The dissertation of Catherine Alice Jackson is approved.

Nina Hyams

Nina Hyams

Paul Satz

Paul Satz

W. Donald Shields

W. Donald Shields

Susan Curtiss

Susan Curtiss, Committee Co-Chair

Victoria A. Fromkin

Victoria A. Fromkin, Committee Co-Chair

University of California, Los Angeles

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property of Susan Curtiss

for you, Susie, with love. Cathy

UNIVERSITY OF CALIFORNIA

Los Angeles

The grammatical consequences of early focal damage to the left hemisphere of the brain

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy in Linguistics

by

Catherine Alice Jackson

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The linguistic consequences of early focal damage to the left hemisphere of the brain

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VITA

November 6, 1954	Born, Upland, California
1972-1975	National Merit Scholarship, University of Redlands Redlands, California
1975	B.A., with distinction, Communicative Disorders University of Redlands Redlands, California
1977	Graduate Clinical Assistant and Research Assistant University of Wisconsin-Madison
1977	M.S., Communicative Disorders University of Wisconsin-Madison
1977-1978	Teacher for the Severe Language Handicap/Aphasia Program San Juan Capistrano, California
1978-1979	Speech/Language/Hearing Specialist Los Angeles County Superintendent of Schools
1979-1981	Assistant Professor/Clinical Supervisor University of Redlands Redlands, California
1981-1987	Research Assistant Department of Linguistics, UCLA
1984	M.A., Linguistics University of California, Los Angeles
1984-1986	Research Speech Pathologist School of Medicine University of California, Los Angeles
1986	C. Phil, Linguistics University of California, Los Angeles
1986-1989	Research Speech Pathologist Veterans Administration Medical Center Sepulveda, California

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ABSTRACT OF THE DISSERTATION

The linguistic consequences of early focal damage to the left hemisphere of the brain

by

Catherine Alice Jackson

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Professors Susan Curtiss and Victoria A. Fromkin, Co-Chairs

This dissertation examined the relationship between linguistic knowledge and the presumed neural substrate of that knowledge early in development. It is claimed that some aspects of grammatical knowledge (core principles of UG) are part of the genetic endowment, while other aspects of the grammar (peripheral aspects of a language-particular grammar) are learned on the basis of the idiosyncratic facts of the language at hand. Children who had suffered early focal left hemisphere damage (FLHD) were studied to test a number of questions concerning early brain damage and linguistic knowledge. A variety of tests were used to assess their linguistic knowledge. A formal test battery was used to confirm that they appear to demonstrate delayed performance on such measures. The experimental battery included comprehension, judgement and production tasks to assess in detail which aspects of grammatical knowledge appeared to be intact, and which appeared to impaired.

First, the children demonstrated impaired performance on formal measures of lexical and morphosyntactic knowledge, consistent with previous findings. With regard to the lexicon, although they evidenced delays on a receptive vocabulary measure

and/or difficulties with word retrieval, their performance on a word fluency measure indicated that their lexicons appeared to be organized in a manner similar to that of nonimpaired children. No consistent patterns were observed to account for their impaired performance on the morphosyntactic measures.

The central findings of the work concern the performance of the FLHD subjects with regard to comprehension, judgement and production tasks constructed to evaluate their morphosyntactic knowledge. A great deal of variability was seen for the subjects across tasks, but the subjects were able to demonstrate knowledge of some of the core principles on at least one task. Thus, knowledge of recursion in NP and knowledge of NP movement in passives was largely intact. However, knowledge of PRO and control and the binding principles was compromised in many of the subjects.

The FLHD subjects also evidenced impaired performance on measures of verbal inflection (tense/aspect and agreement morphology). Their performance was impaired on both experimental tasks as well as in spontaneous speech. Thus, the hypothesis that knowledge of this aspect of the grammar would be compromised was supported.

It was also noted that the performance of the FLHD subjects was extremely variable across tasks. It is proposed that non-linguistic variables (attention, memory) interfered with performance in an inconsistent way.

Finally, there was no significant effect of age at onset of the damage, although this finding requires confirmation with a larger population.

CHAPTER 1

INTRODUCTION

1.1 THE BASIC ISSUES

The question of how children acquire grammar has long intrigued and puzzled psychologists and philosophers as well as linguists. This dissertation seeks to investigate a specific aspect of this general issue; namely, the issue of the nature of the relationship between the grammatical[1] knowledge of young children, presumed by some to be biologically endowed, and the neuroanatomical foundation for this innate human language faculty.

There is no single universally accepted theory of child language acquisition. One approach views child grammars as being discontinuous with adult grammatical knowledge in the sense that child grammars initially embody different principles from those of adult grammars and then are restructured during the acquisition process. The early grammars are considered to be semantically or communicatively based, only later becoming organized along grammatical principles (Bowerman, 1973; Schlesinger, 1971; Maratsos, 1982).

An alternative approach assumes that children are innately equipped with abstract, formal grammatical principles which constitute Universal Grammar, or UG, the set of principles or operations which hold across all languages (Chomsky, 1980). These abstract principles guide the construction of the child's grammar, and predispose the child to entertain only certain structurally-defined hypotheses about the input language (e.g. Hyams, 1986; Crain and McGee, 1986; Crain and Nakayama, 1985; Tavakolian, 1981; Roeper, 1988; Bloom, 1990). In this view children do not learn or

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[1] This dissertation deals only with syntax and morphology; phonology and semantics, while part of the grammar, are not included in this investigation.

acquire fundamental grammatical constructs; these are already present as acquisition starts (they are the acquisition "givens"). Rather, they learn only the idiosyncratic aspects of their language; e.g. vocabulary, aspects of the phonetic and phonological system, and language-particular syntactic facts.

If this second view of acquisition is correct, an important question must be addressed. If children come to the task of language acquisition with basic syntactic knowledge (in the form of UG), why is adult grammatical competence not instantaneous? Two answers to this question have been proposed. One is that the as yet nonfunctioning grammatical principles are invoked or "triggered" by data which are only gradually made available to the child (Pinker, 1984). The specific data are either literally unavailable at early stages in development (i.e. are not used in speech to the child) or not accessible due to the constraints of immature nonlinguistic cognitive or perceptual systems, e.g. limitations on memory interacting with input processing in some way. A second proposal is that the data are always available, but that the relevant grammatical principles needed to interpret the data "mature" in the same way that other biologically governed behaviors mature and develop over time (Borer and Wexler, 1984). However, as Roeper (1988) notes, both maturation and triggering of latent abilities could apply to different portions of the grammar, and at different times[2]. In any case, syntactic knowledge is viewed as biologically predetermined; even a "maturational" view does not imply that grammatical principles are learned (one would not say that a child "learns" to increase short-term memory, for example, or "learns" hormonal changes at puberty).

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2 Further, these two proposals are not unrelated. The term maturation and its implications for the language acquisition process and UG have not yet been fully evaluated by child language researchers.

Recent work within this general theoretical framework has begun to make explicit which aspects of grammatical knowledge might be innate. This purely linguistic acquisition theory, however, is not a neurolinguistic theory (nor should it be), which would be concerned with the neural or anatomical bases for presumed innate grammatical knowledge, nor concerned with how examining the neural bases for grammar could shed light on the theory of acquisition. This dissertation focuses on the innately specified aspects of linguistic knowledge, and investigates how damage to the left, "language" hemisphere early in development may affect specific aspects of syntactic and morphological knowledge which are acquired later in childhood. Should a specific effect of early left- hemisphere damage on the acquisition of grammar be found, the argument for an innate biological basis of UG and grammar acquisition would be strengthened.

1.2 EARLY LANGUAGE-BRAIN RELATIONSHIP

1.2.1 Early brain damage and theories of hemispheric specialization

A major source of data used to support theories about the relationship between grammatical knowledge and its neurological substrate in the mature system has been studies of adults with localized brain damage. For over 100 years, research on adult aphasias have documented the linguistic impairments which occur in cases of left- but not right-hemisphere damage for right-handed males (beginning with Broca [1863] and Wernicke [1874]). However, the study of the role of the left hemisphere in language *acquisition* has not always yielded the same unambiguous results. Early studies of focal cortical damage of varying etiology in children found that right- as well as left-hemisphere damage led to later deficits in language (e.g. Sachs and Peterson, 1980; Basser, 1962; Hood and Perlstein, 1955a; 1955b). These data led Lenneberg (1967) to hypothesize an equipotentiality of the cortical hemispheres for language acquisition during the first two years of life, with neither hemisphere yet specialized to support language at birth. This hemispheric equipotentiality was attributed to the immature character and plasticity of the brain at birth. According to Lenneberg, specialization for language begins around age two and continues to develop in the left hemisphere until puberty, at which time lateralization is complete and plasticity lost.

After re-examining Lenneberg's data, Krashen (1972) modified Lenneberg's hypothesis by determining that the data suggest that lateralization is complete by age five in normal cases, although some acquisition of language could take place after this completion of lateralization (hypothesized as due to compensatory support of linguistic functioning by the right hemisphere). Thus, a distinction was made between lateralization and plasticity of neural tissue. Further, Kinsbourne (1976; 1979) and many others (see Witelson, 1977, for example) proposed that left-hemisphere specialization exists at birth, with the asymmetry in function beginning before overt language skills are apparent[3]. Kinsbourne and Hiscock (1977) specifically criticized the notion that language is only gradually biased towards left-hemisphere representation, stating "...we know of no animal model and of no human analogue to the idea that, for a given behavior, the brain base shrinks with increasing functional sophistication" (p. 134). They supported a developmental invariance hypothesis, in which there is a preprogrammed asymmetry favoring left-hemisphere specialization for language from birth.

More recently, studies of brain damage in children, which have largely excluded etiologies with a likelihood of bilateral involvement and which have also been conducted since the advent of more accurate methods of lesion localization, support the position of innate hemispheric differences. Several studies have found that acquired aphasia or language disturbance in children, as in adults, is more often the result of left-

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3 Witelson (1977) notes that this pattern is completely compatible with plasticity, which may well decrease with increasing age.

hemisphere focal damage (Annett, 1973; Alajouanine and Lhermitte, 1965; Hecaen, Perenin and Jeannerod, 1984; Woods, 1980a; Woods and Carey, 1979; Woods and Teuber, 1978). This is also the conclusion of Satz and Bullard-Bates (1981) who apply a strict set of criteria in interpreting the various data (including knowledge of premorbid handedness and evidence of speech development before the onset of the lesion).

