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Narrative Discourse in Children with Early Focal Brain Injury

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Children with early brain damage, unlike adult stroke victims, often go on to develop nearly normal language. However, the route and extent of their linguistic development are still unclear, as is the relationship between lesion site and patterns of delay and recovery. Here we address these questions by examining narratives from children with early brain damage. Thirty children (ages 3;7–10;10) with pre- or perinatal unilateral focal brain damage and their matched controls participated in a storytelling task. Analyses focused on linguistic proficiency and narrative competence. Overall, children with brain damage scored significantly lower than their age-matched controls on both linguistic (morphological and syntactic) indices and those targeting broader narrative qualities. Rather than indicating that children with brain damage fully catch up, these data suggest that deficits in linguistic abilities reassert themselves as children face new linguistic challenges. Interestingly, after age 5, site of lesion does not appear to be a significant factor and the delays we have witnessed do not map onto the lesion profiles observed in adults with analogous brain injuries. © 1998 Academic Press

More than 120 years ago, research on the effects of unilateral brain injury in adults led to the conclusion that the left hemisphere plays a specialized

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role in the mediation of language functions. This conclusion has withstood the test of time and has been extended in a number of interesting directions (e.g., left hemisphere specialization for American Sign Language—Poizner, Klima, & Bellugi, 1987). However, two important sets of findings during the past three decades invite refinement of this hypothesis:

(1) The finding that children with left-hemisphere damage do not show the same severe and irreversible aphasias that are observed in adults with homologous injuries (Alajouanine & LHDermitte, 1965; Almli & Finger, 1984; Annett, 1973; Aram, 1988, 1991; Aram, Ekelman, Rose, & Whitaker, 1985; Aram, Gillespie, & Yamashita, 1990; Aram, Meyers, & Ekelman, 1990; Bishop, 1981; Dall'Oglio, Bates, Volterra, DiCapua, & Pezzini, 1994; Eisele & Aram, 1993, 1994; Dennis, 1980; Dennis & Kohn, 1975; Dennis & Whitaker, 1976; Feldman, Holland, Kemp, & Janosky, 1992; Hamill & Irwin, 1966; Hecaen, 1976; Hecaen, Perenin, & Jeannerod, 1984; Kohn, 1980; Levy, Amir, & Shalev, 1992; Rasmussen & Milner, 1977; Reed & Reitan, 1971; Riva & Cazzaniga, 1986; Thal, Marchman, Stiles, Aram, Trauner, Nass & Bates, 1991; Vargha-Khadem, O'Gorman, & Watters, 1983, 1985; Vargha-Khadem, Isaacs, Papaleloudi, Polkey, & Wilson, 1991; Vargha-Khadem, Isaacs, Van der Werf, Robb, & Wilson, 1992; Woods & Carey, 1979; Woods & Teuber, 1978; Wulfeck, Trauner, & Tallal, 1991);

(2) The finding that adults with right-hemisphere injury do show deficits in some aspects of language, including prosody (Ley & Bryden, 1982; Ross, 1985), humor (Brownell, Michel, Powelson, & Gardner, 1983), metaphor (Brownell, Simpson, Birhle, Potter, & Gardner, 1990), idioms (VanLancker & Kempler, 1986), and aspects of narrative discourse (Gardner, Brownell, Wapner, & Michelow, 1983; Hough, 1990; Joanette, Goulet, & Hannequin, 1990; Kaplan, Brownell, Jacobs, & Gardner, 1990).

In the present study, we bring these two lines of research together to examine the effects of early unilateral brain injury on the production of narrative discourse in children between 3;6 and 10 years of age. To frame our hypotheses for this study, we begin with a brief review of relevant issues and findings in each of these research domains and in the area of discourse development in normal children.

LANGUAGE DEVELOPMENT IN CHILDREN WITH PRE- AND PERINATAL BRAIN INJURY

Children with early focal brain injury generally go on to acquire language that is within the normal range, although subtle deficits have been observed (for reviews, see Aram, 1988; Satz, Strauss, & Whitaker, 1990; Stiles & Thal, 1993; Stiles, 1995). Although this basic finding is clear, its nature and implications are still controversial. As Satz et al. point out, the theoretical pendulum has swung back and forth in this field between two opposing views:

(1) The doctrine of equipotentiality, i.e., that the human brain is completely plastic for language, with no initial biases (e.g., Lashley, 1951; Lenneberg, 1967).

(2) The doctrine of irreversible determinism, i.e., that regional specialization for language is already established at birth, so that any alternative form of organization following early brain injury will be inadequate (e.g., Isaacson, 1975; see comments in Fletcher, 1993; St. James-Roberts, 1979).

Irreversible determinism achieved prominence in the late 1970s and early 1980s, in response to several different sources of evidence. First, studies of children with left vs right hemispherectomies showed that removal of the left hemisphere can lead to selective deficits in language, particularly on difficult syntactic tasks; children with right hemispherectomies also showed a lowering of performance relative to controls, but their impairments seemed to be more broadly distributed across verbal and nonverbal measures (Day & Ulatowska, 1979; Dennis, 1980; Dennis & Kohn, 1975; Dennis & Whitaker, 1976, 1977; cf. Bishop, 1981). Second, studies of children with more restricted unilateral lesions (usually due to stroke) reported subtle but persistent deficits in language (Riva & Cazzaniga, 1986; Vargha-Khadem et al., 1983, 1985), particularly in children with injuries on the left. Third, studies of speech processing in healthy newborn infants revealed a left-hemisphere bias for complex speech sounds, suggesting that a left hemisphere bias for linguistic stimuli may be present at birth (Molfese & Segalowitz, 1988; Kinsbourne & Hiscock, 1983; for discussions, see Almli & Finger, 1984; Smith, 1984; Springer & Deutsch, 1989; Hellige, 1993). Taken together, these findings suggested that the left hemisphere is innately specialized for language and that there may be limits on plasticity and compensatory forms of organization for language tasks (Gazzaniga, in press; Geschwind, 1965, 1972).

In the studies cited above, the investigators have always been careful to point out that the disadvantages displayed by children with left-hemisphere injury are quite modest, with performance that is usually within the normal range (i.e., the injured children are not aphasic). However, some secondary sources citing these studies have overstated the case, suggesting that normal language abilities cannot be achieved at all if the ''language hemisphere'' is seriously damaged. This conclusion is unwarranted. Indeed, many studies have failed to find any evidence at all for language deficits in children with left-hemisphere injury (Vargha-Khadem et al., 1991; Feldman et al., 1992), and others report only characteristic left-hemisphere effects when the focal lesion is accompanied by additional complications, e.g., seizure disorders (Vargha-Khadem et al., 1992) and/or subcortical involvement (Aram, 1991). Furthermore, the correlations between behavioral measures and lesion type in children do not always map onto the familiar patterns observed in brain-damaged adults. For example, Thal et al. (1991) studied the first stages of language development (i.e., from first words to first word combinations) in infants and toddlers with pre- or perinatal injuries to the left or right hemisphere. They report that initially, irrespective of lesion site, children were delayed in production, but that delays in word comprehension were actually more common in children with right-hemisphere lesions (see also Wulfeck et al., 1991). Eisele and Aram (1993) also report greater delays in certain aspects of sentence comprehension among children with right-hemisphere injury.

Related findings come from Bates et al. (1994) in a study of 53 infants with pre- or perinatal injuries between 10 and 44 months of age. In this study, there was no significant difference between left- and right-hemisphere children as a group in any aspect of early language production; however, there were specific delays in word and sentence production between 10 and 44 months of age in children with injuries involving the left temporal lobe. In adults, left temporal injuries are more often associated with fluent aphasia, accompanied by moderate to severe deficits in comprehension. None of the left-temporal cases in the Bates et al. study had comprehension deficits, despite their delays in production. Based on findings like these, Thal and her colleagues conclude that ''the regions responsible for language learning are not necessarily the same regions that mediate maintenance and use of language in the adult.'' At the very least, one must conclude that correlations between linguistic symptoms and lesion site undergo considerable change from infancy to adulthood.

Most investigators in this field now accept a compromise view, midway between equipotentiality and irreversible determinism (Satz et al., 1990; Stiles, 1995). The left hemisphere may be innately predisposed to process language—either because it is prewired for specific language functions or because it has more general computational properties (e.g., speed and mode of processing) that are advantageous for fluent and efficient language use. However, these predispositions are sufficiently plastic and/or indirect that other forms of organization for language are possible, under some conditions (see also Bradshaw & Nettleton, 1981; Hellige, 1993; Springer & Deutsch, 1989). This conclusion is compatible with a rich literature on cortical plasticity in other species (e.g., Frost, 1982; Irle, 1990; Kennard, 1936; Killackey, 1990; Merzenich, Recanzone, Jenkins, Allard, & Nudo, 1988; O'Leary & Stanfield, 1989). Furthermore, based on a comparison of developments in language, emotion, and spatial cognition in the focal lesion population, Stiles and colleagues have proposed that plasticity may be greater for language than it is for other, phylogenetically older, cognitive functions (Reilly, Stiles, Larsen, & Trauner, 1995; Stiles & Nass, 1991; Stiles & Thal, 1993; Stiles, in press; Stiles-Davis, 1988; Stiles-Davis, Janosky, Engel, & Nass, 1988).

This compromise view is appealing, but it leaves many questions unanswered, including the following:

(1) Does recovery exact a lasting price? Does it involve suboptimal modes of processing that are very good, but never quite as good as the default form

of neural organization for language that would have emerged in normal circumstances?

(2) Does recovery for language occur once, at a particular point in time? Or must it recur each time the child moves on to a higher linguistic level?

(3) What is the relationship between lesion type (side, site, and size) and the patterns of delay and development in language ability? Are the correlations between brain and behavior that are observed in the focal lesion population persistent over time? Or do they change with the specific linguistic challenges that children face at each stage of development (e.g., from first words, to grammar, to narrative discourse)?

If it is the case that there are alternative routes to recovery, i.e., multiple forms of neural organization for language in the face of early focal brain injury, there may be more than one answer to each of these questions. It is sometimes argued that plasticity involves a switch: from left hemisphere processing to the mediation of language in the homologous perisylvian zones of the right hemisphere (e.g., Woods & Carey, 1979; Woods & Teuber, 1978). However, a classic study by Rasmussen and Milner (1977) suggests that this is not always the case. These investigators looked at the results of sodium amytal injection to each hemisphere (i.e., the Wada test) in more than 200 adults who had suffered unilateral injuries to the left hemisphere early in life (usually before 1 year of age). In approximately 40% of these patients, all speech functions were interrupted by sodium amytal injections to the left hemisphere (i.e., they were still left-hemisphere dominant for language). In another 20%, speech functions appeared to be distributed across the two hemispheres (e.g., repetition was mediated by one hemisphere, naming by the other). Only the remaining 40% of these patients displayed the expected pattern of right-hemisphere dominance for language. As adults, these individuals were candidates for neurosurgery to correct severe seizure conditions. Thus, it may be that their results are specific to this population and do not generalize to the focal lesion population as a whole. Rasmussen and Milner also point out that the probability of left- vs right-hemisphere dominance interacted with lesion site (e.g., the expected switch to language dominance in the right hemisphere was more likely if the patient's original lesion involved the classic temporal-parietal language zones). Nevertheless, this study provides clear evidence that language recovery can be achieved with several different forms of inter- and intrahemispheric organization for language.

