorial “Cat Story” or explicitly stated in the “Rooster Story” but rather had to be inferred. Moreover, the causal relations that had
to be inferred were limited in scope for both stories. Further studies are warranted to examine expression of causal relations by utilizing stories with more complex causal relations in children at different developmental stages.

The discourse deficits in our CHI group could not be accounted for solely by performances on isolated measures of vocabulary or memory. The group results did not reveal a clear association between performance on a vocabulary measure and discourse. Despite the fact that the results for the head-injured group were significantly lower than those for the normal control group on the vocabulary measure, the effect of injury severity on discourse remained significant even after controlling for vocabulary. The role of verbal memory in explaining discourse impairments (particularly on the retell task) was also considered because memory deficits are well documented in CHI populations. Similar to the findings for vocabulary, verbal memory was significantly reduced for the head-injured group. However, the discourse deficits were not accounted for solely by a disturbance in memory.

Nonetheless, the evidence of impaired vocabulary and memory may indeed contribute to the deficits in processing discourse for individual head-injured children, as has been previously reported (Dennis & Barnes, 1990). While the group results did not show a straightforward relationship between discourse and vocabulary or memory measures, performances by individual CHI children suggested that a relationship may be apparent in certain children. That is, vocabulary and memory deficits were evident on the structured measures and in the disrupted discourse of some CHI children (Appendix C.3). However, other CHI children showed disparate performances, performing relatively well on the vocabulary and memory measures and performing poorly on the discourse measures.

With regard to age at injury, the preliminary evidence suggested that the early injured children (<5 years) manifested greater discourse deficits than the late injured group (≥5 years), even though the groups were comparable in age at testing and in initial injury severity. The early injured group tended to perform worse than the late injured group on the linguistic and information structure measures for the auditory retell task. While these results are preliminary and must be interpreted cautiously due to the small sample size, the pattern suggests that children with earlier injuries may be at greater risk for long-term deficits. The lower performance in the early injury group than in the late injury group cannot be accounted for by the injury–test interval difference since the early injury group had the longer interval from injury.

Growing evidence indicates that if a pediatric brain injury precedes or occurs during the stage of skill acquisition, subsequent development of that particular skill may be disrupted in a myriad of ways, including speed of acquisition, developmental lag, and development of different strategies (Ewing-Cobbs et al., 1987). Basic narrative abilities are developed around 5 to 6 years of age, although narrative discourse increases in complexity with advancing age (Botvin & Sutton-Smith, 1977; Westby, 1984). Thus,
for the present study, the cerebral insult predated or occurred during the developmental stage of basic narrative structure for the early injury group, but after the critical developmental stage for the late injury group. These preliminary data suggest that despite a longer recovery interval, children injured at a young age (<5 years) showed a trend toward more severe disruption of discourse than the children injured at 5 years or later, at least as measured by a story retell task.

Despite previous documentation of a relationship between focal brain lesions and linguistic disturbance in children (Aram, Ekelman, & Whitaker, 1987; Chapman et al., 1992; Dennis, 1980a), we were unable to confirm a relationship between size of focal lesions and language structure in our CHI population. The consequences of a severe head injury on language may have been obscured in this CHI group with complex, heterogeneous neurologic profiles with both diffuse and focal areas of abnormal brain signal.

The failure to find language differences in the group study of CHI children with focal lesions may also be due to less severe lesions in our group (or many CHI children, in general) than those for children in other studies with largely vascular pathology. In view of growing evidence documenting the high frequency of focal lesions overlaid on diffuse injury, it remains important to pursue the possibility of specific language disturbances associated with focal lesions after CHI. Therefore, a more illuminating approach to examine language brain relations in CHI populations may be the identification of single cases with relatively large lateralized lesions. The evidence from individual cases injured >5 years in this study supported previous characterization of simplified narratives at both sentential and discourse levels in CHI pediatric populations with left frontal lesions and reduced information in right frontal CHI cases despite a normal amount and complexity of language (Chapman et al., 1992).

For children injured at a young age, however, the relationship between lesion focus and language is less clear. The failure to find a relation between focal lesions in CHI and language ability in our early injured children (<5 years) may be due to a young brain that is less specialized for language. That is, language may be disrupted regardless of lesion focus in a young child. Our finding of greater reduction of language in the two early injury case studies irrespective of lesion focus (left versus right frontal lesions) lends support to the view that both cerebral hemispheres are important in the early stages of language development (Goldman, 1974). Whether these early injured children go on to develop a differential language disruption similar to that in the two late injured cases according to left or right localization remains to be seen.