In addition, there are a number of studies which have showed that focal left hemisphere lesions in children result in different outcomes depending on the age at onset of damage. Focal left-hemisphere damage later in childhood is associated with more profound linguistic deficits as compared to early damage (e.g. at least before age one; Woods and Carey, 1979; Satz, Orsini, Saslow and Henry, 1985; Riva and Cazzaniga, 1986 [but see Vargha-Kadem, O'Gorman and Watters, 1985 for some conflicting findings]).

Consistent with the data above, Woods has formulated an "initial potential equipotentiality theory" (1980b), in which the hemispheres are equal in their capacity for language acquisition at birth. However, because the left hemisphere may be prepotent for its specialization for language, the continuing lateralization of the representation and processing of language by the left hemisphere overrides the potential of the right hemisphere to subserve language. Thus, the linguistic potential of the right hemisphere is realized only if development of the left hemisphere is hampered in some way; further, it's capacity apparently diminishes over time.

1.2.2 Neurological evidence of hemispheric asymmetry

There is additional evidence for the view that hemispheric asymmetries may exist at birth and trigger the left hemisphere's specialization for language. Neuroanatomical asymmetries have been demonstrated in the "language zones" in adults, with the left planum temporale (roughly corresponding to Wernicke's area in the temporal lobe) larger in the majority of cases (Geschwind and Levitsky, 1968), resulting in a longer and more horizontal Sylvian fissure, with greater volume in the auditory association cortex. Geschwind and Levitsky conclude that the anatomical asymmetry is "compatible with the known functional asymmetries (p.187)". There are other asymmetries in the adult brain which favor the frontal and temporal areas of the left hemisphere, including increased amounts of neurotransmitter activity in the left temporal lobe (Amaducci, Sorbi, Albanese and Gianotti, 1981; Glick, Ros and Hough, 1982) and in Broca's area (Braak, 1979).

Asymmetries have been found in the brain in utero as well as at or shortly after birth. Gross structural asymmetries have been found in key portions of the left temporal lobe of the fetal brain (e.g. a larger left planum temporale) which are present by the 29th gestational week (Witelson and Pallie, 1973; Wada, Clark and Hamm, 1975; LeMay and Culebras, 1972). However, left-hemisphere structures do not always exceed homotopic right hemisphere structures in absolute volume or size. In spite of the larger appearance of parts of the left hemisphere at 29 weeks, Chi, Dooling and Gilles (1977) found that structures surrounding the planum temporale may appear in recognizable form in the fetal brain earlier in the right than in the left, indicating slower growth of certain "language areas" of the left hemisphere.

An early asymmetry favoring the right hemisphere is also apparent at the level of the dendrites, or the branches of the neurons. Initially in the young child there is greater dendritic complexity found in the right hemisphere, with the left and right hemispheres alternating in this regard until the age of three to four years, when the left hemisphere establishes and maintains greater dendritic complexity (Simonds and Schiebel, 1988). Thus, it may be that the left hemisphere develops more slowly, but for a longer period of time, and that it eventually surpasses the right in dendritic complexity. It has been suggested that the final establishment of greater dendritic complexity in Broca's region in the left hemisphere corresponds with the presumed lateralization of hemispheric function at about age five (Schiebel, Paul, Fried, Forsythe, Tomiyasu, Wechsler, Kao and Slotnick, 1985).

It is difficult to link these anatomical, cytoarchitectonic and metabolic differences directly to linguistic functioning, but it is clear that the cerebral hemispheres are structurally and functionally different, in some aspects early on, in ways which may be linked to language acquisition and continuing support for language functioning.

1.2.3. Behavioral asymmetries: Response of the normal brain to linguistic stimuli

In addition to neurological asymmetries, there are also perceptual asymmetries for processing linguistic vs. non-linguistic sounds found in neonates and young children, indicating that at birth or shortly thereafter, the hemispheres differ in their response to language stimuli. Researchers have found strongly lateralized responses in infants using dichotic listening techniques (Entus, 1977) and EEG activity (Gardiner and Walter, 1977), with the left hemisphere implicated to a greater extent in processing linguistic vs. nonlinguistic (music) stimuli. Likewise, studies utilizing electrophysiological data from auditory event-related potentials, or AERP's (Molfese, 1973; Molfese, Freeman and Palermo, 1975; also see Molfese and Betz, 1988, for a thorough review of this research) have found hemispheric differences in AERP's, although the language/nonlanguage distinction is not so clear. For example, categorical perception of consonants via voice onset time (VOT) typically elicits a right hemisphere response in infants, while perception of consonantal place of articulation typically elicits a left hemisphere response.

These response asymmetries, while not necessarily directly linked to lateralization of (adult) cognitive functions, imply a biologically fixed program in which the infant's brain is asymmetrically sensitive to certain kinds of input, with the left hemisphere specially prepared to process linguistic information. The implications of these asymmetries for the specifics of language acquisition, however, remain unclear.

1.3 LANGUAGE ACQUISITION FOLLOWING SPECIFIC BRAIN DAMAGE IN CHILDREN

If the left hemisphere is neurobiologically preprogrammed for language, how does damage to this neural substrate affect language acquisition? Data from three classes of individuals are relevant: 1) cases with early focal cortical lesions, 2) cases of early hemidecortication[4], and 3) cases with identified language disorders (e.g. developmental dyslexics) who were then found to have evidence of atypical brain structure or organization. Each of these populations will be discussed in turn.

1.3.1 Focal cortical lesions in early development

Children with unilateral focal cortical lesions acquired during birth or in early childhood face the task of language acquisition with a damaged hemisphere. Many of the early studies of this group were impressionistic and concerned with clinical issues, i.e. classification of disorders according to adult aphasia typologies, degree of recovery to premorbid level of functioning, etc. (Guttman, 1942; Benson, 1967; Brown and Hecaen, 1976; Hecaen, 1976; Alajouanine and Lhermitte, 1965; Visch-Brink and van de Sandt-Koenderman, 1984; Van Hout, Evrard and Lyons, 1985).

Clinical issues aside, it is unclear what is revealed about the effects on the acquisition of linguistic knowledge of children with focal lesions by the studies discussed above. Information about the specific linguistic abilities of children following focal damage is rare in these reports, with information about the extent to which language had been acquired before the neurological difficulties still rarer. When objective assessment of linguistic abilities was included, it consisted most often of verbal intelligence testing. Until recently, few groups of researchers have attempted to

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[4] The terms hemidecortication and hemispherectomy are often used interchangeably in the neurolinguistic literature, but it should be noted that these represent somewhat different surgeries.

evaluate specific linguistic (including morphosyntactic) knowledge. Woods and Carey (1979) were among the first to use tests designed to evaluate knowledge of specific aspects of language as well as tests in academic-related areas with their left-hemisphere patients (aged 10 to 25 years). They found only an impairment in spelling in patients with lesions before age 1;0. For the late lesion group (mean age 5.7 years) significant impairments were found on a naming task, performance on the Token Test, sentence judgement and completion tasks, and on a test of knowledge of kinship terms. However, many of their tasks involved more than linguistic abilities; e.g. their sentence completion task required good reading comprehension ability. Further, the data were presented in terms of scores on individual tests; no interpretation of error types or patterns was given.

There are a few additional studies which, on the basis of standardized test performance (typically IQ tests), support the hypothesis that very early damage to the left hemisphere results in no overt linguistic impairment (e.g. Bullard-Bates and Satz, 1983; Satz et al., 1985; Landsdell, 1969). However, most other recent research efforts have found an association of early brain damage with linguistic deficits of one sort or another. Beginning with early, prespeech milestones, Marchman, Miller and Bates (1989) found some differences in the character of early babbling and in the onset of first words, with early vocalizations being considered to be less complex (containing fewer true consonants) than those of controls. However, at least three of their five subjects were performing comparably to the controls by 22 months of age. There is only one study which investigates phonological knowledge, and it looks only at very young children. Keefe, Feldman and Holland (1989) evaluated the utterances of four children aged approximately two to four years of age who had suffered brain damage within the first week of life. They found no significant differences between controls and brain-damaged individuals in terms of the phonological processes which characterized their spontaneous speech (e.g. most children had evidence of the operation of age-appropriate phonological processes, such as cluster reduction, and did not produce utterances reflecting the presence of a phonological operation atypical of their age, such as unstressed syllable deletion).

Several studies note a relationship between brain damage in either hemisphere and an impairment in lexical knowledge (Annett, 1973; Aram, Ekelman, Rose and Whitaker, 1985; Rankin, Aram and Horowitz, 1981; Kiessling, Denckla and Carlton, 1983 [although the results of this last study were not statistically significant]), with the deficit apparent even at the point of acquisition of first words (Marchman et al. 1989). Thal, Marchman, Stiles, Trauner, Nass and Bates (1989) studied 11 cases with focal damage to one hemisherevery early in development, and found the following: 1) left-hemisphere damage was associated with near normal word comprehension but a significant delay in the onset of word combinations and decreased expressive vocabulary; 2) right hemisphere damage was associated with a deficit in word comprehension with an equivalent or lesser deficit in production of single words. They found little effect of lesion size or severity (see also Vargha-Khadem, et al., 1985). Keefe, Feldman and Holland (1989), using a task requiring learning novel lexical items, found that brain-damaged children, regardless of the side of damage, required more presentations of the novel words to learn them (both in comprehension and production).

One of the first reports of deficits in morphosyntax comes from the case studied by Dennis (1980c). She studied a child 9 years old who was tested three months post onset of a left temporal-parietal cerebral infarct. A wide variety of neuropsychological tests were administered, with the child described as nonfluent and as having difficulty in repeating sentences. She was able to comprehend single words and short utterances, but was impaired in "...her expression and understanding of more complex language..." Unfortunately, no detailed analysis of specific structures was reported. Further, the child was only studied shortly after onset of the brain damage. Spontaneous recovery even in adults is known to continue at least until six months post onset (Sheewan, 1986) and possibly longer; thus, in this case, we do not know what might have occurred with further recovery.

Thal et al. (1989) reported on early acquisition of word combinations and grammatical markers by focally-lesioned subjects. They found a variety of patterns for their subjects, but found that right hemisphere lesions were associated with abnormally high numbers of "closed class" items (grammatical morphemes), which they took to be evidence of a reliance on formulaic utterances (such as "want dat" instead of "want cookie" or "want go"). Left posterior lesions were associated with a high reliance on nominals at the expense of closed class items. According to this account, posterior lesions in adults and children have different consequences. Thal et al. speculate that the anterior cortex becomes responsible for phonological and syntactic processing (the computational component) only with time, as certain key language functions become automaticized. Early on, the posterior cortex may be responsible for not only lexical but grammatical and phonological development as well. However, these patterns were variable, with one left anterior subject performing normally and one performing like the right hemisphere subjects. In addition, there is no evidence to suggest that the reported difficulties with grammatical formatives reflect a lasting deficit.