In the present study, we address these issues by concentrating on narrative discourse from 3.6 to 10 years of age, in children who suffered unilateral injuries to the left or right hemisphere before 6 months of age, i.e., before children normally show any signs of word comprehension or production. Although the relationship between outcome and age of injury is still unclear (Kennard, 1936; Marchman, 1993; Smith, 1984; Riva & Cazzaniga, 1986;

Aram, 1988), most investigators agree that plasticity should be maximal in this population. We will look at several different aspects of linguistic performance in a story-telling task, including lexical diversity, grammatical well-formedness, and narrative complexity. First, however, we present a brief overview of narrative development in normally developing children.

NARRATIVE DEVELOPMENT IN CHILDREN

Most developmental linguists agree that by age 4½ to 5 years, normally developing children have access to most of the morphology and syntax of their language. Nonetheless, the ability to fluently recruit these structures to linguistically encode the nuances and relationships required by various discourse genres continues to develop well into late childhood and beyond. Narratives represent a discourse genre that emerges relatively early. However, even though children as young as 2½ years can produce the rudiments of a story (Appleby, 1978; Umiker-Sebeok, 1979), studies which include older children and adults (e.g., Bamberg, 1987; Reilly, 1992; Berman & Slobin, 1994) have made it clear that narrative competence continues to develop until adulthood. Thus, the ability to produce both a semantically coherent and a linguistically cohesive narrative is a complex developmental task, and its acquisition continues through the school years. As such, it provides a rich context in which to explore later language development, with respect to both the linguistic encoding of narrative elements and the access and recruitment of complex syntax to serve narrative functions.

Studies of narratives and their development have focused on different aspects of stories: One perspective has been to explore the child's understanding of the event structure of narratives and their underlying story schema, as in studies by Mandler and Johnson (1977), Rumelhart (1975) and Stein and her colleagues (e.g., Stein & Glenn, 1979; Stein & Policastro, 1984; Stein & Trabasso, 1982). Their findings suggest that well-formed narratives are represented in hierarchical story schema and that this schematic knowledge facilitates both the comprehension and the recall of stories. A second approach has concentrated on the acquisition of specific linguistic devices characteristic of the narrative genre (e.g., Berman & Slobin, 1987; Berman, 1988), including connectors, pronouns, and particular kinds of tense and aspect marking. Finally, in an attempt to complement and bridge the conceptual and linguistic approaches, Bamberg and his colleagues (Bamberg, 1987, 1997; Bamberg & Damrad-Frye, 1991; and Bamberg & Marchman, 1990) and most recently, Berman and Slobin (1994) have addressed how children integrate an emerging conceptual framework for narratives with their developing linguistic abilities. One focus of these studies has been how the child integrates local and global facets of the story and how these aspects of narrative coherence are linguistically realized.

With respect to the developing structure of narratives, previous studies of normally developing children (Karmiloff-Smith, 1979, 1981, 1984; Reilly, 1992; Bamberg, 1987; Berman & Slobin, 1994) indicate that 3- and 4-year-olds tend to tell rather idiosyncratic stories which focus on local details, while 5- to 7-year-old children pay more attention to general story organization. Then, from about 8 years and upward, children begin to integrate both top-down and bottom-up perspectives within the broader context of relating an event sequence. Berman (1988), who collected stories in Hebrew, notes that 3- and 4-year-olds ''lack command of the precise discourse functions associated with the grammatical forms and lexical items they use; nor have they achieved mastery of the accepted ways of story telling in their culture'' (1988, p. 488). However, by the time the children are school age, Berman found that they have reached the stage of ''grammaticization''; they know what it means to tell a story. These narratives ''take the form of sequential chaining of chronologically related events'' (p. 487). Studies of English and German stories (Bamberg, 1987; Bamberg & Marchman, 1990) concur with those of Karmiloff-Smith and Berman. Their findings indicate that at age 5, children focus on local events, stringing these together in a linear fashion. By age 9, children are becoming aware of the more global aspects of a story, integrating them with local aspects as they organize them in terms of episodes. During this transition from a local to integrative framework, we would expect to see increasing use of complex syntax to appropriately foreground and background narrative information. Finally, by adulthood, stories are fully organized into hierarchical structures in which character intentions and causal links are made fully explicit.

Labov and Waletzsky (1967) proposed that in addition to referential information about the characters and the sequence of unfolding events, narratives include evaluative information. That is, good narratives have a point, and particular evaluative devices reflect the narrator's perspective on the characters and their activities. Several recent studies have investigated the emergence of evaluative aspects of narratives (Bamberg & Damrad-Frye, 1991; Reilly, 1992; Bamberg & Reilly, 1996). They report that preschool children tend to depend heavily on affective prosody. By age 5, children are inferring causal motivation for character behavior. By age 7, children no longer rely on paralinguistic affective expression, but are now increasing both the type and the frequency of lexically encoded evaluative narrative devices—a trend that continues into adulthood.

Interestingly, when we look more broadly at language profiles of adult stroke patients, important aspects of narrative competence appear to be mediated by the right, rather than the left, hemisphere. Right-hemisphere patients appear to have lost some of the organizational principles that normal children acquire slowly across the period from elementary school to adulthood. Let us now consider the literature on language loss in brain-damaged adults, to derive our major hypotheses concerning the effects of early left- vs right-hemisphere injury on narrative discourse in children.

RIGHT-HEMISPHERE CONTRIBUTIONS TO LANGUAGE

According to the strongest versions of the left-hemisphere hypothesis for language, the right hemisphere of normal right-handed adults should be ignorant of all linguistic functions. However, it is now clear that the right hemisphere does participate in some aspects of language processing in adults. Visual hemifield studies of normal adults have provided evidence for certain kinds of lexical priming when words are presented to the left visual field (and hence to the right hemisphere; Chiarello, 1985). Studies of split-brain patients have also provided evidence for word comprehension and priming in the right hemisphere; indeed, there is some evidence that split-brain patients can make judgments of grammaticality with the right hemisphere, even though the same patients cannot use this syntactic information to comprehend complex sentence structures (Gazzaniga, 1994). Hence the right hemisphere does appear to play a role in lexical and (perhaps) aspects of grammatical processing.

Accruing evidence from normal adults and aphasic patients suggests that the right hemisphere may also handle some language tasks *better* than the left, including aspects of narrative discourse (Joanette et al., 1990). But again, there is still considerable controversy regarding the proper interpretation of these findings, i.e., whether they are due to a domain-specific deficit in linguistic pragmatics (e.g., Gardner et al., 1983) or to a primary deficit in attention and information integration that has secondary effects on discourse (Heilman, Watson, & Valenstein, 1985). For our purposes here, the point is that normal language processing seems to involve contributions from both cerebral hemispheres. From this perspective, it is perhaps less surprising that young children can achieve normal or near-normal language abilities following injury to the classic left hemisphere language zones. To be sure, some alternative form of brain organization is necessary for this to occur, but the reorganization may be less extensive than would be predicted based on the strong versions of the hypothesis that language is uniquely a left hemisphere function.

Given these results for both normal adults and adult stroke patients, what patterns of impairment might we expect (if any) in children with left-hemisphere vs right-hemisphere lesions? A first pass through the adult literature would lead to the following predictions:

(1) Children with left-hemisphere injuries will be selectively impaired on measures of lexical diversity and grammatical well-formedness compared to children with injuries on the right.

(2) Children with right-hemisphere injuries will be selectively impaired on measures of narrative coherence and complexity.

(3) Overall, focal brain injury may lead to suboptimal performance (compared with matched normal controls) on all aspects of language production, from single words to stories.

Note that these predictions are based on a static vision of brain–behavior relations, where the relationship between lesion type and linguistic symptoms remains constant across all stages of development. As Thal et al. (1991) and Bates et al. (1994) have shown for the first stages of language development, these static assumptions may be incorrect. The regions responsible for language processing may change over time, as children solve acquisition problems at one level and move on to another. It is possible, for example, that the specific correlations between lesion type and language outcome observed before 4 years of age will resolve over time, with all children moving toward a stable and workable form of brain organization for language. In the present cross-sectional study, we will compare children in the focal lesion population with normal controls across the period from 3;6 to 9;6 years of age, the range in which many of the most important developments in oral and written discourse normally take place (Appleby, 1978; Peterson & McCabe, 1983; McCabe & Peterson, 1991; Karmiloff-Smith, 1979, 1984; Stein & Glenn, 1979, 1982; Bamberg, 1987; Berman, 1988; Berman & Slobin, 1987, 1994).

METHOD

Subjects

Children in the study included 13 children with right-hemisphere damage (RHD) (ages: 4;1–9;1, *M* = 6;6), 18 children with left-hemisphere damage (LHD) (ages: 3;7–9;4, *M* = 6;1), and 31 neurologically intact normal controls (ages: 3;5–9;4, *M* = 6;4). Analyses of variance confirmed that there were no significant differences across the three groups in age or gender. All of the children with brain injury have unilateral focal lesions which occurred before 6 months of age as indicated by MRI or CT scan. One child with bilateral congenital anomalies was included, as the anomalies were judged by the consulting neurologist to be incidental to the injury. All insults are of pre- or perinatal origin, except for 1 child who suffered a head trauma at 6 months of age. A subset of the children have had seizures in the past; however, for all children in this study, with one exception, all seizures have been medically controlled. Overall, our subject group represents an exceptionally well-defined and homogeneous focal lesion sample. Details of neurological involvement, including lesion side, site, past seizure history, as well as presence and extent of subcortical involvement, are included in Table 1.

The literature on narrative development suggests that there are major developmental changes in narrative discourse at about 5 years of age, and by 5, normally developing children have access to the vast majority of grammatical structures in their language. For these reasons, the children in each lesion group, as well as controls, were divided into two age levels: less than 5 years of age (Younger) and greater than or equal to 5 years of age (Older). This division yielded 7 children with left-hemisphere injury, 4 children with right-hemisphere injury, and 11 controls in the youngest age group; there were 11 children with left-hemisphere injury, 9 children with right hemisphere injury, and 20 controls in the older age group. Because these sample sizes are unequal and relatively small (particularly the younger RHD group), interactions between age and lesion type should be interpreted with caution.

Procedure

To allow the children to become comfortable with the setting and to accustom them to the task, each child first looked at a short picture book *The Balloon Story* (Karmiloff-Smith, 1979).