To conclude, this study documents discourse disruption following severe CHI within a narrow age range of young children. The findings contribute to the growing evidence that expressive language (discourse, in particular) is substantially affected after closed head injury in children (Dennis &
Moreover, the preliminary evidence supports the view that brain injury sustained during a period of rapid emergence of language may result in worse sequelae (Ewing-Cobbs et al., 1989; Kolb, 1989; Thal, Marchman, Stiles, Aram, Trauner, Nass, & Bates, 1991). However, much remains to be learned about age effects (with regard to both age at test and age at injury), subsequent development of discourse, and contributions of lesion focality to language abilities after CHI. Finally, the influence of language intervention must be considered a critical variable. Perhaps the late injury children had greater access to intervention in the public school setting during an important stage of recovery, beyond that offered in the acute state at a rehabilitation facility for very young children. The late injured children were of school age at the time of injury (5 and older) and may have had exposure to daily stimulation in a school setting, whereas the early injured children may have been injured several years before reaching school age. The point is that the more stimulation the better, particularly during the first few years after the injury. It is now well established that stimulation has major effects on behavioral recovery (Greenough, 1986). We have identified individual differences, neurologic indices of injury, and cognitive variables which may contribute to the breakdown of discourse after CHI in pediatric populations. A greater understanding of these factors (e.g., age at injury, neurologic profile, vocabulary, memory, nature of task, amount and type of intervention) is needed to elucidate the nature of discourse impairment in CHI and to establish appropriate methodologies for rehabilitation.

APPENDIX A

Narrative Stimuli and Core Propositions

Rooster Story

Once upon a time, there were two roosters. They were always fighting over who would be ruler of all the hens. One day, they decided to really fight it out. Finally, one rooster was beaten. The poor defeated rooster hid himself in the corner. The other rooster, who won the fight, flew to the very top of the henhouse—and began crowing and flapping his wings to brag about his victory over the other rooster. Suddenly, an eagle swooped down, grabbed the boasting rooster, and carried him far away. Now, this was good luck for the defeated rooster because now he could rule over the chicken yard and have all the hens that he wanted.

A priori propositions.

1. There were two roosters.
2. They were in the chicken yard.
3. The roosters were fighting.
4. One rooster was defeated.
5. He hid himself in the corner.
6. The other rooster flew to the top of the roost.
7. He began crowing.
8. He began flapping his wings.
9. He boasted of his victory.
10. An eagle/hawk/crow swooped down/came by.
11. The eagle grabbed the rooster.
12. The eagle carried him away.
13. This was good for the defeated rooster.
14. He could rule over the chickens.
15. He could have all the hens.
16. He desired to have the hens.

Note. Semantically equivalent statements are acceptable.

Cat Story

A priori propositions
1. A little girl has a cat.
2. The cat is up the tree.
3. The little girl is upset.
4. The girl tells her father.
5. The father decides to help/tries to get the cat.
6. The father climbs the tree.
7. The cat reacts to the father’s advances.
8. The father reaches for the cat.
9. The cat jumps down.
10. The little girl responds.
11. The father slips.
12. The father gets hung up on the tree.
13. The little girl cries.
14. The fire department is called/came.
15. The fireman rescues the father.
16. The cat is on the ground content/safe.

APPENDIX B

Discourse Variables

Domain I: Language Structure

The Language Structure domain was composed of three measures:

1. Total number of words in story production. The total number of words in the child’s story text was calculated including all revisions and whole word repetitions, but excluding all “filler” verbalizations such as “um,” “er,” “uh.”

2. Total number of T-units. A T-unit was defined as one independent clause and all the dependent clauses that modify it (Hunt, 1965). An independent clause consists of a noun-phrase and a verb-phrase unit and represents the main clause. All other clauses are dependent clauses including subordinate clauses (i.e., preceded by since, when, that, and other subordinate conjunctions) and nonfinite clauses (i.e., infinitival and gerundal clauses). A T-unit is roughly equivalent to a sentence.

3. Sentential complexity. Sentential complexity is derived by dividing the number of dependent clauses by the total number of clauses (dependent plus independent clauses). The resulting percentage represents the complexity of sentences produced by the child in terms of the relative amount of clausal embedding produced.

Domain II: Information Structure

Information structure was assessed using the following three variables: (1) amount of information, (2) story structure, and (3) macrostructure—a measure of the gist or global story content.