Aram and co-workers (Rankin et al., 1981; Aram et al., 1985; Aram, Ekelman and Whitaker, 1986; Aram and Whitaker, 1988) have contributed a substantial body of data utilizing standardized tests as well as analyses of spontaneous speech. Rankin et al. (1981) found that right hemiplegic children (indicating left hemisphere pathology) performed less well than left hemiplegic children on various lexical and syntactic measures, including comprehension and elicited production of morphosyntax on the Northwestern Syntax Screening Test (NSST; Lee 1971). The NSST, which utilizes an picture pointing task in comprehension, and a sentence completion task for elicitation, is a screening measure and not an in-depth assessment instrument, however. The left-hemisphere damaged cases also demonstrated delayed early language milestones (e.g. onset of first words and word combinations). Aram et al. (1985) studied a group of children aged 1.67 to 8.1 years. They found that 1) both left and right-lesioned cases had impaired lexical comprehension and production, with the left-damaged group performing slightly better than the right-damaged group, and 2) left-hemisphere cases were significantly impaired as compared to normals on mean length of utterance (MLU; calculated as in Miller, 1981), on a measure of syntactic complexity of sentences from spontaneous speech (DSS; Lee, 1966) and on their comprehension of various morphosyntactic structures (on the NSST). Data from the spontaneous speech of these same cases (Aram et al., 1986) indicated that the left- but not the right-lesioned cases produced fewer grammatically correct sentences than their controls. Using the weighted scoring system of the DSS (Lee, 1974), deficits were found in the left-lesioned subjects when compared to their controls (and generally, as compared to the right-lesioned subjects as well). They made more errors overall in the use of verbal morphology. No deficit was noted for pronoun use. They made more errors in simple sentences and in wh-questions, but no significant difference was found for negative constructions. On a separate analysis of syntactically simple versus complex (multi-clause) constructions, the left-lesioned cases produced more malformed complex constructions than their controls.

The data from these studies suggest that brain damage in either hemisphere may have consequences for early speech and first word combinations (although possibly short-lived) as well as consequences for lexical learning more generally. Further, there appears to be a morphosyntactic deficit in many individuals following early focal left-hemisphere lesions. Specifically, there is evidence that comprehension and production of verbal morphology might be impaired. Additionally, production of simple as well as complex syntactic constructions appears to be at risk. It is difficult, however, to make any linguistically-informed generalizations about the patterns observed in the data to date.

It should also be noted that there appears to be some variability in performance observed in linguistic performance of the focally brain-damaged children, e.g. children who can perform well on word comprension tests but who have lexical deficits in production (Thal et al., 1989). There are numerous other examples in the literature of apparent unexpected dissociations of performance abilities: adult "agrammatic" aphasics who can make grammaticality judgements for structures they cannot produce or comprehend (Linebarger, Schwartz and Saffran, 1983; Goodglass and Menn, 1985); adult Wernicke aphasics who are insensitive to grammatical cues to word order in any but the most simple sentences, and yet who are fluent and appear to control word order in their own spontaneous speech (von Stockert and Bader, 1972). This performance variability issue is relevant to the classic question as to whether deficits on experimental tasks reflect performance factors or deficits in linguistic competence. Thus, while all tasks invariably require some "performance" abilities as well as underlying linguistic competence, inconsistent performance across tasks is thought to be incompatable with a competence (or underlying representational) deficit.

1.3.2 Surgical removal of a single hemisphere

A second population, that of patients who, as children, have had surgical removal of part or all of one hemisphere, have also been studied in an attempt to elucidate the status of language functions following damage to the proposed neurological substrate. Kohn (1980) studied twelve patients who had demonstrated some evidence of left hemisphere pathology (hemiplegia or seizures). The patients had all had surgical excision of the presumed loci of seizures (in the temporal, frontal or parietal lobes), and ranged in age from 15 to 48 years. Of the eight cases with onset of left hemisphere symptoms before age 9 months, five demonstrated impaired comprehension of syntactic structures on the Token Test and in comprehension of passive and negative passive sentences. Of the four cases with onset after 9 months, two demonstrated an impairment in syntactic comprehension.[5]

Within the surgical group, hemidecorticate individuals have received more attention in the literature because of the unusual neuroanatomical situation. Hemidecorticates, individuals who have had surgical removal of the entire cortex of a hemisphere of the brain, differ from the nonsurgery or focal surgery groups in that any role of the damaged hemisphere in supporting a given cognitive function is ruled out. These individuals have been the focus of a number of studies examining the functioning of the isolated hemispheres in a variety of cognitive domains. However, many of the studies have presented conflicting results. In the area of intellectual functioning, some researchers reported above normal IQ scores after both left (Smith and Sugar, 1975) and right (Damasio, Lima and Damasio, 1975) hemispherectomy; others have reported that patients with isolated hemispheres demonstrated borderline (below normal) scores on both verbal and nonverbal (performance) measures of IQ (Strauss and Verity, 1983). It has been suggested that lowered cognitive status, may reflect damage remaining in non-excised brain tissue (Verity, Strauss, Moyes, Wada, Dunn and Lapointe, 1982), with those patients with neurological integrity of the remaining brain demonstrating normal functioning in nonlanguage tests. Still others have reported impaired performance IQ but normal verbal IQ after left hemispherectomy (Bruell and Albee, 1962; Gott, 1973). Studies of visual and spatial functioning, thought to be lateralized to the right hemisphere in the normal brain, and thus an interesting parallel to cases with left hemisphere specialization for language, also have found similarly inconsistent results.

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5 Age at surgery is not noted.

Some reports have indicated visual perception and visuospatial difficulties following right but not left hemispherectomy (Day and Ulatowska, 1979; Kohn and Dennis, 1974). Others found significant visuospatial deficits in both left and right hemidecorticates (Strauss and Verity, 1985; Verity et al., 1982).

In the area of language, in spite of the significant neurological difference between focal lesion cases and hemispherectomy cases, acquisition following removal of the left hemisphere appears in several respects to parallel that of the focal lesion cases. First, initial studies reported that "no clinical disturbance of speech" was found regardless of which hemisphere was removed in childhood (cf. Wilson's (1970) survey of 50 cases studied as long as 19 years post surgery completed at an age ranging from 1.5 to 31 years of age). However, subsequent work revealed evidence of a grammatical deficit on formal tests. Day and Ulatowska (1979) reported that both their right hemispherectomy case (aged 4 to 6 years) and their left hemispherectomy case (aged 5 to 11 years) demonstrated cognitive deficits. However, linguistic performance varied for the two cases. The individual with the right hemispherectomy suffered visual perceptual and visual motor deficits, but her language ability was judged to be basically intact. The individual with the left hemispherectomy demonstrated poor performance on a sentence completion task focusing on production of morphological markers (the Grammatic Closure subtest of the Illinois Test of Psycholinguistic Abilities (ITPA; Kirk, McCarthy and Kirk, 1968), which largely tests prepositions, inflectional morphology and pronouns). She also had difficulties with metalinguistic tasks (sentence correction tasks, explaining similarities between words). However, her own spontaneous speech was fluent, contained complex constructions (e.g. embedded sentences) and was generally morphologically well-formed. It is also interesting that the performance of this second case was judged to be within normal limits at early stages in development (when testing was largely restricted to comprehension of simple commands and knowledge of vocabulary); later testing indicated the deficits noted above.

The most often cited research in this area are the studies of Dennis and colleagues (Dennis, 1980a; 1980b; 1983; Dennis and Kohn, 1975; Dennis and Whitaker, 1976; Dennis, Lovett and Wiegel-Crumpp, 1981). Their conclusions are based on data from a group of individuals whose age at the time of hemidecortication ranged from shortly after birth to as old as 20+ years, and who were tested at least 8, and as long as 17 years post surgery. They found that the isolated (and presumed to be intact) right hemisphere was superior to the left in some nonlanguage measures (specifically, on measures of visual and spatial functioning). They also found that both isolated hemispheres were able to acquire language to some extent, with no significant differences in receptive or productive lexical skills (including word retrieval). However, the isolated (and presumed to be intact) left hemisphere was superior to the isolated right hemisphere in many of the computational aspects of language. The finding of the superiority of the left hemisphere for syntactic processing was based on the subjects' performance on tasks which test knowledge judgements without nonlinguistic cues to the meaning of structure (e.g. semantically reversible active/passive - affirmative/negative combinations). These results are especially surprising in light of the apparent competence on all of these structures for all subjects in most communicative situations. This is consistent with the Day and Ulatowska findings (1979). It is important to note that in less linguistically informed research, the Dennis et al. subjects might have been erroneously assessed as having no language deficit (as was assumed before the work of Dennis and colleagues). In spite of the interesting implications of Dennis's work, however, Bishop (1983) raises some critical issues with respect to Dennis's research findings, citing the lack of normal controls on some tasks, statistical inadequacies (and errors), and the variability of Dennis's subjects' performance as well as the variation in the normal population on relevant tasks.

One additional case has been followed throughout the preschool years (Curtiss and Jackson, to appear). SM had the cortex of his left hemisphere removed at 13 months. On formal tests of lexical knowledge (Peabody Picture Vocabulary Test-Revised, or PPVT-R, Boston Naming Test), he demonstrated performance within normal limits. On formal tests of grammatical knowledge (the Curtiss-Yamada Comprehensive Language Evaluation [CYCLE]; Curtiss and Yamada, 1985), he demonstrated below age-level performance in both comprehension and elicited production, with persistent problems with negative scope and some aspects of morphology (non-lexical grammatical markers as well as pronouns and prepositions). However, an extensive analysis of spontaneous speech revealed a different picture. At the first data point, SM showed deficits in the length, well-formedness and morphological elaboration of his utterances as compared to those of his peers. This is not surprising given probable late start in the process of acquisition with only a right hemisphere substrate (certainly sometime after his surgery at 13 months). However, by the final data point (age 6) he performed comparable to age-matched peers on formal measures of lexical, semantic, and syntactic knowledge (the CYCLE).

SM did evidence some continuing problems. His spontaneous speech was ill-formed in the area of morphology (consistent with his errors on the CYCLE), and he also evidenced continuing production problems linked to intelligibility, revision and reformulation of his utterances. He also continued to have difficulty in interpreting negative scope on a formal comprehension test. He had no other evidence of a grammar which was deviant in its construction. He did not demonstrate difficulties with other types of constructions which have been reported to be difficult for other hemispherectomy or surgery cases (e.g. the passive; Dennis, 1980a; Kohn, 1980).