TABLE 1
Neurological Profiles of Subjects

Subject No.	Age	Side of lesion	Subcortical involvement	Seizure	Lesion description
1	3;7	Left	Y	N	Frontal
2	3;7	Left	Y	N	P-T > F frontal-parietal temporal (small frontal)
3	4;1	Right	Y	N	Frontal horn dilation, subcortical only
4	4;2	Left	Y	N	Temporal
5	4;7	Right	Y	N	P > T mostly parietal subcortical only
6	4;7	Right	Y	N	Parietal, subcortical only
7	4;7	Left	Y	N	Parietal-temporal, small frontal (posterior)
8	4;8	Left	Y	Y	Temporal-parietal > occipital > frontal
9	4;9	Left	Y	N	Middle cerebral artery infarct, encephalomalacia
10	4;7	Right	Y	N	Temporal, parietal, occipital, subcortical only
11	4;11	Left	Y	N	Parietal porencephaly
12	5;0	Left	Y	N	Frontal periventricular cyst, subcortical only
13	5;2	Left	Y	N	Temporal parietal > frontal > occipital
14	5;3	Left	N	N	Temporal
15	6;1	Left	Y	Y	Frontal porencephaly
16	6;2	Left	?	Y	Parietal, occipital and temporal
17	6;7	Right	Y	N	Temporal porencephaly, subcortical only
18	6;10	Right	Y	N	Frontal-parietal
19	6;10	Right	Y	N	Parietal-temporal
20	6;11	Right	Y	N	Posterior temporal
21	7;0	Right	Y	N	Parietal
22	7;1	Right	?	Y	Frontal-temporal-parietal-occipital porencephaly
23	7;2	Left	Y	Y	Parietal-temporal > occipital
24	7;8	Right	Y	N	Frontal-temporal > parietal
25	8;0	Left	Y	N	Frontal-temporal-parietal
26	8;7	Right	?	Y	Hemiatrophy, ventricular dilation
27	8;10	Left	?	Y	Parietal-temporal-occipital
28	8;10	Left	Y	Y	Frontal-temporal-parietal
29	9;0	Right	Y	N	Frontal-temporal-parietal-occipital porencephaly
30	9;1	Right	Y	Y	Frontal-parietal-temporal
31	9;4	Left	Y	N	Parietal encephalomalacia

The children described the pictures as they looked through the booklet, and then they retold the story with the book available for reference. The same procedure was followed with a 24-page picture book, *Frog, Where Are You?* (Mayer, 1979), a story about a boy, a frog, and a dog. Like the practice story, this book has no words. As the story opens, the boy and the dog are looking at a frog in a jar. During the night, the frog escapes, and in the morning when the frog is discovered to be missing, the boy and the dog set out to find him. In their search they meet and interact with a variety of animals in the forest. Finally they find the frog, another adult frog, and a clutch of baby frogs. The boy takes one of the baby frogs home. The children told the story to the experimenter as they looked through the book; later, they retold the story. The present study is restricted to the first telling of the Frog Story only.

Transcription and Coding

The children's narratives were both audiotaped and videotaped, and both tapes were used for transcription purposes. Utterance boundaries were determined by intonation contours as well as by pause length. The CHAT format from the CHILDES system was used for transcription (MacWhinney, 1991). The children's stories were compared on the following parameters.

Overall Story Length

If individual children differ (by age or lesion group) in the absolute length of their stories, then obviously this fact will have an impact on every other linguistic index in our data set. Therefore, we began by examining age by group effects in overall length, operationalized in several ways.

First, using the FREQ program of the CHAT coding system (MacWhinney, 1991), the total number of word types (the number of different words) and word tokens (the number of exemplars of each individual word type) were calculated for each child's narrative. These figures could then be used as the denominators for more detailed explorations of lexical production (see below). The word lists generated by FREQ were also used to derive an estimate of total number of nouns and total number of pronouns, to be used as denominators in specific analyses of pronoun use as described below.

Second, the total number of propositions used by each child was tallied. In this propositional analysis, a proposition is defined as a verb and its arguments. From a semantic perspective, a proposition corresponds roughly to a single event. Each clause in a compound or complex sentence was considered to represent one event and, therefore, one proposition. For example, the utterance ''The boy was mad at the dog for breaking the jar'' counted as two propositions, as would ''The boy was mad at the dog; he broke the jar.'' In contrast, ''He's trying to get out'' was counted as one proposition. Pauses and intonation contours helped to mark propositional boundaries. Based on Stein and Glenn (1979), we tallied the number of relevant propositions in each child's telling of the story. This included all propositions that contributed to the story and did not diverge from the content of the episodes, e.g., utterances such as ''I have a bracelet just like yours, but mine's pink.'' Assuming there are group differences in length, structural and narrative measures can be expressed as a ratio of number of propositions.

Lexical Measures

Type/token ratios. Using the type and token counts from the FREQ program (see above), lexical type-token ratios were computed for all child utterances to provide an index of lexical diversity.

Evaluation. Adapted from classic narrative analyses (Labov & Waletzsky, 1967) as well as more recent developmental approaches (Bamberg & Damrad-Frye, 1991; and Reilly, Klima, & Bellugi, 1991; Reilly, 1992), evaluative comments were tallied as one means to assess lexical diversity. In contrast to reporting factual or ''referential'' information, evaluative comments reflect the narrator's perspective and the significance of events to the storyteller. Examples include situations in which the child infers the internal state of the characters by using labels for emotional states and behaviors, e.g., ''An' when he woke up he was very sad'' or ''He was crying.'' Others may be the evaluation of an action or a character, e.g., ''He was a nasty owl.'' In addition, mental verbs were also included in this category, e.g., ''He was wondering where that frog had gone,'' as were causal markers reflecting the motivation of the protagonists, e.g., ''He looked in the hole to see if his frog was in there.'' Finally, hedges, which indicate a level of certainty/uncertainty, as in ''He probably is/might be/ maybe is in the hole,'' were included in these tallies. Summing across all exemplars of these subcategories for each child, a total score for *frequency of evaluation* was obtained. Assuming that there prove to be group differences in number of word tokens, these evaluation token scores will be analyzed as a percentage of all word tokens. In addition, the range of evaluation subcategories represented in the child's narrative (emotional states and behaviors, mental verbs, causals, and hedges) was tallied and by adding the ''yes/no'' answers for each category a score for *evaluative diversity* was obtained.

Forms of reference. The nominal and pronominal forms that children choose to refer to the actors and objects in the story constitute a lexical domain that is tightly tied to discourse skill. For present purposes, several different measures of pronominal reference were derived from the transcripts. Every pronoun that a child used in the story was categorized along two dimensions: (1) whether the antecedent of the pronoun could be inferred from the text and (2) whether the pronoun and its antecedent noun were explicitly encoded in the same sentence. We assumed that the former reflects a degree of naivete or egocentrism in pronoun use, while the latter should be an index of the child's efforts to mark coreference explicitly at the sentence level. Three proportion scores were derived: noun/pronoun ratios; proportion of all ambiguous pronouns, i.e., those in which the antecedent could not be inferred from the text; and proportion of all pronouns that were coreferent with a noun in the same sentence.

Structural Indices

Narratives also provide a rich context in which to investigate the child's mastery and deployment of particular linguistic constructions. As such, all morphological errors as well as all complex sentences were tallied and categorized.

Morphological errors. All errors of commission or omission were tallied. Subcategories included errors in pronouns (e.g., ''*him* lost it''); verb auxiliaries (''they 0 hollering at him'' or ''they was hollering''); determiners (''0 dog run faster than the bee''); noun plurals; errors in verb tense (''he *fall* down in there'') or number marking (''he *have* his horns stickin' up''); and finally prepositional errors (''he's lookin' *up* those woods''). These scores were calculated as a ratio of morphological errors to total number of propositions in the story.

Pragmatic connectors. These are conjunctions that serve to connect two separate utterances, rather than two clauses within one sentence intonation contour (see complex sentences below). Pragmatic connectors introduce a new utterance or event, ''*And then* he looked in the hole.'' These items were also expressed as a ratio of all propositions.

Complex syntax. Complex sentences are multiple propositions falling within a sentence intonation contour and are categorized according to the following scheme:

(1) coordinate sentences (and, or, or but);

(2) sentences with subordinate adverbial clauses (e.g., when, where, since, because, if, then, and so);

(3) sentences with verb complements (e.g., say (that)+S, try+V, start+V, keep+V, want+V/S);

(4) relative clauses (''the boy was calling for the frog that was lost''); and

(5) passives, both full (the dog's being chased by bees) and ''got'' passives (''he got throwed in the water'').

The number of individual complex sentences in a child's story were tallied to yield the Frequency of Complex Sentences. This number was divided by the number of propositions in the child's story to give us the *proportion of complex sentences.* The number of different sentence types employed by the child (from categories 1–5 above) were counted to yield *syntactic diversity.*

Narrative Measures

Measures of narrative structure included the following.

Story components. As a measure of story complexity, we conducted an episodic analysis (adapted from Marchman, 1989) and tallied the extent to which children included the following eight basic components of the story: Setting; Instantiation (the frog escapes); Search episodes (search for the frog: interaction with bees; gopher biting; interaction with owl; interaction with deer; falling in pond); Resolution (the boy finds the frog). Because this is, in fact, a picture-description task, one might argue that all the components of the story are available to the child. Nonetheless, some children omitted basic elements. Moreover, linking the events in the book and understanding the relationship between them require that the child infer a great deal of information that is not readily apparent from the pictures on the page. For example, there is no explicit indication that the frog on the last pages is the same frog as the original lost frog and that this segment therefore represents a resolution or that all the boy's episodes entail a search and are motivated by his having initially lost the frog. Story components were analyzed as total scores (with a possible range from 0 to 8), and the ratio of story components to total propositions was analyzed to determine whether this measure was affected by overall length.

Search. To explore the degree to which children understood the motivation for the boy's behavior and the general theme of the story, we noted whether the child explicitly mentioned that the frog was missing and that the boy was searching for him (range = 0–2), 1 point for mentioning each aspect of initiating the search theme: frog missing; boy looking). Whether the ''search'' theme was reiterated later in the story was also noted; this served as an indication of the child's understanding of the boy's continuing behavior (again, range = 0–2 in which 0 = no additional mention; 1 = one or two additional mentions; 2 = multiple additional mentions).

Using the written transcripts, each variable was tallied by two independent coders who achieved better than 90% reliability for lexical, morphological, syntactic, and narrative scores. Disagreements were discussed until resolution was achieved.

RESULTS AND DISCUSSION

Quantitative results within lexical, structural, and narrative categories will be presented first, and then a more qualitative view of developmental effects and group differences follows.

Quantitative Results

Each of our language outcome measures was subjected to a 2×3 analysis of variance, with age group (<5 years of age; >5 years of age) and lesion group (LHD, RHD, normal controls) as between-subjects variables. When lesion group effects emerged, post hoc *t* tests (two-tailed) were carried out to ascertain the locus of this effect. Specifically, we asked whether there were significant differences in children with left- vs right-hemisphere damage and whether the two lesion groups taken together were significantly different from normal controls. In addition, following up on findings by Bates et al. (1994) for word and sentence production between 10 and 44 months, we conducted ancillary 2×2 analyses on the clinical sample only, comparing children with injuries that involve left temporal cortex to other focal lesion children whose injuries spare that area (i.e., both right-hemisphere children and LH children with temporal sparing).