1. Amount of information. This was measured by analyzing how many core propositions were expressed by each child. As stated previously, each story contained 16 propositions. These propositions (units of information) were used as a template against which the children’s story productions were compared to determine the total number of core propositions included in the
child’s story. Information produced that was not represented by the core propositions was coded as either elaborative or incorrect. Elaborative information was relevant to the story and served to enrich the story, whereas incorrect information was irrelevant to the story or incorrect as matched against the original stimulus.

2. **Story structure.** This was analyzed by utilizing a story component analysis described by Labov (1972). Labov’s discourse analyses defined the essential story components as setting (identification of characters, time, and place), complicating action (sequence of events and turning point of story), and resolution (final outcome). These components define the canonical organization of stories and are represented in most grammars of story organization. Story structure was assessed according to completeness of episodes. The child’s story was coded as one point for each of the essential components produced, resulting in three points when the child produced a complete episode reflected in setting, action, and resolution information.

3. **Global story content (macrostructure).** This is analogous to a skeletal outline of the most important information and is commonly referred to as the “gist” of the text (van Dijk, 1985). In order to evaluate intactness of global story content, a set of 5 propositions (identified from the original 16 story propositions for each story) was established *a priori* based on the semantic organization of the story. For these two particular stories, the central meaning is derived from interpreting the change of roles for the main characters. For the Rooster Story the winning rooster loses in the end, as a consequence of his bragging. For the Cat Story, the man rescuing the cat has to be rescued in the end. The gist propositions provided a way to examine the selective nature of information reduction. The relevant issue addressed by this global story content variable is a qualitative assessment of the nature of information reduction for this head-injured population. For example, it may be that the gist of the story is preserved despite the fact that total amount of information is reduced.

**Domain III: Flow of Information**

Flow of information was assessed according to two measures, both related to efficiency of expression:

1. **Ratio for amount of language relative to amount of information.** The total number of words in the unedited version was divided by the total number of core propositions produced. This ratio revealed how much language the child used (in words) to express each unit of information. This ratio was also included to address whether CHI children use more language than normal control subjects to express the same amount of information, a pattern found in CHI adults (Ehrlich, 1988).

2. **Total number of mazes.** Analysis of the child’s transcript included placing all revisions or repetitions which disrupted the flow of information
within the story in a maze. A maze is a unit of hesitational phenomena (Hunt, 1965). This measure was used to determine whether CHI children exhibit increased disruptions in flow of information compared to normal children.

APPENDIX C.1

Sample Narrative Retells from a Non-Brain-Injured Control Subject and a CHI Patient

A. Non-Brain-Injured Control (Age: 6.7)

The following stories illustrate a well-formed story with regard to both language (complex sentences) and information (episodic structure intact, gist preserved) measures.

``Cat story.''
Once upon a time a little girl lost her kitty up in a tree. Her father tried to climb up the tree and get the cat. He tried to get it but it hissed at him. Then the cat fell and he got stuck on the branch and then the fireman came.

(Number of trials to sequence pictures: correct on first attempt.)

``Rooster story.''
Once upon a time there were two roosters and they fought a lot and (um) one day they decided to have a real battle to see who would (um) rule the chicken coop and one day, one got defeated. So the other rooster stood up on the fence and (um) talked about how good he was and how he defeated the other. Just then a big eagle swooped down and picked up the rooster. That was good luck for the defeated rooster and he now got to be the boss of all the chickens and have any chickens he wanted.

B. Case: No. 5; Severe CHI (Age at test: 6.8; GCS: 4)

The following “Cat Story” shows stereotypic repetitive sentence structure (i.e., “I see . . .”). The child states the events as if describing a picture rather than creating a narrative. The story structure (omission of a resolution) and the gist are impaired (i.e., failure to state the role reversal of the man getting stuck in the tree and needing to be rescued). Notice difficulty in logically organizing information reflected in the number of trials to correctly sequence pictures.

``Cat story.''
I see the little girl crying, and I see the man who climbing up the tree trying to get the cat, and I see, (see, see) the man trying to get it, the cat, (cat,) and I can see the man drop the cat, and the girl trying to catch (unintelligible) and then she started crying . . .

(Number of trials to sequence pictures: six.)

The following Rooster Story reflects difficulty in selecting specific vocabulary to retell the story and in remembering the story information. Story structure is impaired as manifested by the omission of both setting and reso-
lution information. The gist is reduced in that the role reversal is not clear (i.e., the defeated rooster was the winner at the end).