While the typical approach to elucidating the relationship between key areas of the left hemisphere and grammatical competence is to study cases with damage to these areas, investigations taken from the opposite perspective are also enlightening. In the next section we shall consider investigations which have focused on the neurological integrity of individuals who have a documented language impairment.

1.4 BRAIN DAMAGE IN LANGUAGE-IMPAIRED INDIVIDUALS

Two populations present evidence suggesting that developmental language disorders can be linked to anomalies of the cortex in the left hemisphere or evidence of unusual patterns of cerebral dominance. Developmental dyslexia has been attributed historically to incomplete brain lateralization since the work of Orton (1937). This hypothesis is supported both by behavioral studies as well as studies of functional or anatomical asymmetries in areas of the left hemisphere known to be key to linguistic abilities in normal adults. Cortical abnormalities found in the post-mortem studies of individuals with developmental dyslexia have been primarily neuronal and architectonic anomalies in the perisylvian region of the left hemisphere (Galaburda and Kemper, 1979; Galaburda, Sherman, Rosen, Aboitiz and Geschwind, 1985; Drake, 1968). Liederman (1988) notes that these findings are a good example of how "bigger is not always better", as the Galaburda et al. cases had planum temporale symmetric in their total amounts of tissue, possibly due to a lack of selective cell death in the right hemisphere. Additionally, regional cerebral blood flow (rCBF) studies (Lassen, Ingvar and Skinhoj, 1980) and topographic mapping of brain electrical activity have both indicated that dyslexics have reduced activity in key portions of the left hemisphere (but also in some regions of the right hemisphere).

There have been several studies linking linguistic deficits (primarily deficits in comprehension of morphosyntax) with developmental dyslexia (Vogel, 1975; Whitehouse, 1983). Kean (1984) has reported results which specifically address the integrity of grammatical principles within the Government-Binding framework. In her study of the syntactic knowledge of adult dyslexics, she found that they made errors on sentence judgement items involving coreferential noun phrases (noun phrases which share a referent within a sentence). Thus, there is evidence that a specific aspect of UG (Binding) is impaired in this population. Evidently judgement of the grammaticality of other types of constructions hinging crucially on principles of UG (e.g. subjacency) and those testing a variety of other types of morphosyntactic constructions (passives, items testing subcategorization and selectional restrictions, definiteness, prepositions and subject verb-agreement) did not reveal any abnormal response patterns. Measuring reaction time on a word monitoring task, Kean found that the adult dyslexics were delayed in their ability to process determiners ("the") in comparison to their reaction times for items from other syntactic categories (nouns, verbs, adjectives, prepositions and quantifiers), indicating (according to Kean) a possible deficit in processing grammatical markers in general. These findings are important because they point to specific deficits in judging and processing aspects of grammar in a population with demonstrated cortical abnormalities.

A second group which has a language impairment as its primary deficit is the group of children with developmental language disorders. These children, like the group of dyslexic individuals, are not homogenous, but display different linguistic profiles and nonlinguistic deficits. Further, while there are studies describing the patterns of their delayed/disordered language acquisition (Morehead and Ingram, 1973; Johnston and Kamhi, 1984; Lee, 1966), until recently little was known about the linguistic basis for their deficits. Curtiss, Katz and Tallal (to appear) interpret their data to suggest that language-impaired children were constructing grammars along the same lines as their normal controls, and that their linguistic impairments were due to processing rather than representational deficits.

As with developmental dyslexia, primary language impairment has long been suspected as having a neurological basis, e.g., atypical hemispheric specialization (hence the term "childhood aphasia", another common term used to describe children with primary language disorder). However, the data have been somewhat equivocal concerning patterns of asymmetry, beginning with dichotic listening studies (Springer and Eisenson, 1977; Bryden, 1970; Witelson and Rabinovitch, 1972). Historically, "soft" neurological signs rather than demonstrable neurological damage have been reported. However, in two studies, specific regions of the brain are implicated. Landau, Goldstein and Kleffner (1960) have presented the only case with severe receptive and expressive language deficits that has been brought to autopsy; they noted the presence of old bilateral cystic infarcts involving the superior temporal gyrus. Plante and colleagues (Plante, 1988; Plante, Swisher and Vance, 1989), studying three language impaired children with MRI, reported no evidence of focal damage per se. However, the three cases demonstrated abnormal patterns in the perisylvian area, with two subjects having equivalent area in both hemispheres in this region, and one having a clear but atypical asymmetry (the right greater in area than the left), suggesting an abnormal pattern of localization.

To summarize, it appears that some developmental language impairments are associated with abnormal brain organization or stucture, a finding which complements the earlier discussed linguistic deficits in overtly brain-damaged populations.

1.5 RESEARCH QUESTIONS

The work reviewed in this chapter may be summarized as follows. First, in children and adults, language impairment typically follows left but not right hemisphere damage. Thus, language functions appear to be lateralized to the left cerebral hemisphere very early in development (if not at birth). However, some reports have indicated that cases with very early damage, e.g. the first year of life, appeared to be exempt from serious deficits.

Second, there is evidence that the linguistic deficit in children with left hemisphere damage is primarily morphosyntactic, with a lexical deficit associated with damage to either hemisphere.

Third, there appears to be some variability in performance with regard to language abilities across tasks on the part of brain-injured subjects.

However, many questions remain unanswered about the syntactic knowledge of children with focal hemispheric damage. Much work remains to be done to delimit the specific linguistic consequences of early cortical damage. The previous investigations of syntactic abilities are less than conclusive for several reasons. As mentioned above, the criticisms of Dennis' work justify a replication. The work of Aram et al.(1985) employed only relatively gross measures, such as screening tests or standardized tests; their 1986 study does provide some evidence that producing "complex" constructions may be difficult for these children. However, we do not have an explanation of the nature of the errors, nor an analysis of the deficits. These lacunae lead us to address a number of remaining questions.

This dissertation research addresses the following questions regarding grammatical knowledge in children with focal left hemisphere damage (hereafter, FLHD).

1. Is there a demonstrable linguistic deficit in children with FLHD?

The dissertation research first addressed this question in an attempt to confirm and expand on the findings of Aram et al. (1985; 1986). Lexical as well as morphological and syntactic knowledge was included in the focus to investigate the extent to which a grammatical deficit, if found, exists in isolation or in tandem with a lexical deficit.

2. <u>If there is a grammatical deficit, what specific areas of the grammar are involved?</u>

Excluding phonology, what is the impact of FLHD on each of the following components of grammar: the lexicon, morphology and syntax?

3. <u>Does the age at which neurological damage occurs effect grammatical knowledge?</u>

The research relating to this question tested the hypothesis generally supported in the literature: namely, that impairments in various components of language become more profound when age at onset is older. This question is concerned with the decreasing ability of the right hemisphere to assume traditional left hemisphere support of language (reflecting, in part, the decreasing plasticity of the brain).

4. <u>Are the linguistic deficits of left-hemisphere damaged children due to impairment in the underlying representations of knowledge or in language processing mechanisms?</u>

More specifically, is the performance of the FLHD subjects somewhat variable, implicating processing rather than representational deficits? Access to or implementation of structural knowledge may be impaired on one or more tasks, while their correct performance on other tasks may indicate that the structural knowledge itself is intact and accessible on tasks which do not overly tax the damaged brain. Thus, there may be only one or two tasks on which these individuals can demonstrate their "best" linguistic performance.

The remainder of the dissertation is organized as follows. Chapter 2 will outline the specific grammatical principles to be investigated, along with specific hypotheses concerning the acquisition of each of these principles by the children involved in this study. Having covered basic syntactic and morphological theory as well as the neurolinguistic data from Chapter 1, Chapter 2 will conclude with the basic hypotheses to be tested by the data of this research. Chapter 3 will present the methods used herein. Chapter 4 will present the results, with Chapter 5 summarizing and discussing the implications of the findings.

CHAPTER 2

PRINCIPLES OF GRAMMAR:

THEORETICAL ANALYSIS AND NORMAL ACQUISITION

2.1 INTRODUCTION

This dissertation investigates the morphosyntactic knowledge of children with FLHD, and is formulated within the framework of the Government-Binding Theory (Chomsky, 1981; 1982; 1986). The basic tenet of this theory is that UG, or Universal Grammar) is that part of the grammar which is biologically endowed or "given". UG is viewed as containing subsystems, each of which has specific properties which affect various aspects of grammatical constructions. The result of the "modular character of grammar" (Chomsky, 1981) is that a given grammatical phenomenon arises from the interaction of these subsystems. A brief overview of relevant aspects of the theory is presented here; the reader unfamiliar with the basic organization of the grammar is referred to Radford (1988) for a more complete explanation and discussion of the theory.

The general organization of the rule system is as exemplified below in Figure 1:

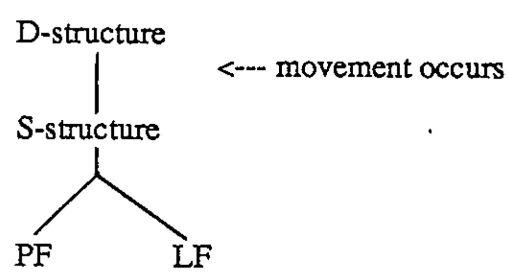

Figure 1: General organization of grammar

Within these various levels of grammatical representation, there operate various subsystems of principles which constrain grammatical representations (e.g. the Binding theory, principles of control and other principles to be discussed in the following sections). The (at least partially) independent principles interact, resulting in various grammatical constructions.

In D-structure, the principles of X-bar theory constrain the phrase structure, determining the word order of the constituents (e.g. NP --> Det NP; IP (formerly S ---> NP INFL VP). By viewing phrase structure as relationships between specifiers and complements, specifying unique phrase structure rules for the maximal projections of the lexical categories becomes unnecessary. Thus, only two rules are needed: XP = SPEC X' and X' = X YP. An example of these rules can be seen in the phrasal spell-out for IP:

IP = NP I'; I' = INFL VP .

At S-structure, (roughly surface structure) "move alpha" has applied, allowing optional movement of constituents. This rule is restricted from unwanted activity by other principles of grammar, such as theta-theory and the principle of subjacency. Thus, the fact that only certain constituents can be moved to specific locations is not the result of complicated movement rules, but of the restrictions of other aspects of the grammar on a single, simple rule of constituent movement.

Application of phonological rules, including various deletion operations, and the rules which characterize the scope of variables result in the levels of PF and LF respectively.

The primary difference between the current analysis of the grammar and previous generative accounts is the focus on general rules which are constrained by various principles within the submodules of grammar rather than formulating many transformational rules to generate the various sentence types.