Overall Story Length

Propositional length. The 2×3 analysis of variance on total number of propositions yielded a significant main effect of lesion group ($F(2, 61) = 6.52$, $p < .003$), but no effect of age group and no group by age interaction. Two-tailed t tests revealed no significant difference between the left- and the right-hemisphere groups ($t = 0.81$, $p > .42$). However, when the two lesion groups together were compared with normal controls, the difference was reliable ($t = 3.62$, $p < .001$). Hence we may conclude that children with focal brain injury produce shorter stories overall than their age-matched normal controls. We also conducted a 2×2 analysis of variance with the focal lesion sample only, regrouped to reflect those with and without left temporal involvement. This analysis yielded no main effect of lesion type and no interaction with age.

Total word tokens/types. We conducted separate 2×3 analyses of variance on total word types and total word tokens. In both cases, we found main effects of lesion group (for tokens, $F(2, 61) = 8.56$, $p < .001$; for types, $F(2, 61) = 11.87$, $p < .0001$), but no main effects for age and no age by lesion group interaction. The t tests comparing left- vs right-hemisphere groups uncovered no reliable effects of lesion side (for tokens, $t = 0.71$, $p > .48$; for types, $t = 0.89$, $p > .38$). The lesion group difference apparently derives from the focal lesion children as a group, compared with normal controls (for tokens, $t = 4.12$, $p < .0001$; for types, $t = 4.74$, $p < .001$). Additional 2×2 analyses of variance looking at presence/absence of left temporal injury revealed no effects of lesion type and no interaction with age.

It appears that there are no age effects on the sheer amount of speech produced by children in this narrative context, and there are no effects of lesion site. However, children with focal brain injury tend to produce less speech overall. Their stories are shorter in number of propositions; they use fewer word types as well as fewer word tokens. It is clear that any further explorations of these data will have to take story length into account. To determine whether it would be appropriate to use only one denominator (e.g., number of propositions) to adjust all remaining scores, we carried out a multivariate analysis of variance comparing these three length measures (types, tokens, and propositions) as a function of age and lesion groups (i.e., left vs right vs normal controls). This analysis did reveal a significant interaction between type of length measure and lesion group ($F(4, 112) = 5.83$, $p < .0001$), which means that the relationship among these length measures is not equivalent across the relevant clinical groups. In the analyses that follow, the denominator that we use for proportion scores (or the length measure used in covariate analyses) will vary depending on the nature of the target measure (i.e., lexical, structural, or narrative).

Lexical Indices

Type–token ratio. Children with focal brain injury produced fewer word types and tokens than normal controls, an obvious correlate of the overall length differences reported above. However, the type–token ratio should take these differences in length into account. This ratio is often taken to be an index of lexical diversity, holding total output constant. However, the analysis of variance yielded no significant main effects of age or lesion group in the present study, and no significant interaction. Overall, the average type–token ratio in our children was .348, with remarkably little variation over groups (i.e., a range in group means from .342 to .365). Type–token ratios may be more sensitive when the content of discourse is allowed to vary (e.g., in studies of free speech). When subjects are asked to describe the same story, there may be much less room for variation. Similar negative findings were obtained in a 2×2 analysis for the lesion sample only, as a function of age and presence/absence of left temporal injury.

Evaluation. Evaluation token scores were divided by the total number of word tokens used by each child. Analysis of variance on these proportion scores yielded no significant effects, although the main effect of age group reflected a trend ($F(1, 61) = 3.50$, $p < .07$) toward proportionally more use of evaluative lexical items in older children. In the analysis of raw scores for evaluation diversity, there was a reliable main effect of age ($F(1, 61) = 7.47$, $p < .008$), but no main effect of lesion group and no interaction. We did not treat evaluation diversity as a proportion score, because this measure summarizes over broad categories (with a possible range from 0 to 4) rather than word types. However, to determine whether group differences in evaluation diversity have been masked by variations in length, we repeated the age by lesion group analysis of variance, treating number of propositions as a covariate. Nothing changed: there was still a main effect of age group ($F = 6.62$, $p < .02$) with no other significant effects. Similar negative results were obtained in a 2×2 analysis looking for interactions of age with left temporal involvement.

Forms of reference. Noun/pronoun ratio is a measure that varies widely in different forms of adult aphasia following left-hemisphere injury. However, in the present study this measure did not prove to be an interesting index of age or lesion group. The analysis of variance yielded no significant main effects or interactions for noun/pronoun ratios. The mean ratio was .50

(i.e., approximately one pronoun for every two nouns), but the range was enormous, from .04 to 1.88. The 2×2 analysis looking for left temporal effects also failed to yield reliable effects of lesion type or age.

We also looked at the use of pronouns for which there was no recoverable antecedent. Whether we looked at this measure as a raw number or as a proportion of all pronouns used, there were no significant effects of age or lesion group. Indeed, failed anaphors of this kind occurred across the age range from 4 to 10 years, constituting a mean of 25% of all pronouns used ($SD = 21.4\%$). The 2×2 analysis looking at left temporal effects also yielded no reliable effects.

Finally, we looked at all cases in which children used a pronoun and its noun antecedent within the same sentence, on the assumption that this measure would reflect efforts to stage more complex and complete referring expressions. This measure was expressed as a ratio of all pronouns used. The 2×3 analysis of variance revealed a significant main effect of age group ($F(1, 61) = 4.78$, $p < .033$), but no main effect of lesion group and no interaction. The age effect was in the predicted direction: younger children use pronouns in the same sentence with their antecedent 10.9% of the time ($SD = 11.5\%$), compared with a mean of 25% for older children ($SD = 28\%$). The 2×2 analysis regrouping the lesion sample by presence/absence of left temporal damage also yielded no main effect of lesion type and no interaction with age.

To summarize so far, there are changes in lexical output depending on age. These include an increase in both the use and the range of evaluative terms and increased use of pronouns that are coreferential with a noun in the same sentence in the Older group. However, we have failed to find any effects of lesion group on these lexical measures, above and beyond the tendency for brain-injured children to produce shorter stories with respect to word types or tokens. We must conclude that children with focal brain injury are able to keep up with their age mates on these aspects of lexical and narrative development.

Structural Indices

Proportion of morphological errors. The 2×3 analysis of variance yielded a significant main effect of age group ($F(1, 61) = 8.17$, $p < .01$) and a significant main effect of lesion group ($F(2, 61) = 5.13$, $p < .01$). The interaction was not reliable ($F(2, 61) = 0.45$, ns). Individual scores are presented in Fig. 1, with regression lines to indicate age trends within each group. As expected, the age effect reflects a significant drop in the frequency of morphological errors with development, from a mean of 0.36 in children with brain damage under 5 (approximately one error every three propositions) to a mean of 0.15 in 5- to 10-year-olds (approximately one error every seven propositions), collapsed across lesion groups. To explore the effect of

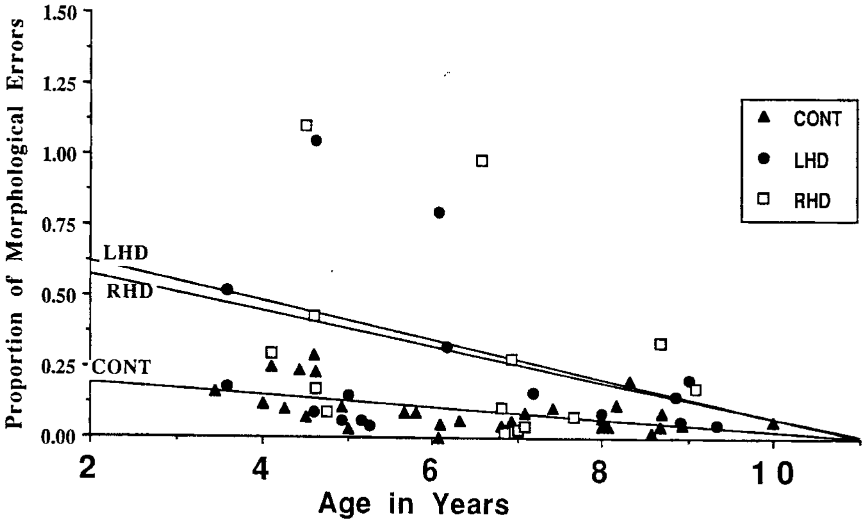

FIG. 1. Morphological errors of individuals.

lesion type in more detail, we carried out a series of post hoc comparisons (two-tailed *t* tests). There was no significant difference between left- and right-lesioned children ($t = -.40$, $p < .69$). Right-hemisphere subjects produced significantly more morphological errors than normal controls ($t = 2.42$, $p < .04$), and the difference between left-hemisphere-damaged subjects and controls just missed significance ($t = 1.95$, $p < .07$).

We then regrouped the lesion sample only, to reflect presence/absence of left temporal involvement, and conducted a 2×2 (age group by site) analysis of morphological error scores. This time we obtained a significant main effect of age group ($F(1, 30) = 5.05$, $p < .04$), and a significant interaction between age group and lesion type ($F(1, 30) = 5.24$, $p < .03$), but no main effect of lesion type. The interaction is illustrated in Fig. 2, which indicates that younger children whose injuries involve left temporal cortex seem to produce more errors than children whose lesions spare that area, a difference that is not observed after 5 years of age. To explore this interaction further, we conducted post hoc *t* tests (two-tailed) within each age group, comparing children with and without left temporal involvement. Neither of the *t* tests was reliable, which means that we should interpret the interaction in Fig. 2 with caution.

We may conclude that all groups show improvement over time (keeping in mind that this is a cross-sectional design), but brain-injured children lag consistently behind controls in controlling grammatical morphology. There may also be a selective disadvantage in morphological development among younger children with left temporal involvement, in line with findings by

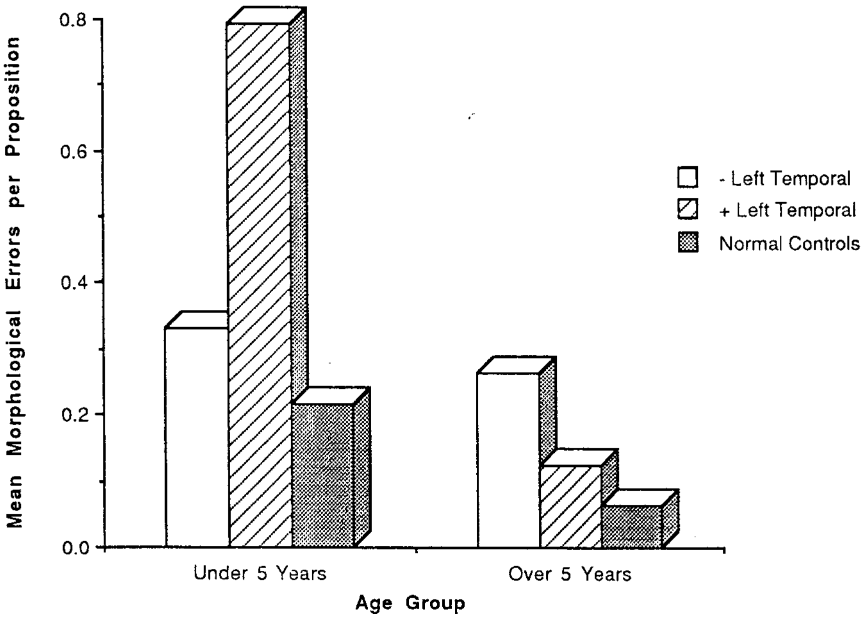

FIG. 2. Morphological errors as a function of age and presence/absence of left temporal damage.