“Rooster story.” Once upon a time there was . . . (I never heard that story before. I was listening but I never heard that story before. What was the story about?) Two chickens. The one that’s defeated slept in the corner. And (the other roos,) the chicken who won, (uh,) flew up on the whatever you call it. When he went up to that thing an eagle came and kind of got him and took him far away. That’s all I remember.

APPENDIX C.2

Sample Stories from Severe CHI Children with Late Injury (>5 years) and Early Injury (<5 years)

Late Injury

Case: No. 19 (age: 7.6; GCS: 7; primarily left frontal damage)

The following stories show impairment in the language domain (reduction in amount and complexity of language) and in the information structure domain (reduction in amount of information and impairment of story structure and gist).

“Cat Story.” There was a cat up in the tree. He climbs up, gets stuck up there. Jumps the cat. And now a fireman comes to get him down.

(Number of trials to sequence: three.)

“Rooster Story.” It was about a hen. And a hen that was beside the corner. And the hen that won a fight. And the hen that lost the fight. That’s all I know.

Case: No. 13 (age: 7.8; GCS: 7; primarily right frontal damage)

The following stories illustrate preservation in the amount and complexity of language and in the amount of information. Notice difficulty with reference in “Rooster Story” in that there is limited distinction between the winner and the loser, resulting in impairment of gist. Story structure is better preserved than in CHI Case 19 with primarily left frontal damage.

“Cat Story.” Once upon a time there was a, once upon a time there was a girl named wait, wait, Once upon a time there was a kid and a girl and her cr cat went up the tree. She started crying. A man came and then he climbed up the tree. And then the man he decided to get the cat. And the cat jumped down. And then she started crying again. And the man got hooked on the tree. The end.

(Number of trials to sequence: one.)

“Rooster Story.” Once upon a time there was a hen and another hen who used to fight whoever was to be the ruler. And one day they got into a fight and said who’s the ruler now? One hen got slapped himself and (put) got
put in the corner. Then the other hen got atop the henhouse and then started croaking. And then a eagle came and then flapped his wings and grabbed him and took him far far away. And then (he can grab) he can have any hens he want.

**Early Injury**

For the “Cat Story,” both early injury children showed a reduction in the amount and complexity of language. Both children tended to concatenate the events with minimal embedding although the right-lesioned child produced more information for the “Cat Story.” Neither child was able to retell any of the information from the “Rooster Story.”

**A. Case: No. 9** (age: 7.9; GCS: 6; left lesion)

“Cat Story.” The boy was getting into the tree to get a cat. Then he (he) go up there to get the cat. And the cat go down. And (it he he he) he stay (held) helding up the tree.

(No number of trials to sequence: six.)

“Rooster Story.” (“I don’t know”).

**B. Case: No. 21** (age: 7.6; GCS: 8; large right lesions)

“Cat Story.” Once there was a girl that had a cat. And her dad and her (and her dad) were playing. And her cat climbed up the tree. And her dad tried to climb the tree and get the cat and he threwed the cat down. And then he got caught. And the fireman came.

(No number of trials to sequence: one.)

“Rooster Story.” Once there were two roosters . . . (could not tell more).

**APPENDIX C.3**

Sample Stories from a CHI Child with Vocabulary and Memory Deficits Evident on Both Structured Measures and the Story Tasks

**Case: No. 4; CHI (age: 6.10; GCS: 4)**

CVLT score: 2 out of 15 (Verbal Memory Measure)

WISC-R Vocabulary Scaled Score: 6

“Cat Story.” (Tell me the story . . . Tell me the story from the pictures.) This little girl said, “That kitty is up there and I want him,” and he’s gettin’ up there . . . (She,) he’s beginning to fall down, and dropped the kitty. The kitty cat jumped down and then the fireman got, (got) to put him down.

(No number of trials to sequence pictures: five.)
“Rooster Story.” Examiner (E), Child (C)
The child did not spontaneously give information. Probes were used to see if some information could be retrieved.

E: What were the animals in the story?
C: The roosters.
E: And what did those roosters do?
C: Fight.
E: Why were they fighting?
C: Because they was fighting every time. (Because they) and they fight all the time.
E: What happened after they fought?
C: And then (the rooster was) the other rooster was hurt.
E: What happened to the other rooster that won the fight?
C: Knock hisself.

REFERENCES


Dennis, M., & Barnes, M. A. 1990. Knowing the meaning, getting the point, bridging the gap, and carrying the message: Aspects of discourse following closed head injury in childhood and adolescents. Brain and Language, 39, 428–446.


N. Butters (Eds.), *Plasticity and recovery of function in the central nervous system* (pp. 149–174). New York: Academic Press.