Two additional principles are referred to here:

> The Projection Principle: Representations at each syntactic level (i.e. LF, D- and S-structure) are projected from the lexicon, in that they observe the subcategorization properties of lexical items (Chomsky, 1981:29)
>
> The Theta Criterion: Each argument bears one and only one theta role and each theta role is assigned to one and only one argument (Chomsky, 1981:35).

The projection principle ensures that subcategorized arguments (e.g. NP's) cannot be added or deleted during a derivation. They also cannot move unless they leave behind a trace which in effect holds the original place (and thus the original relationship of nouns to verbs) of the moved element. The Theta Criterion ensures that all NP's are assigned theta-roles at D-structure (e.g. are assigned the role of agent or theme), and are only allowed one role. The results of the interaction of these two principles is to preserve all lexical requirements of verb (e.g. that *put* must have both an object and a prepositional phrase/location following it) and any original role of a word in a sentence that was assigned before movement of constitutents (e.g. that in a sentence like *John is hit by Mary* it is *Mary* who is the agent, not *John*).

An important consequence of this constrained and modular theory of grammatical organization introduced above is that, because constructions are the result of the interaction of grammatical subsystems, mastery of a particular aspect of the grammar may be acquired in a piecemeal fashion. Hopefully, this point will be clear after the discussion of the specific principles in the upcoming sections; however, as an example, it is clear that passive verb morphology, passive word order and the by-phrase do not emerge all at the same point in time.

In summary, UG contains the important grammatical endowment central to all languages. These fundamental principles permit a certain range of variation which restricts possible human grammars and yet permit the diversity seen across languages in grammatical organization. An example of this is the variation in word order seen across languages. Thus, all languages have a consistent relationship between heads and complements within phrasal categories; however, they vary in whether they position heads as the first or the last constituent in the phrasal category (English is a head-first language; Korean is a head-last language).

Once UG is fixed in a certain way, the core grammar of the language is the result. As discussed in Chapter 1, there are other aspects of grammatical knowledge which are considered more peripheral. The grammatical periphery, exceptions to the settings allowed for the parameters of UG, or language-unique features, are the aspects of a specific grammatical construction hypothesized as being later acquired and "learned" in a sense that is not attributed to core grammatical principles, unlearnable on the basis of input. What constitutes the periphery of the grammar may vary from language to language. Thus, in English, infinitives can have lexical subjects under certain circumstances (e.g. *Amanda believes John to be a fool*). However, this type of construction is very much the exception rather than the rule across languages; "exceptional case-marking" is considered peripheral rather than core.

This chapter presents the current theoretical analysis for the set of principles and subcomponents of grammar which form the basis of this investigation. Each principle to be discussed here was chosen for its presumed theoretical importance, as a characteristic of all human grammars and thus part of UG. There were also two practical concerns in the selection of these specific aspects of grammar. First was the necessity that there be adequate research concerning how the principle or subcomponent of the grammar was acquired by normal, non-brain-injured children. Second, as it was somewhat unclear how impaired or delayed grammar acquisition might be in the brain-injured cases, it was important to select principles which were evidenced at very early points in development.

There will also be a discussion of one additional aspect of the grammar; verbal morphology. The model of morphology assumed here is the extended word paradigm theory (Anderson, 1985; 1988a; 1988b), where morphology (in particular, the inflectional component) is considered an independent module of grammar which operates on lexical stems to arrive at phonemic level structures.

2.2 RECURSION IN NP: RELATIVE CLAUSES

2.2.1 Theoretical analysis

One important property of the rules which specify the relationships of heads to complements of phrasal categories (i.e., phrase structure rules) is that they allow for recursion, i.e. the ability to embed one structural category, in another, unboundedly. Recursion in noun phrases (NP's[1]), creates relative clauses, as represented by NP --> Det N CP; CP --> C' IP (the CP being the embedded Comp phrase, or sentence). Relative clauses are analyzed as involving wh-movement and thus a resulting wh-trace, as in 1) and 2)

1) The lion that the bear pushed kisses the horse.

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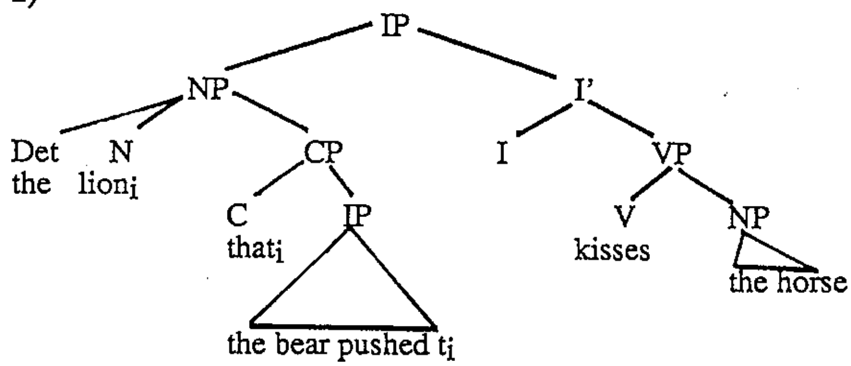
1 I recognize the current question as to whether or not the category traditionally known as NP is, in fact projected from the determiner (D) and not from the noun (N) (e.g. see Abney, 1986). I will use the NP analysis here, recognizing that this is an area of current investigation. Likewise, the question of whether or not the subject NP originates within the VP at the level of D-structure and is then moved at the surface (e.g. Koopman and Sportiche, to appear) is a matter of current interest; this analysis will not be included here.

2)



Here, the relative pronoun <u>that</u> has been moved to the clause initial position Comp. It leaves behind a trace of this movement (t), to which it is coindexed or coreferenced. The theory has stipulations on movement, as well as on linking of traces to the moved constituents. While wh-movement figures in other constructions, we shall restrict our discussion here to the treatment of the recursive clause (or IP) within NP, and to how this aspect of relatives is apparently acquired by the child.

Relative clauses can be subject relatives, with the matrix subject being either the subject of the embedded clause (SS relatives) or the object of the embedded clause, as in 3) and 4) respectively:

3) The dog_i that t_i bit the cat kicked the mouse. (SS rel)

4) The dog_i that the cat bit t_i kicked the mouse (SO rel)

Likewise, object relatives can feature relativized subjects or objects:

5) The dog bit the cat_i that t_i kicked the mouse. (OS rel)

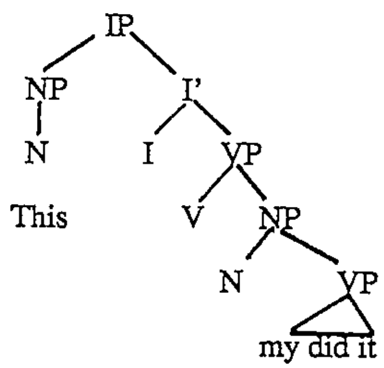
6) The dog bit the cat_i that the mouse kicked t_i. (OO rel)

2.2.2 Studies of normal acquisition

As with VP recursion, there are several domains which the child must master. First, the child must have a grammar which allows for recursion within specific categories (e.g. for relatives, it must allow recursion inside of NP). The child must also have a procedure for interpreting empty elements; here, there must be a method for determining reference for the wh-trace.

In production data there is evidence for early mastery of a recursive NP rule. Hamburger and Crain (1982) propose that as early as 24 months child grammars may contain such a recursive NP rule, as evidenced by the appearance of what they call "protorelatives". They describe protorelatives as consisting of a restrictive IP (or at least a VP) within an NP, as in:

7)



and also exemplified by utterances from my daughter Ellen at about this same point in development:

8) This is Mommy's write

9) This is my read it

As can be seen above, early protorelatives are "headless". The first true relatives are also headless, as in these examples from Ellen at 2;2[2].

10) I want what you have, Mommy.

These headless constructions seem to indicate that early on children are capable of embedding an S, but that some of the mechanics for more complex embedding are not yet mastered. Relative pronouns and mastery of rules of construal for empty elements appear still later, as in:

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2 Following convention, ages of children will be represented in years;months (2 years, 2 months, in this case).

11) I know a girl at school that Miss Jaclyn likes.

12) Dumbo needs the feather that is magic.

As mentioned earlier, a modular theory of grammar would allow (and perhaps predict) this somewhat piecemeal mastery of grammatical constructions. In this case, recursion appears to be an early, core property of grammar, with other aspects of grammar maturing later on.

Most of the initial comprehension studies involving relative clauses indicated that: a) very young children can interpret SS relatives (subject relatives where the matrix subject is also the subject of the embedded clause) (Lahey, 1974; Sheldon, 1974); b) comprehension of object relatives with relativized objects (OO relatives) and object relatives with the matrix object the same as the embedded subject (OS relatives) is initially incorrect, with the subject of the matrix coreferential with the relative pronoun, followed by correct interpretation by around age four to five years (e.g. Goodluck and Tavakolian, 1981; Solan and Roeper, 1978). Later comprehension than production of some types of relative clauses was somewhat problematic for theories of competence; however, with clever methodological changes, even three- to four-year olds are able to show comprehension of OS relatives. Most relevantly, it was found that the number of lexically full NP's in the sentences can affect comprehension; Goodluck and Tavakolian, 1981. Thus recursion in NP is apparent early; the structural analysis needed to correctly interpret or parse empty elements may appear slightly later.

2.3. RECURSION IN VP: VERBAL COMPLEMENTS

2.3.1 Theoretical analysis

Embedded clauses can occur in another grammatical context; they can appear in the VP as a complement to the verb. To comprehend and produce structures with recursion in VP, there a number of principles and domains of grammatical knowledge the child must have access to. First, the base must include a rule which allows the recursive structure to be generated in the base. Thus, sentential complements are generated within VP: VP --> V CP; CP --> C IP (similar to the account of NP recursion). Sentential complements are not the only way that clauses may be "added" within the matrix clause; adjunct clauses, which are not subcategorized for, are hung directly from S, and thus must be analyzed differently).

Second, the child must deal with both tensed and infinitival complements, as in 13) and 14) respectively:

13) I hope you will wait for me.

14) I told you to wait for me.

Infinitival complements such as 14) are also analyzed as containing an empty element known as PRO (this will be discussed further with the analysis presented in section 2.5); thus, the child must have a procedure for interpreting phonologically null categories to successfully interpret this type of complement.

2.3.2 Studies of normal acquisition

The earliest studies of complementation focused on production of complements by young children. Propositional complements (tensed and infinitival) appear early in children's spontaneous speech, at roughly 2 to 2 1/2 years of age (Limber, 1973; Bloom, Takeff and Lahey, 1984) (as in 15) and 16) :

15) I gonna get it

16) Want the man stand up.