Bates et al. (1994) on early grammatical development. We will have more to say later about the qualitative nature of these morphological errors.

Proportion of syntactic complexity. A 2 × 3 analysis of variance on this measure yielded significant main effects of age ($F(1, 61) = 9.15$, $p < .004$) and lesion group ($F(2, 61) = 12.74$, $p < .0001$), together with a small but reliable group by age interaction ($F(2, 61) = 3.66$, $p < .04$). The interaction is graphed in Fig. 3, and data for individual children are presented in Fig. 4 (with regression lines for each group to indicate change over time). Most of these findings are not surprising: use of complex syntax increases with age, and children with brain injury lag behind normal controls. However, the age by lesion group interaction is unexpected: younger children with right-hemisphere damage appear to be doing rather well, but older children with the same etiology fall well behind normal controls.

To determine the source of this interaction, we conducted a series of post hoc *t* tests (two-tailed). Among children under 5 years of age, the RHD group performed significantly better than the LHD group ($t = -3.01$, $p < .03$, two-tailed); the LHD group used significantly fewer complex sentences than the controls ($t = -2.44$, $p < .03$), while the RHD group was indistinguishable from normal ($t = 0.03$, $p < .98$). This is the pattern that we might predict, based on hypotheses drawn from the adult aphasia literature (i.e., left-hemisphere specialization for syntax). However, this predicted effect of

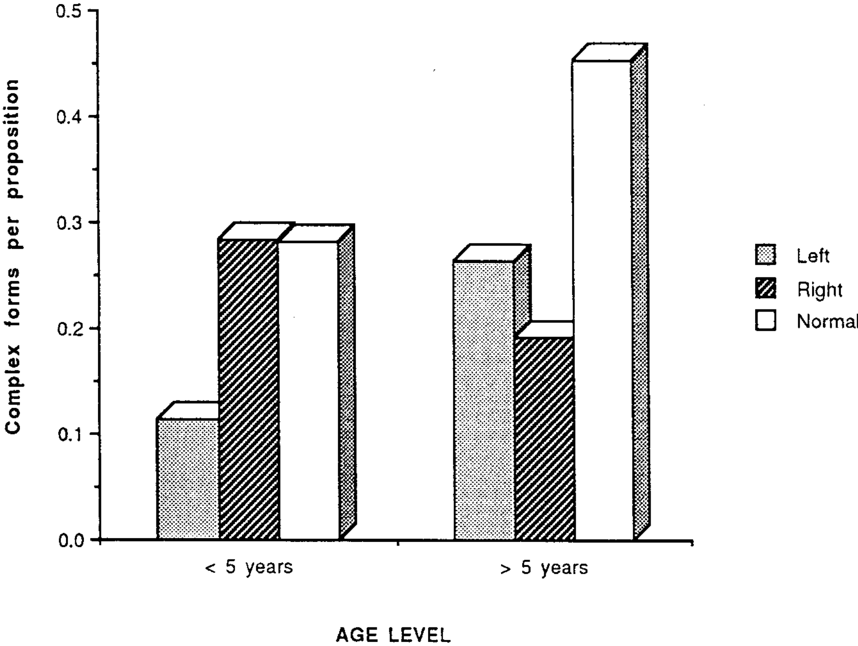

FIG. 3. Frequency of complex syntax as a function of lesion group and age.

lesion type did not hold among children over 5 years of age. Among the older children, post hoc tests indicated no significant difference in frequency of complex syntax as a result of left- vs right-hemisphere injury ($t = 1.41$, $p < .18$). The Older LHD group lagged significantly behind normal controls ($t = -2.78$, $p < .013$), but the difference between Older RHD children and normal controls was also highly reliable ($t = -5.55$, $p < .0001$).

A different perspective on these same data comes from the individual data points and regression lines provided in Fig. 4. It is clear from this figure that deployment of complex syntactic structures increases with age among normal children ($r = +.49$, $p < .002$) and among children with left-hemisphere injury ($r = +.67$, $p < .001$). However, there appears to be no relation between age and use of complex syntax in the RHD sample; indeed, although the correlation is not significant, it runs in the opposite direction ($r = -.25$, $p > .20$). We cannot conclude from these cross-sectional data that syntax stands still in children with right-hemisphere damage, and we certainly do not believe that it decreases over time. However, if there is a selective sparing of complex syntax in RHD children, we may conclude that it has disappeared by age 5 or that the lesions in older and younger children are not comparable. We must also keep in mind that the number of children in the young RHD group is very small ($N = 4$) and that this apparent syntactic sparing may hold for only a specific subset of the RHD population, based on some con-

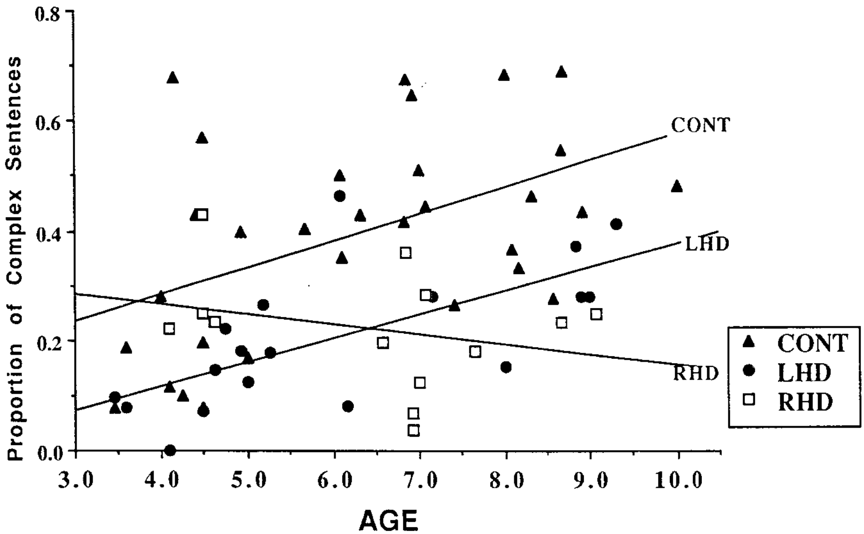

FIG. 4. Complex syntax use by individuals.

founding factor shared by these four children. We will return to this point later.

Finally, we conducted a 2 × 2 (age by site) analysis on the lesion sample only, comparing those children whose lesions do or do not involve the left temporal cortex. There was no main effect of lesion type. The interaction of lesion type with age also failed to reach significance, although there was a trend in the same direction reported above ($F(1, 30) = 2.17$, $p < .10$), reflecting worse performance by younger children with lesions involving the left temporal cortex.

Syntactic diversity. The above measure of syntactic frequency is a measure of sentence tokens, and in principle a child could obtain a high score through repeated use of one particular syntactic structure. By contrast, the syntactic diversity measure looks at the number of complex sentence types in each child's story on a scale from 0 to 5. The two measures are obviously related at a conceptual level. They are also correlated statistically across the sample as a whole ($r = +.57$, $p < .0001$). Nevertheless, syntactic tokens and types are not identical, and they may be sensitive to a different set of neurological and/or developmental factors.

As it turns out, results for syntactic diversity were quite similar to the above results for syntactic frequency: the 2 × 3 analysis of variance yielded significant main effects of age group ($F(1, 61) = 5.28$, $p < .03$) and lesion group ($F(2, 61) = 5.36$, $p < .01$), together with a small but reliable two-way interaction of age and lesion ($F(2, 61) = 3.52$, $p < .04$). The main effect of age group represents (as we might expect) a developmental increase

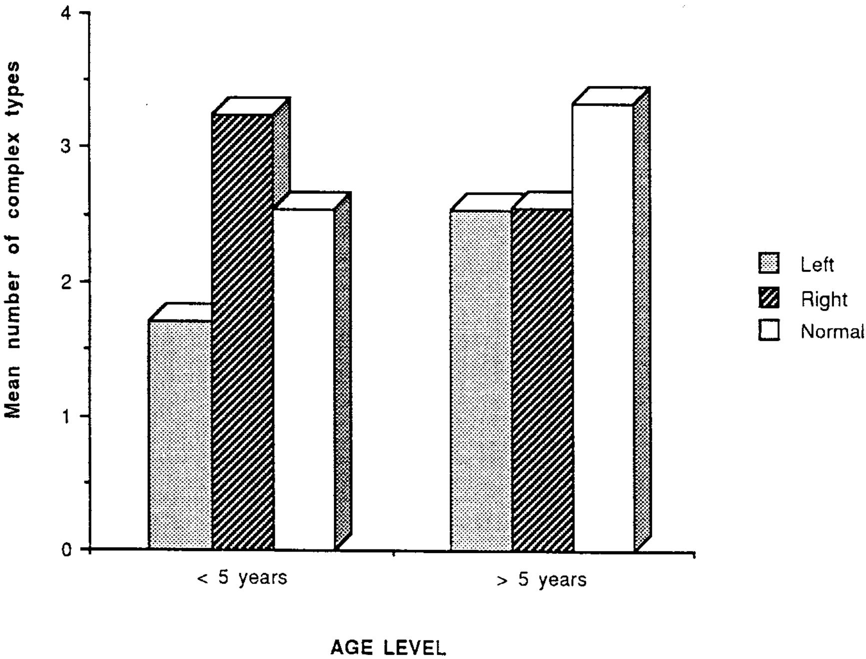

FIG. 5. Syntactic diversity. Mean number of complex types (diversity) as a function of lesion group and age.

in number of syntactic types, from a mean of 2.41 types in children under 5 to a mean of 2.95 types in children from 5 to 10 years of age. The main effect of lesion group reflects a greater range of syntactic types in normal children, but this is conditioned by the interaction between lesion group and age. The interaction is illustrated in Fig. 5.