Data from my daughter Ellen indicate the production of "small clause" complements (non-maximal projections but still clause-like structures) as early as 22 months, with true infinitives like 18) appearing slightly later (at 2;6):

17) I think doggie little bit wet.

18) I expected you to be gone.

Hyams (1987) suggests that both tensed complements and early infinitivals appear as the result of a recursive rule for the VP (VP --> V CP) being introduced into the grammar (although others have claimed that early infinitives are initially nonsentential; see Bloom et al., 1984). According to Hyams, the sentential structure of complements is a core property of the grammar (the phrase structure rule which in child as well as adult grammars allows for recursion within VP). It is acquired early, and provides the basic structure onto which other properties of complementation are mapped.

There are, according to Hyams, some other aspects of verbal complementation which are peripheral and which appear later, such as the appearance of overt complementizers, selection of specific type of complementizer, and S' deletion and exceptional case marking associated with raising verbs.

Research on verbal complementation in the grammars of older children has largely utilized comprehension tasks, and has largely focused on the status of structures with PRO and control; see section 2.5. Acquisition of indirect discourse and wh-complements continues until somewhat later in development, with such things as choice of wh-complementizer and structure of indirect questions taking somewhat longer.

2.4 BINDING OF OVERT NP'S

The principles of binding are included here because of their importance in a wide range of construction types from overt pronouns to null elements, and from single-clause sentences to (crucially) recursive structures. As Lust (1986) notes, anaphora (the relationship between a proform such as a pronoun and an antecedent) may be key to complex sentence formulation, in that an embedded structure " inherently involves redundancy reduction, and therefore provides a domain for possible anaphora (p. 10)".

We shall restrict this discussion to lexically realized NP's. In section 2.5 coreference of one of the null elements affected by the Binding Theory, PRO, will be reviewed.

2.4.1 Theoretical analysis

The original formulation of the binding theory (i.e. Chomsky, 1981) proposed the following:

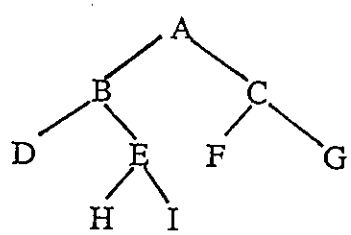
A. An anaphor must be locally bound (bound in its governing category).

B. A pronoun must be locally free (*not* bound in its governing category).

C. An R-expression (or name) must be free everywhere.

Some definitions of these terms are called for. "Bound" means that an NP is c-commanded by and co-indexed (or coreferential) with another NP, with "free" meaning the opposite (thus, not c-commanded by a co-indexed antecedent). C-command (based on Reinhart, 1976) is defined as follows: one element c-commands another if the branching node dominating the first element also dominates the second, and if the first item does not itself dominate the second. This structural relationship is illustrated in 19)

19)



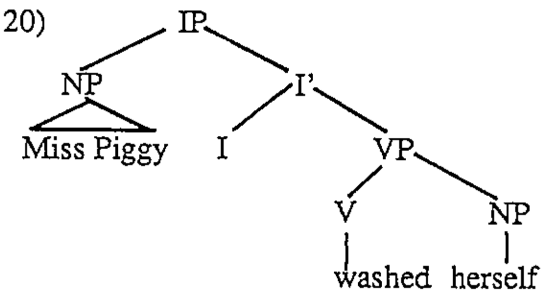
In the above example, B c-commands C, F, and G. E c-commands D, and D c-commands E.[3].

"Governing category" and "local" are terms refering to the syntactic domain in which NP's may or may not be bound. X can be said to govern Y if it is the minimal lexical category (V, A, N, P or AGR [agreement]) which c-commands Y without an

[3] At least so far, c-command appears to be an excellent example of a structural relationship which is difficult to explain in terms of other, more general cognitive principloes. Roeper (1988) notes "...one is forced to the conclusion that...this constraint is essentially pre-programmed into the child"

intervening S or NP barrier. The governing category for X is the minimal NP or S which contains the constituent which governs X[4]. An example of these syntactic relationships is exemplified in 20):

20)



In 20) above, *herself* is governed by the verb *washed*. I' is the governing category for *herself* (it contains the verb *washed*). For our purposes here, the governing category or local domain will largely amount to the clause, or IP (as in 20) above).

Recent reformulations of the binding principles focus on the notion Complete Functional Complex (CFC) (Chomsky, 1986). CFC is defined as follows:

b is a CFC if all grammatical functions theta-marked by a head dominated by b are contained in b.

CFC's, then, are the category in which all constituents theta-marked by a head are contained (i.e. NP or S). Binding theory can be now formulated in terms of CFC. Informally stated, the binding domain for pronouns and anaphors is the smallest CFC (NP or S) in which the binding theory can be satisfied (or, the smallest CFC in which pronouns can be free and reflexives can be bound). This reformulation has implications for acquisition, as we will see in section 2.4.2.

There are some generalizations about each of the binding principles which are discussed below.

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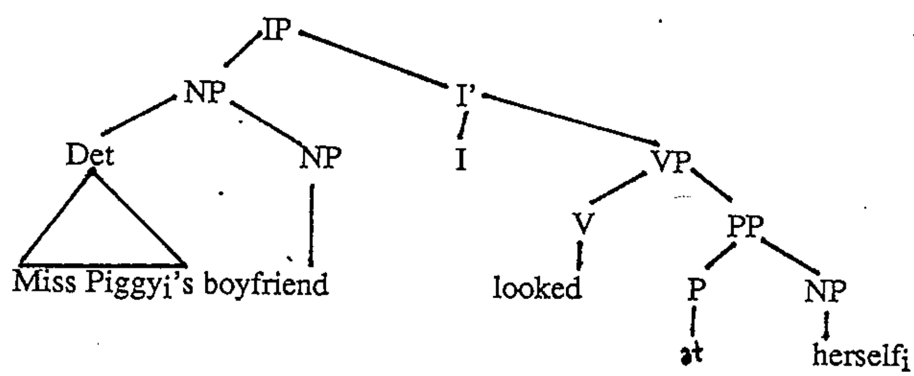
[4] Note that this is a simplified version of this definition; while it will suffice for our purposes here, the reader is referred to the formal definition in Aoun and Sportiche (1980), among others.

The following can be said about lexical anaphors (such as reflexive pronouns): a) they must have an antecedent (a coreferential NP) in the (tensed) clause; b) this antecedent must have a specific structural relationship to the reflexive; it must c-command it (and thus it may not be lower in the sentential tree than the reflexive), and c) the antecedent must be within the governing category (the same clause) as the reflexive. All of these requirements are responsible for the judgements of 21) - 24) below:

21) Miss Piggy looked at herself.

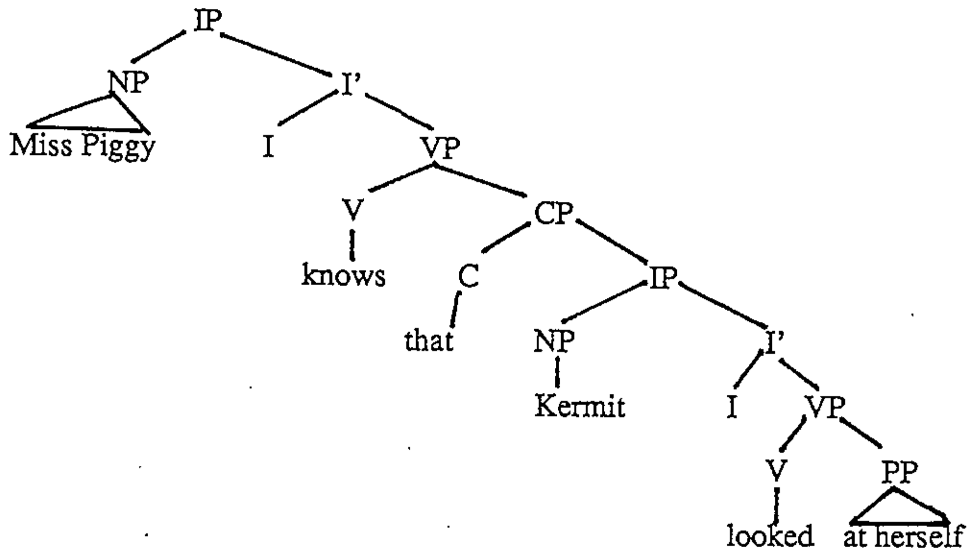
22) *Miss Piggy looked at himself. (*himself* must have a local antecedent but can not be coreferential with *Miss Piggy*).

23) (*)



the antecedent for *herself* must be *Miss Piggy*, but which is contained within a larger NP (a governing category) and is thus too low on the tree structure to c-command *herself*.

24) (*)

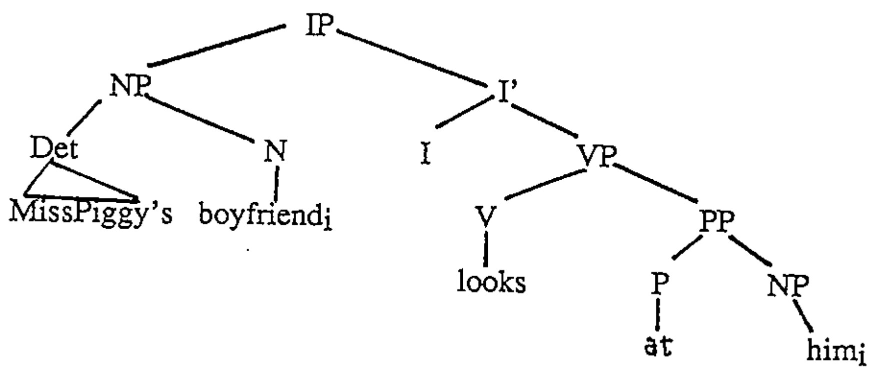


In 24) there is no possible local antecedent for *herself* within the lower clause; thus, it is not grammatical.

In contrast to anaphors, pronouns must be free within their governing category. Thus, the requirements for their grammatical use are: a) pronouns may (or may not) have an antecedent in the same (tensed) clause, but b) if the antecendent is in the same clause, the local antecedent may not c-command the pronoun. The corresponding examples are:

25) *Miss Piggy$_i$ looked at her$_i$. (*Her* is locally bound by *Miss Piggy*, in violation of Principle B).

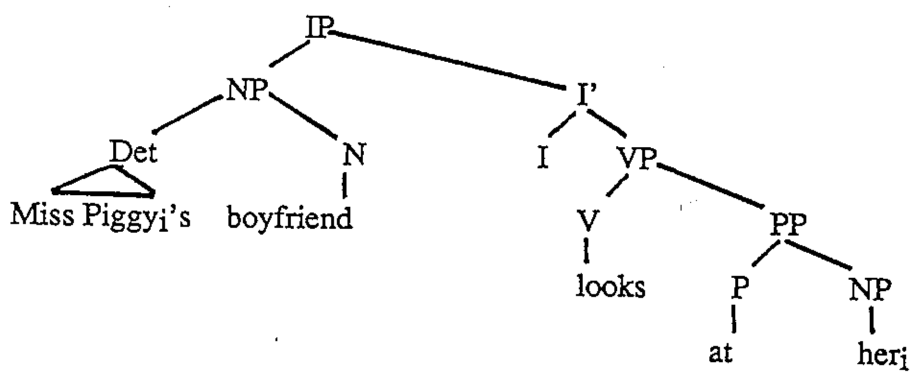
26) (*)



Example 26) is unacceptable in that *him* is locally bound by the c-commanding NP *Miss Piggy's boyfriend* in violation of Principle B.

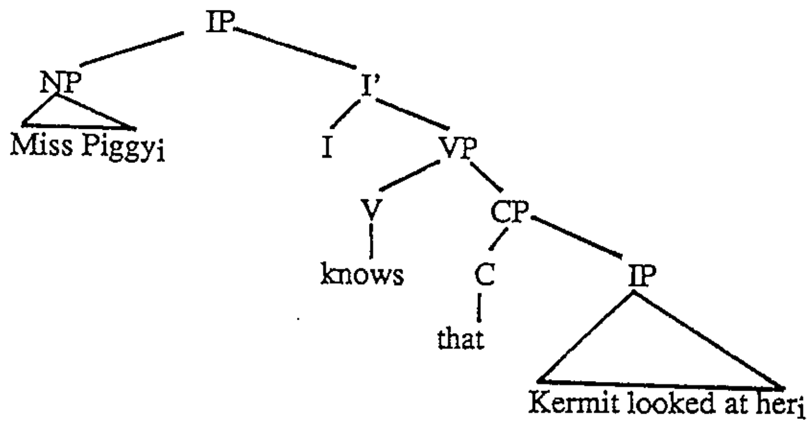
Contrast 26) with 27) below:

27)



Here, the antecedent for *her* is *Miss Piggy,* which does not c-command the pronoun (it is contained within the larger NP *Miss Piggy's boyfriend*), and thus coreference is possible. An additional grammatical example is 28):

28)



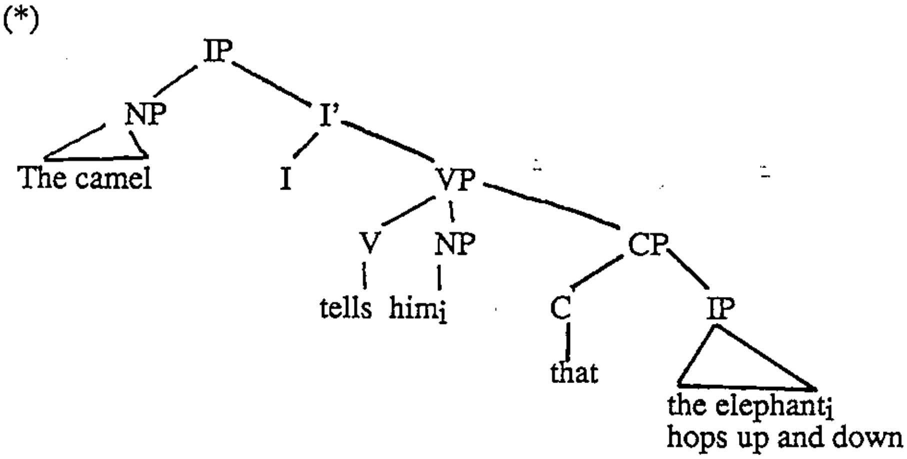
The example above is grammatical because there is no local NP coreferential with *her* in the same clause, which is the governing category of the pronoun.

The final binding condition (C) is as follows: R-expressions, or full lexical NP's, must be free in the entire sentence context. Thus, they may not have a c-commanding referent. Thus, 29) is ungrammatical:

29) *Miss Piggy$_i$ looked at Miss Piggy$_i$.

Likewise, backwards anaphora, or the coreference of a pronoun with a following (full) NP, is restricted by this principle, as in 30):

30) (*)



In 30) the structural configuration of the sentence is such that the pronoun c-commands *the elephant*, violating principle C.

2.4.2. Studies of normal acquisition

Much of the research on mastery of binding concerns Principles A and B. Most studies of acquisition conclude that young children show gradually increasing mastery of Principle A from age 2 to approximately age 4 years, with near perfect performance on experimental tasks by age 5 to 6 years (Wexler and Chien, 1985; Jacubowicz, 1985; McDaniel, Cairns and Hsu, 1989). There are several interpretations of this early but apparently less than instantaneous acquisition of Principle A. McDaniel et al. propose a series of specific stages:

1) children do not recognize reflexives as anaphors; thus, Principle A does not apply (similar to Wexler and Manzini, 1987; see below).

2) reflexives are recognized as anaphoric NP's; Principle A applies. Some children in this stage get the domain for binding anaphors wrong and allow reflexives to refer to higher subjects in infinitives.

3) Principle A is obeyed (reflexives are locally bound), but children may have a subsequent confusion as to whether reflexives can be subjects (this is related to their acquisition of the emphatic reflexive).

4) reflexives are fully acquired (the adult grammar is attained).

To account for the slight delay in acquisition of Principle A, Wexler and Manzini (1987) following Borer (1984) proposed the Lexical Learning Hypothesis; namely, that children must learn only which words are anaphors. They then apply the innately specified Binding Conditions to the appropriate words.

Most of the data concerning Principle A seem to support this hypothesis, with performance gradually improving over time. However, the data concerning Principle B are not explained by this hypothesis. The first studies in this area uniformly found that children continue to make errors on pronominal reference even after age 6. Specifically, they allow pronouns to have local antecedents (Koster, 1986; Wexler and

Chien, 1985; Jacubowicz, 1984). It cannot be the case that children simply "learn" pronouns later, as they are producing pronouns with free reference in their spontaneous speech very early in development, as in these examples from my daughter at age 1;9:

31) He drinking the juice.

32) No take the book out me.

Thus, the Lexical Learning Hypothesis is not sufficient to explain these results in that if the child had not yet sorted out which items were pronouns, errors in spontaneous speech would be expected (e.g. free interchange of pronoun and anaphor).

Further data from other languages have complicated the picture. First, children learning Chinese and Icelandic do well on tasks with both anaphors and pronouns by around age 5 to 6 years (Chien and Wexler, 1987; Hyams and Sigurjonsdottir, 1990). Further, some languages (such as Korean, Icelandic and Chinese) have non-locally bound anaphors, with children learning these languages showing different patterns across languages (e.g. in Icelandic, children apparently obey B early on and prefer nonlocal binding of anaphors; in Korean the pattern is that children do not follow B and prefer local binding of anaphors [Lee, 1987]). Varela (1989), Hyams (1989) and Hyams and Sigurjonsdottir (1990) explain some of these confusing results by proposing that: a) children do "know" the binding theory early on, and b) they "know" the lexical properties of various NP's (and hence are producing pronouns from very early points in childhood). Further, they note that children assume anaphors must be locally bound according to the subset theory (Wexler and Manzini, 1987) unless faced with evidence to the contrary (as in Chinese). What children do not know, according to Hyams (1989) is the *domain* for the binding theory, erroneously assuming that the VP can be the CFC. Thus, in the case of 26) the pronoun is free within the VP, satisfying the binding conditions. Thus, for the child, it would be possible for the subject NP to be coreferent with the pronoun, while this is not possible within the adult grammar.[5]

To date, then, there is no clear consensus on an explanation of the apparent delay of acquisition of knowledge of binding with regard to pronouns. However, the most recent work suggests that knowledge of Principle B, like that of Principle A, is innate, with other factors preventing children from demonstrating adult knowledge of Principle B.

With regard to principle C, the literature reports that at least some children allow violations of principle C with the age of acquisition variable from study to study (e.g. as old as five years of age, C. Chomsky,1969; most children by age three to four years, Crain and McKee, 1986). Hsu, Cairns, Eisenberg and Schlisselberg (1989) using an act-out task, found that many children under age five (and also two adults) allow violations of Principle C (or backwards anaphora) on sentences such as 33)

33) The lion tells him_i that the $zebra_i$ will jump over the fence.

Given the performance of the adults, it is possible that some aspect of the experimental task interferes with performance. This was also found in the study by McDaniel et al. (1989), where only two three-year-olds did not know Principle C, with some other children having difficulty on the long sentences (such as 33) but not on short sentences such as 34):

34) He is washing Grover.

Thus, at least within the domain of the single clause, the evidence suggests that Principle C is acquired quite early.

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[5] Their analysis goes much farther, and attempts to explain crosslinguistic differences with regard to principle A; see Hyams and Sigurjonsdottir for a more complete discussion.

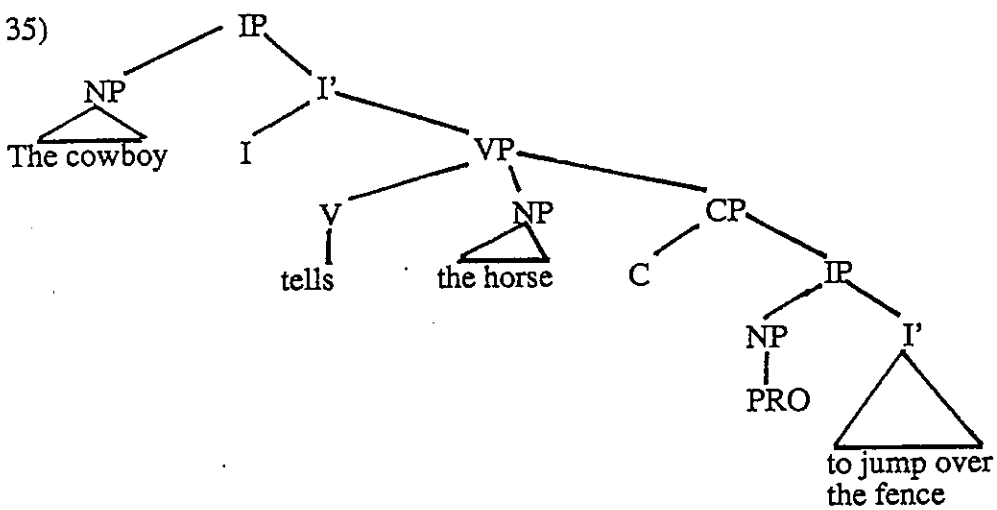
2.5 CONTROL

This section is concerned with one particular type of NP found as the subject of infinitives, PRO. The facts concerning interpretation and coreference of PRO are accounted for within the "control" submodule of grammar.