To explore this interaction, we again conducted post hoc comparisons between the lesion groups, in children under and over 5 years of age. Among the younger children, LHD children had significantly lower syntactic diversity scores than the RHD group ($t = -2.87$, $p < .02$). The young RHD children actually had higher scores than normal controls, although this difference did not reach significance by a two-tailed test ($t = 2.00$, $p < .08$); the young LHD children had lower scores than normal controls, although this difference also failed to reach significance ($t = -1.55$, $p < .16$). Hence it does appear that the younger RHD children are spared in sentence types as well as tokens, compared with the LHD group. However, similar to our findings for syntactic frequency, the apparent effect of lesion side on syntactic diversity is no longer evident after 5 years of age. Among the older children, there was no significant difference between the LHD and the RHD groups ($t = -0.02$, $p < .98$). Scores for the LHD group were significantly lower

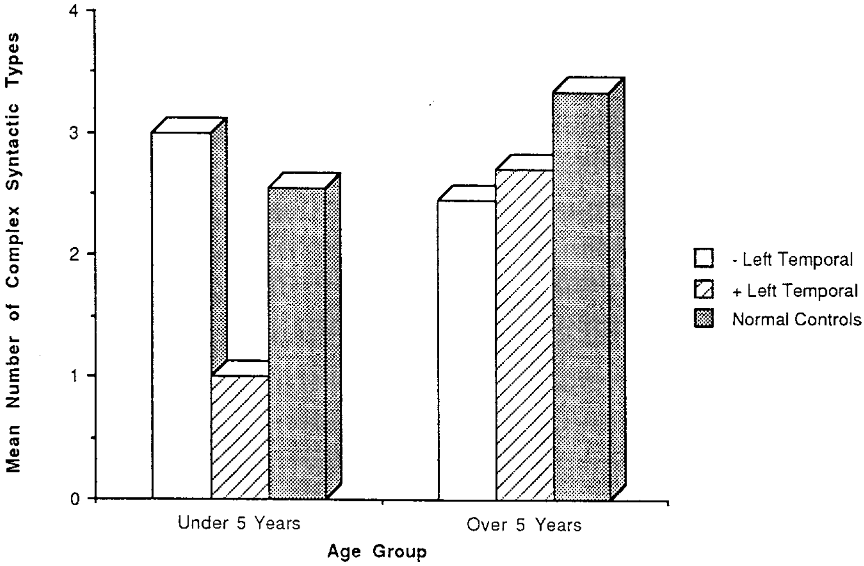

FIG. 6. Syntactic diversity as a function of age and presence/absence of left temporal damage.

than those for normal controls ($t = -2.78$, $p < .013$), and scores for the RHD group just missed significance ($t = -2.15$, $p < .054$). Since the Older LHD scores (mean = 2.55) and the Older RHD scores (mean = 2.56) are virtually identical, this small difference in reliability is simply an artifact of sample size.

We also regrouped the clinical sample into subgroups with and without left temporal involvement and conducted a 2×2 analysis of the syntactic diversity scores. This analysis yielded no significant main effects of age or lesion type, but there was a reliable age by lesion interaction ($F(1, 30) = 10.83$, $p < .003$), illustrated in Fig. 6. Post hoc t tests (two-tailed) indicate that, among the younger children, the four children with left temporal involvement produced significantly fewer complex types (a mean of 1.0) compared with the six children whose lesions spare the left temporal area (a mean of 3.00; $t = 3.91$, $p < .007$). A t test of the corresponding lesion site effect among the older children failed to reach significance ($t = -0.64$, ns).

Proportion of pragmatic connectors. In contrast with the morphological and syntactic findings, there were no effects of age or neurological status on children's use of pragmatic connectors to relate episodes (expressed as a proportion of total propositions). Nor were there any reliable effects in a 2×2 analysis comparing children whose lesions involve or spare left temporal cortex. Across groups, connector scores averaged .26, which means that such connectors were provided approximately once for every four propositions. Apparently this kind of device is fully acquired and used fluently by all the children in our sample.

Narrative Measures

Story components. Possible scores in this category could range from 0 to 8, and the mean across groups was 5.9. A 2 $\times$ 3 analysis of variance over age and lesion group yielded significant main effects of age ($F(1, 61) = 6.37$, $p < .014$) as well as lesion group ($F(2, 61) = 12.41$, $p < .0001$), but no age by lesion interaction ($F(2, 61) = 0.42$, ns). The age effect reflects (as we might expect) a marked increase in the number of story components that children include in their narratives from a mean of 5.0 in children under 5 years of age to a mean of 6.4 in the older group. Post hoc tests to explore the main effect of lesion group showed that there was once again no significant difference between LHD and RHD children ($t = -0.66$, $p > .50$), but there was a significant difference between the brain-injured children as a group and their normal controls ($t = 4.77$, $p < .0001$). We did not calculate story components as a proportion of propositions (on the assumption that one is not a proper subset of the other), but we did repeat the 2 $\times$ 3 analysis of variance using number of propositions as a covariate. Results were quite similar: a main effect of age ($F = 5.94$, $p < .02$), a main effect of lesion group ($F = 9.31$, $p < .0001$), but no significant interaction. The ANCOVA was repeated looking at left- vs right-hemisphere children only, but no effect of lesion side emerged ($F = 0.53$, ns). When the same analysis was repeated with brain-injured children grouped together (a 2 $\times$ 2 analysis), the lesion group factor did reach significance ($F = 18.47$, $p < .0001$).

A separate 2 $\times$ 2 analysis was conducted on the clinical sample only, looking at age by presence/absence of left temporal damage. There was no main effect of lesion type and no lesion by age interaction.

Search and reiteration of search. The unifying theme of the narrative is the boy's search for the frog. Hence the initial and subsequent mention of the search theme provides a good index of story coherence. The 2 $\times$ 3 analysis of variance on initial mention of the search theme produced a main effect of age ($F(1, 61) = 8.89$, $p < .004$), but no main effect or interaction with lesion group, $F(2, 61) = 1.51$, ns; for the interaction ($F(1, 61) = 0.47$, ns). By contrast, a 2 $\times$ 3 analysis of variance on reiteration of the search theme later in the narrative produced a main effect of lesion group ($F(2, 61) = 5.76$, $p < .005$), as well as a main effect of age ($F(1, 61) = 12.71$, $p < .001$). The interaction failed to reach significance ($F(1, 61) = 0.161$, ns). The age effects reflect a developmental increase in initial mention and later reiteration of the search theme, as we might expect. Post hoc analyses to explore the main effect of lesion type on later mention of the search revealed no significant difference between LHD and RHD children ($t = 0.20$, $p > .80$). However, both groups reiterated the search theme significantly less often than normal controls (LHD vs normals, $t = -2.44$, $p < .021$; RHD vs normals $= -2.38$, $p < .029$). A 2×2 analysis of the data for the lesion sample only yielded no significant main effect of left temporal involvement and no interaction with age.

Because the two search measures are not a proper subset of any of our length variables, we did not treat them as proportion scores. However, to control for possible confounds with length, we repeated the above two analyses of variance using number of propositions as a covariate. Effects were unchanged. The only significant effect on first mention of the search theme was a main effect of age ($F = 8.30$, $p < .006$). For reiteration of the search theme, there were significant effects of age ($F = 11.80$, $p < .001$) and group ($F = 3.61$, $p < .03$) but no interaction. A subsidiary analysis showed that there were also no specific effects attributable to left temporal involvement within the lesion sample.

Qualitative Results

Considering these results as a whole, the emerging profile depicts children with early brain injury as significantly delayed in grammar and discourse. However, in these cross-sectional data, there is clear evidence of change and development on all fronts. Below we discuss our findings in more detail, citing individual cases that represent general trends as well as those who appear to be marching to slightly different tunes. This should give the reader a broader picture of the developmental and neurological effects reported above.

A Qualitative Look at Lexical Evaluation

As noted above, with respect to the lexical measures overall, children with brain damage group with their normal age mates, and for both groups, older children use evaluation more often than their younger counterparts. Similar to Bamberg and Damrad-Frye (1991), we found important differences with age in the use of evaluative lexical devices. When younger children did infer a character's state, they often remarked on emotions that were directly observable from the picture. For example, after the dog falls from the window breaking the jar, the boy is holding the dog and the expression on the boy's face is rather stern. Several children noted this:

> (NC 4;6) An then the jar broke an' then the boy got 'im and the boy was very mad/
> (LHD 4;9) He's ma:d 'cause he br:oke it/

Or when the boy is cowering from the owl:

> (RHD 4;6) An' da owl jus' came and the/ and the kid was was [skæud]/

Older children are just as likely to make inferences based on more subtle situational cues (recruiting their broader world knowledge), rather than on directly observable facial expressions, as in the following:

> (NC 8;0) When they wake up, the *find out* the frog is missing/
> (NC 8;1) In the morning, the dog and the kid *start getting sad because* the frog jumped out.
> (NC 8;7) He goes into the thing that he *thought looked like* some kind of hanger or something and it turns out to be a moose/
> (RHD 6;10) They wake up and they *see* the frog's not there anymore/
> (RHD 7;8) The boy fell down *because* the owl pushed him and the bees were following the dog/
> (LHD 8;10 in reference to the dog being chased by bees)
> Now he's *REALLY getting into trouble*
> (LHD 8;10 after the deer has thrown the boy and the dog into the water): An the dog and the boy *made up* and they're *goin to look for* the frog again.

Additionally, as is clear from the last example, the boy's search for the frog is explicitly mentioned as motivation for his activities.

In our recent study on the nonverbal expression of emotion in infants and toddlers with focal brain damage (Reilly et al., 1995), we found that the infant behaviors mapped onto the adult profile. That is, children with left posterior damage cluster with normals, responding appropriately to both negative and positive situations and smiling frequently and easily in naturalistic interactions. In contrast, the babies with right posterior damage exhibit decreased positive affect and increased expression of negative affect in freeplay situations. These data strongly suggest that the posterior region of the right hemisphere is instrumental in the expression of affect from at least 6 months of age. Given this similarity to the adult profile for affective expression (e.g., Borod, 1992, for a review; Blonder, Burns, Bowers, Moore, & Heilman, 1993; Ross & Mesulam, 1979), we might have expected to see a distinctive profile in the use of emotional terms according to brain lesion site. However, the adult pattern reported by Borod and her colleagues (1985, 1986, 1988) in which adults with RHD use fewer and less intense emotional labels than patients with LHD or controls is not evident in the children's data. It may be that in tasks specifically designed to elicit emotional words, we will see a greater disparity in group performance.

A Qualitative Look at Morphological Errors

As we have already seen, morphological errors decrease as children get older. By age 5, the control children commit very few errors, including omissions. For the children with focal brain damage, however, this point of competency is not reached until approximately age 7. We uncovered no significant differences between LHD and RHD children in the frequency of morphological errors, although we did find an interaction between age and left temporal involvement (i.e., more morphological errors in the left-temporal group, prior to age 5).

Examination of the raw data suggests that these differences reflect a delay in morphological development, but there is no evidence here for a qualitative deviation from the normal pattern. In fact, the kinds of morphological errors produced by the children with brain injury are very similar to those of the normal controls. Errors include missing copula, lack of third-person verb agreement, errors in past tense verb forms, especially with irregular verbs, and overregularization of past tense, e.g., (NC 4;2) ''a boy falled down.'' Case marking for pronouns caused some children problems and although infrequent, there were unusual prepositional uses in both groups (e.g., ''He mad *of* the frog'' in NC 3;6). Table 2 provides examples from children of both groups illustrating the types of morphological errors occurring in the narratives.

Because English is not particularly rich in grammatical morphology, the range of possible errors is fairly narrow. Nonetheless, the fact that all of the errors observed in the stories of the children with brain damage also occur in the normal data suggests that brain damage has not severely disrupted language acquisition as much as slowed the process down. If there are qualitative differences in the errors produced by children with different forms of early focal brain injury, they may not become apparent until information is available on languages with richer systems of grammatical morphology.

A Qualitative Look at Syntactic Complexity

Overall, older children use a greater number and a greater variety of complex sentence structures than the younger group. This profile holds for nor-

TABLE 2
Examples of Morphological Errors

(NC 4;1)	He's waiting by <u>hisself</u>/
(NC 3;6)	They <u>0</u> hollering at him/
(NC 3;6)	He <u>fall</u> down in there/
(NC 3;6)	He <u>0</u> mad <u>of</u> the dog/
(NC 4;0)	The dog jumped out here and <u>finded</u> the rock/
(NC 4;1)	Then that boy <u>gets fallen</u> = and he/he/he wants/ the reindeer <u>wants him fallen</u> down/
(LHD 3;7)	An' what the boy<u>'s</u> doing?
(RHD 4;6)	The dog <u>0</u> licking <u>0</u> in the face/
(LHD 5;0)	Then they <u>seed</u> the two frogs again.
(LHD 5;3)	He's tryin' to get <u>out</u> o' the rock/
(LHD 6;1)	<u>Him</u> went and <u>him</u> ran/ The bees <u>was</u> following him/
(LHD 6;7)	He <u>don't</u> like the doggie/
(RHD 7;1)	Ouch he said to the boy to <u>hisself</u>/
(LHD 7;2)	Then the boy i' goin' like this an' covering <u>him</u> (self) an' he <u>0</u> walking on the/ just walking on the rocks.

mal children and for most of the children with focal brain injury, although (as a group) the brain-injured children lag behind. In fact, when we look more closely at the transcripts, the range of linguistic structures that children use is impressive even for those who obtain relatively low proportion scores. Table 3 presents examples from the children's narratives to give a flavor for the types of complex sentences and contexts in which children deploy them. From these examples, it is clear that even the youngest children with brain damage have a wide array of syntactic structures in their repertoire. It suggests that children between 3 and 10 years of age have access to and can use a variety of grammatical forms; the developmental and neurological differences reported above reflect children who know their grammar but recruit the more complex grammatical forms less frequently. Hence, the problem does not appear to be structural per se so much as the recruitment of these structures. And that is the task at hand: later language development consists

TABLE 3
Sample Syntactic Constructions

Infinitival complements
- (LHD 4;8) The frog was trying to wake him up/
- (LHD 5;2) An' then the boy tried to get out/ (of the water)
- (LHD 4;8) Here he's tryin' ta climb up the tree ta get the beehive/

Object complements
- (LHD 5;3) An' now they're watching 'em jump away/ (the newly discovered baby frogs)
- (LHD 4;9) An' then they didn't know what to do, so they:
  ''Fro:g where are you?'' (high and loud)
- (RHD 7;8) The/ the boy wakes up and he finds that the frog is gone/

Object relative clauses
- (LHD 4;11) he/he/he wooked in what the fwog was in/

Subject relative clauses
- (RHD 7;8) That thing that he was holding onto was really deer's antlers/

Adverbial clauses
- (RHD 7;8) The boy fell down because the owl pushed him and the bees were following him/
- (LHD 6;1) Then after him got up, him went down but him was really scared/
- (LHD 4;8) Well, you know uh uh when uh bunnies are outside they go underground too/
- (LHD 3;7) Looks like he's lookin' at the beehive/
- (RHD 4;1) He's lookin' at the window when it wen' out there/ (when the dog fell out the window)

Coordinate clauses
- (LHD 5;3) He looks in the sock an' he's not there/ (the boy when he discovers the missing frog)

Passives
- (LHD 4;9) He got carried by a an:gry moose/
- (RHD 4;6) an' the dog being sased from a bees/
  he's getting carried away/

of acquiring fluency and facility in the deployment of these complex sentence types.

We might also note here that despite the clear increase in complex syntax evidenced in the control children, the use of complex sentences in these contexts reflects a personal choice. Whereas grammatical morphology is obligatory and is a domain in which there is a clear developmental trend for all groups, the use of complex syntactic structures is optional. A sequence of simple sentences, although perhaps not as interesting, is perfectly grammatical and for an adult may reflect a sophisticated perspective. However, for children who find language to be a continuing challenge, this may be one domain in which they can conserve their energy. This may partially explain the apparent lack of increase in this arena for the older children with RHD and the rather modest increase for those with LHD.

A Qualitative Look at Narrative Complexity

The focal lesion group tends to tell shorter stories than their controls, another indication that language fluency continues to be a challenge for these children across the elementary school years. More telling perhaps are the other narrative measures. Children with brain damage also include fewer episodes in their stories than their normal counterparts, a tendency that holds for both the younger and older groups. Given that the children have the pictures in front of them, this lag does not reflect a memory problem. It seems more likely that the focal lesion children have a different notion of what it takes to tell a good story. For example, there was no effect of lesion group on initial mention of the search theme (generally, when the frog escapes); however, the focal lesion children at both age levels more frequently failed to reiterate the search theme later in the story; this required making inferences about the boy's behavior and recalling a nonpresent character. Specifically, this subsequent mention of the search theme reflects a broader understanding of the story as a whole, i.e., a global sense of the narrative and its purpose. The search provides a motivation for the boy's behavior and ties the initiation of the problem (the escape) to its ultimate resolution (finding the frogs). Failing to repeat the search theme not only renders a story less coherent, but also may reflect a lack of narrative competence at the global level. Although the brain-injured children lagged behind normal controls, there were no effects of lesion type on these narrative measures.

On many of the measures discussed so far, children with brain damage perform more poorly than their normal counterparts; these measures have focused on individual aspects of the stories. However, we have not yet investigated the nature and quality of individual stories as whole entities. To this end, we have chosen to look more carefully at a subset of the narratives, those from the middle age group which includes the stories from children with brain damage and their controls from ages 6;0 to 7;11 ($N = 20$). All

TABLE 4
Scale for Evaluation of Narratives

Theme: The search is explicitly mentioned during the search episodes (1, search is integrated with protagonists' actions; 2, search is mentioned several times; 3, search is not mentioned)

Plot: Frog is lost; Boy searches for Frog; Frog is found (1, all components explicitly mentioned; 2, 2 components mentioned; 3, only 1 component)

Elaboration of events: Narrator mentions each of the events and elaborates on them (1, rich description of events, includes all episodes; 2, includes most episodes, little description; 3, few episodes, no elaboration)

Evaluation: Narrator attributes internal states to protagonist's (1, extensive use of evaluatives: causals, emotional terms, hedges, and mental verbs; 2, few mentions of evaluatives; 1, no mention of evaluation)

Storiness: Use of linguistic linguistic connectors to integrate events into a narrative (1, uses several different integrative devices, i.e., a range of conjunctions; 2, uses and or and then only; 3, no linking or integrating devices)

Reference: Referents are clearly established for pronouns (1, pronouns are used and reference is clear; 2, some ambiguity exists, but infrequently; 3, pronouns frequently have ambiguous referents)

20 stories were evaluated blind and rated by five coders on a 3-point scale which included features of a good narrative; Level 1 includes the best stories and Level 3 the worst. The Narrative Scale (shown in Table 4) has six dimensions with a 3-point scale in each category for a total possible 18 points. Stories were rated on all six dimensions. Totals were then divided by 6 to obtain three groups: Level 1 Stories (scores 1.0–1.67); Level 2 Stories (scores 1.68–2.33); and Level 3 Stories (scores of 2.34–3.0). Interrater reliability was .84; disagreements were resolved by discussion. A one-way ANOVA was conducted with status (LHD/RHD/Normal) as the between-subject variable. Brain status was significant ($F(2, 17) = 4.307$, $p < .03$. Subsequent post hoc analyses using Fischer's test revealed no significant differences between children with LHD and those with RHD. However, consistent with the individual results from the linguistic and narrative measures discussed above, children with brain damage (either left or right) scored lower than their normal counterparts ($F(1, 19) = 8.91$, $p < .01$).

As can be seen from Fig. 7, in narratives from both normal and brain-damaged (BD) children, there is a fair amount of variability. In fact, of the best stories (Level 1), one is by Subject 21 (7;0), who has a right parietal grade 2 lesion with subcortical involvement, and the rest of the stories were from controls. The Level 3 stories (poorest), however, were all told by the BD group. However, those Level 3 stories are quite different and display a range of deficits. In the following section we present excerpts from the search sequence from some of the better and poorest stories to convey the range and quality of the children's narratives. These excerpts reflect the sequence in which the boy and the dog have left the house to enter the forest in search

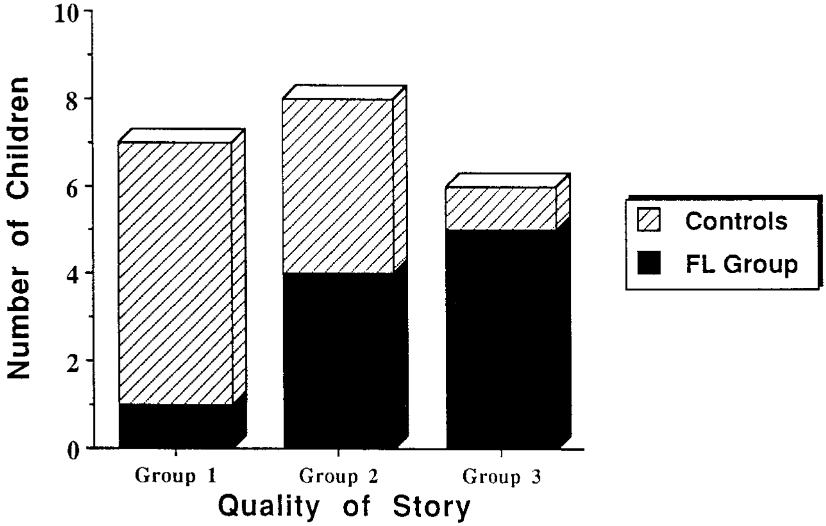

FIG. 7. Global evaluation of narratives.

of the frog. The dog finds a beehive in a tree, which he subsequently knocks down, and the bees then chase him. In the meantime, the boy looks in a hole and a gopher pops out and bites him. Then the boy climbs up a tree to look in a hole and an owl comes out, flaps his wings, and the boy falls from the tree. The boy then runs to a rock, cowering from the owl. (For clarity, hesitations, repairs, and experimenter prompts/comments have been omitted except when the child's utterance is a response to an experimenter question.)

Level 1 search excerpts. As a basis for comparison, we first present search excerpts from two of the best stories:

[Subject 21, 7;0 M; grade 2 lesion: Right parietal with subcortical involvement (+S)]:

> And the boy called the frog and the dog called the frog. The boy called the frog and the dog called the frog. The dog, no, the bees, got out of the beehive and the dog put his tail against the beehive. And the boy was trying to look for the the frog. And the boy fell and the dog was running. The boy was itching his head 'cause he fell. And the boy and the dog were trying to look for the frog.

(Control Subject, 6;11 F):

> They started calling for the frog again. The boy looked into a hole in the ground and he was calling for the frog in there but the squirrel lived in there and the dog was barking at the bees. The beehive fell off the tree and all the bees flew out and the boy was looking in the tree, in the tree hole, and a bee started flying. Went away and the boy fell down and the dog ran away. And an owl was flying around and the boy hit his head on the rock.

In Level 1 stories, children incorporate the search theme into their stories.

The episodes are horizontally integrated with some backgrounding, as reflected by the linguistic cohesion markers. There is also some sense that the search is motivating the protagonists' behavior, as in the example above, ''looked into a hole in the ground and he was calling for the frog.'' In addition, Level 1 stories, as those above, provide some descriptive modulation, e.g., by using aspectual verbs: ''*trying* to look for the frog'' or ''a bee *started* flying;'' these stories also include some evaluation, e.g., ''The boy was itching his head 'cause he fell.'' Interestingly, there are very few pronominal references in these two exemplars.

Level 3 search excerpts. Overall, the stories in this group are impoverished; they are shorter and the utterances tend to be terse and lacking elaboration; these texts more closely resemble a linear set of minimal picture descriptions rather than narratives:
(Subject 16, 6;2 M; grade 5 lesion: L t-p-o +S):

> He's calling the dog. The dog is going up the tree. The boy is climbing up to get all the way. He fell! There's a bird.

(Subject 19, 6;10 M; grade 5 lesion: R t-p+ S):

> He's yelling in a hole. He's hunting on a tree. There's a skunk. Then he fell. The boy's yelling in the tree. The dog's running away. The owl's flying.

(Subject 20, 6;11 M; grade ??: R post t+ S):

> They call for him. They called for him. What's that? A Squirrel? (uh huh). It's a animal. The animal bit him. Is that a tree? (uh huh) He goes inside there with the bees in there. The bees come out at the dog. He's calling for 'em. He's calling for 'em.

In these first three examples, single unembellished propositions are provided for each picture. These are conveyed as unconnected events, and resemble individual picture descriptions rather than a narrative. In this respect, these three texts share some properties of those related by normal 3-year-olds. According to Labov and Waletzsky (1967), a narrative is the telling of temporally sequenced events. For these examples, it is only by their temporal ordering that we can infer a narrative at all. There are no linguistic markers of cohesion, not even simple chaining reflected by the use of *and.* With respect to integrating the search theme into the story, for subject 20 there is some indication that the boy and dog are looking for something, but because there is no referent for the pronoun, the subject of the search is not explicit. Consistent with the lack of explicit reference, subject 20 uses other semantically empty forms, e.g., *He goes* inside *there* with the bees in *there.* Subject 19 shares a reference problem in that the referent for *he* is ambiguous. For neither subject 16 nor subject 19 is there any allusion to an ongoing search activity. These stories also lack descriptive evaluative information.

Subjects 15 and 17 are two girls with Level 3 stories. Subjectively, how-

ever, theirs are worse than the three stories above as well as qualitatively different from them. The two texts below stray from the storyline by adding irrelevant and incomprehensible material. Neither would qualify as a narrative, or even a series of picture descriptions:
(Subject 15, 6;1 F; grade 4: L fr + S):

> Then him saw the dog. Saw the bees. Him went over there and him saw the bees and him got the dog and him grounded. Him went there and him got to the bees and him saw all the bees running to the dog. Him went and him ran. The bees was following him. When him got to the top, him saw (xxx).

In subject 15's text above, she uses only the accusative form of the third person singular pronoun. However, later in the story, she also uses the nominative form. Thus, she does have access to multiple third person pronominal forms. In addition to the lack of referents for this frequently used pronoun, other semantically empty proforms (e.g., ''went there'') often occur in her text. We should also note that these two girls have the highest proportion of morphological errors in the entire group of older brain-damaged children.

The following text, from subject 17, diverges even more significantly from the story:
(Subject 17, 6;7 F; grade 3: R t, subcortical *only*):

> Why lookin' in there? Got his head there. Lookin' for him. He got bit. (By who?) A bug. The dog, the doggie take him out and ate him. And he went up in the air and then the doggie took it out and they dump it. The boy fell down. Then he went up in the bee and the boy died. (Who's that?) A bird. He went died. An' eating it. And he ate it all up and he big. And it's about five dinners.

The text from subject 17 differs from that of subject 15 in that she confabulates. Both girls use some cohesive devices, mostly *and,* to chain propositions, but neither succeeds in conveying a text that resembles a normal child's production on this task. Although control 3- and 4-year-olds do add irrelevant information to their narratives, the information is usually either related to something in the story or reflects some personal observation or experience. For example, when talking about the bees, one child told about a recent beesting, and another commented on the experimenter's jewelry.

SUMMARY AND CONCLUSION

To summarize, we have documented significant changes with age in aspects of lexical production (evaluative terms, use of pronouns that are coreferent with a noun in the same sentence), morphological errors (which decrease over time), syntactic complexity (which increases in frequency and diversity), and narrative complexity (including number of story components and the explicit mention and reiteration of the search theme). In every domain except the lexical measures, children with focal brain injury are (as a group) delayed relative to age-matched normal controls. In addition, the brain-injured children produce much shorter stories (in words and/or propositions), but since length does not increase as a function of age in this narrative task, it would be inappropriate to interpret this reduction in output as a form of developmental delay; rather, it might be considered a reluctance to use language in view of its continuous developmental challenge.

In addition to the global lag displayed by the focal lesion group, we did find some interactions between age and lesion type in the persistence of morphological errors and in the frequency and/or diversity of complex structures. The four younger children with RHD scored well within the normal range for their age in the frequency and diversity of complex syntax. However, the RHD children in the older group were no different from older children with damage on the left, and both focal lesion groups performed significantly below normal controls. Hence if there is a sparing of grammar in children with right-hemisphere injury, it appears to be very short-lived. Looking only at the clinical sample, we also found a significant interaction between age and presence/absence of left temporal damage in morphological errors and in syntactic diversity, suggesting a specific effect of left temporal damage on grammatical development prior to (but not after) age 5.

Because these interactions between age and lesion site are based on small samples, and because so few effects emerged across a large number of comparisons, we present them with a strong note of caution. We can only speculate on why the four youngsters with RHD performed so well on these measures (or why the four with left temporal damage did so badly), when the same groups did not stand out at all on the other linguistic variables. For one thing, by the kind of coincidence that bedevils studies of rare populations, the four youngsters with RHD have subcortical involvement only (subjects 3, 5, 6, and 10). This might help to explain the relative sparing of complex syntax for these subjects, although it does not explain why we failed to see analogous sparing in the other language measures. For example, the story from one of these children (subject 6) is one of the least competent of the entire group: it is repetitive, full of irrelevant material, fails to mention the search at all, and explicitly mentions only one of the eight components of the story. We should also mention that we tested one additional $4\frac{1}{2}$-year-old child with a right-hemisphere lesion (FTP $>$ O) who was not able to perform this task at all. Had we added her scores to the data set (i.e., a long list of zeroes), the apparent RHD advantage for children under 5 would have disappeared.

On the other hand, our data are consonant with those of Bates et al. (1994) on the emergence of grammar between 10 and 44 months of age. These investigators found no significant differences between LHD and RHD children per se on any measure of language production, but they did find significant delays in both vocabulary and grammar in children whose injuries involved left temporal cortex. The data we have presented here suggest that this particular correlation between language symptoms and lesion site may continue up to age 5, but it does not appear among our older children. It is tempting to conclude that this site-specific effect has resolved by age 5, the point in development at which most normal children have completed acquisition of most grammatical structures. However, as noted above, the children with focal brain damage are still challenged by morphology until age 7. Because our data are cross-sectional, it is only by following these children longitudinally that we can clarify this issue.

With these findings in mind, it is now appropriate to return to our original hypotheses:

(1) Children with left-hemisphere injuries will be selectively impaired on measures of lexical diversity and grammatical well-formedness compared with children with injuries on the right.

(2) Children with right-hemisphere injuries will be selectively impaired on measures of narrative coherence and complexity.

(3) Overall, focal brain injury may lead to suboptimal performance (compared with matched normal controls) on all aspects of language production, from single words to stories.

In the younger group, there is evidence in our data to partially support Hypothesis (1). We did find an advantage for children with right-hemisphere damage on syntactic frequency and diversity, and for children under age 5 with left temporal damage, there was a complementary deficit on both morphological and syntactic measures. These site-specific profiles are no longer observed after 5 years of age. We found no evidence for Hypothesis (2), since LHD and RHD children were equally delayed on narrative length and complexity compared with normal controls. We did find solid evidence in favor of Hypothesis (3). On many of our measures, children with focal brain damage do lag behind their normal counterparts. Nonetheless, we see evidence of change and development in every domain: morphological errors decrease; frequency of complex syntax increases; stories include more components and children are making more inferences with respect to narrative theme. And so we can return to our earlier questions:

(1) Does recovery exact a lasting price? Does it involve suboptimal modes of processing that are very good but never quite as good as the default form of neural organization for language that would have emerged under normal circumstances?

(2) Does recovery for language take place once, at a particular point in time? Or must it recur each time the child moves on to a higher linguistic level?

(3) What is the relationship between lesion type (side, site, and size) and patterns of delay and development in language ability? Do the correlations between brain and behavior that are observed in the focal lesion population change with the specific linguistic challenges that children face at each stage of development (e.g., from first words, to grammar, to narrative discourse)?

It does appear that early focal brain damage exacts a lasting price (i.e., Question 1), but the price tag changes with the linguistic challenge at hand. And it is also clear that recovery is a continuing process in these children (i.e., Question 2), with delays observed in most domains (there were no group differences at all on our lexical measures, suggesting that this domain may have stabilized by 3½ years of age). In these respects, our findings for language development mirror those of Stiles and her colleagues on the development of visual–spatial cognition. However, our results for language deviate from Stiles' findings for spatial cognition in one key respect: *the delays that we observe do not map onto the lesion profiles observed in adults with analogous injuries.* In her studies of spatial cognition (which involve many of the same children studied here), Stiles finds subtle but consistent differences in the deficits observed following left- vs right-hemisphere injury. For example, children with RHD find it difficult to integrate the parts of a visual display into a coherent whole, although they are able to extract the relevant details; children with LHD have no problem with ''the big picture,'' but they find it difficult to locate and/or to reproduce finer-grained aspects of the same pattern. This is, of course, precisely the pattern that is found in adults with right- vs left-hemisphere lesions (Robertson & Delis, 1986; Robertson & Lamb, 1988, 1991). By contrast, we do not find the predicted differences between children with LHD and RHD on structural and narrative measures after age 5, and the few effects that we do find before this point are restricted to specific aspects of grammar, which appear to be particularly delayed in children with left temporal injuries (i.e., injuries that normally produce fluent aphasia with comprehension deficits in adults).

The effects of lesion site on language development have proven frustratingly difficult to pin down throughout this literature. Some studies find effects in the predicted direction, but many do not, and still others find significant effects that are quite unlike those usually reported for adults. As discussed by Stiles and Thal (1993) and Stiles (1995), there are a number of reasons that the relationship between linguistic deficits and lesion site is so unreliable in this population. First, because language evolved more recently than most visual–spatial functions, it may retain a greater degree of plasticity. Second, because language is a highly valued and highly visible skill, there may be more social pressure and support for language development than there is for cognitive functions that are not so prominently displayed. Third, recent studies of brain activity during language stimulation using event-related brain potentials and/or positron emission tomography suggest that language acquisition and language use may draw on a large number of different neural systems (e.g., Mills, Coffey, & Neville, 1993a, 1993b; Petersen, Fiez, & Corbetta, 1992). In some respects, this may make language more vulnerable—especially in the early stages. But in the long run, there may be more alternative ways to deal with the challenges of language learning and language use. The complex problems posed by narrative discourse fit this profile well: there are many problems to solve, but there may also be many alternative ways to solve the problem.

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