2.5.1 Theoretical analysis

The structure in 35) provides an example of the type of VP complement analyzed within the GB framework as containing the empty or phonologically null element PRO:

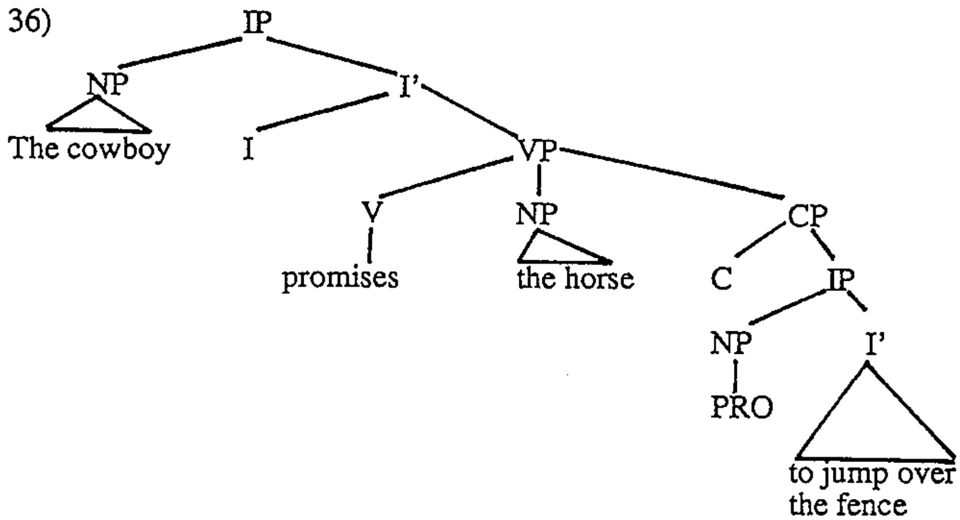
35)



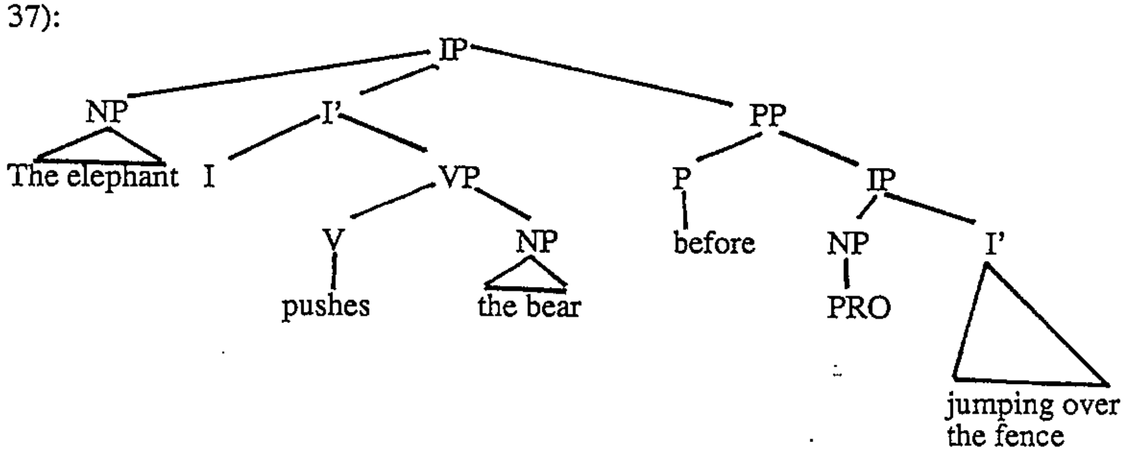
The embedded clause lacks an overt subject, but the adult native English speaker interprets the sentence as if there were a subject of the embedded clause, and as if that subject were *the horse*. This empty subject is postulated to be PRO, and is proposed for a number of theoretically motivated reasons not discussed here.

In 35) above, the controlling NP is the object of the matrix clause. However, in 36), the subject of the matrix clause is the controller:

36)



A large measure of the correct interpretation of infinitival complements is knowledge of the lexical information regarding the control properties of the verb (*tell* is an object control verb, while *promise* is a subject control verb). However, PRO also appears in other types of constructions. For example, in adverbial complements such as 37):

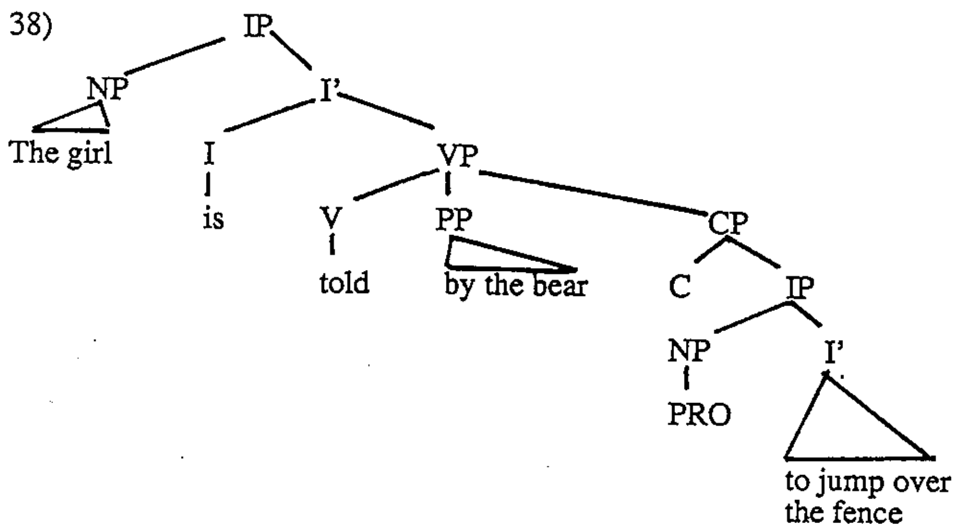


Here, syntactic facts concerning the relationship of the controlling NP and PRO become crucial to the interpretation of the empty element. The controlling NP must c-command PRO. In sentences such as 37) above, *the elephant* must control PRO, as *the bear* does not c-command PRO.

2.5.2 Studies of normal acquisition

There have been a number of studies looking at children's knowledge of contrastive object and subject control verbs (the "ask" and "tell" sentences) (e.g. C. Chomsky, 1969; Maratsos, 1974; Sherman and Lust, 1986). The initial major finding was that young children (until as late as 10 years of age) tended to interpret all verbs as being object controllers (or as having the object of the matrix clause coreferential with the subject of the embedded clause), including "promise", which is a subject control verb. C. Chomsky (1969) proposed this was the result of the children obeying a Minimum Distance Principle (MDP), selecting the closest NP to the missing subject of the infinitive. However, Goodluck (1981) and Hsu, Cairns and Fiengo (1985) found that in clauses with an intervening PP (such as 38) young children interpret PRO as coreferential with the matrix subjects.

38)



This has been interpreted as reflecting a sensitivity to c-command (a structural vs. a linear analysis): the children apparently know that the NP inside the PP (*the bear*) cannot c-command PRO, and they correctly interpret the structure as involving subject control (Hsu, 1981 cited in Hsu, Cairns and Fiengo, 1985).

With regard to control in complements, it appears that normal children demonstrate a progressively mature notion of control as follows (McDaniel et al., 1989; Goodluck and Behne, 1988):

1) children lack knowledge of control (PRO = arb)

2) children have "subject control" via a "highest S" strategy (subject of higher clause is interpreted as subject of lower clause for all constructions, including relatives and adjuncts).

3) children have control but attach adjuncts to the VP instead of S. Their knowledge of c-command (and the Minimal Distance Principle) leads them to object control for adjuncts.

4) children have mixed control, due to variable attachment of adjuncts to S or VP (with nongrammatical factors [e.g. processing overloads] being responsible for the occasional attachment to VP).

5) by seven years of age children attain consistent S-attachment of adjuncts and thus adult grammars.

McDaniel et al. (1989) propose that children always appear to have knowledge of c-command, but must learn control facts and structural attachment facts.

Production data reveal that children produce utterances with catenatives such as *wanna* and *hafta*, precursors to true infinitives, very early on (Bloom, Lightbrown and Hood, 1975; Brown, 1973). My own production data indicates the following examples (ages in parentheses):

39) You hafta cook them. (1;11)

Thus, while there is an early stage where children do not appear to know PRO and control facts, children are sensitive to c-command and know that PRO must be controlled early on, with the control facts concerning adjuncts mastered by age 7. Some infinitival complements are also produced very early on.

40) There's something I have to do. (1;9)

41) I expected you to be gone. (2;6)

42) I expected it to be milk. (2;6)

2.6 NP MOVEMENT, LINKING OF THETA ROLES AND THE PASSIVE

The passive provides yet another example of how constructions arise through the interaction of several different modules of grammar. The movement of Noun Phrases (NP's) is possible via "move alpha", resulting in noncanonical word order, but there are principles of grammar which serve to constrain NP movement (the projection principle and the theta criterion). There is also evidence suggesting that the passive is difficult for the isolated right hemisphere (the work of Dennis and colleagues as discussed earlier). Difficulty in detecting the thematic roles of arguments (and not difficulty in decoding syntactic information) has been argued to be a central deficit in adult aphasia (Linebarger, Schwartz and Saffran, 1983; Grodzinsky, 1984). Thus, this component of the grammar may be particularly at risk in the case of brain damage.

2.6.1. Theoretical analysis

One of the grammatical options for generating sentences with noncanonical word order is a general rule of "move alpha". As mentioned earlier, "move alpha" is a maximally general rule which is constrained by other principles of grammar. Here we discuss one type of movement, NP movement, where an NP is moved to another NP node which is base generated by the PS rules as containing a null element. The passive is the type of construction which we will examine here that depends on NP movement. In 43), there is the D-structure representation of a sentence, with 44) showing the S-structure resulting from NP movement ("e" shows the base generated empty node, and "_" indicates the site from which the constituent was moved):

43) e was hit John by Mary.

44) John was hit _ by Mary.

Two principles are discussed here which account for a relatively constrained application of NP movement: the projection principle and the theta criterion (see pp. 25-26). The projection principle arose from observations such as the following: in passives (such as 44)) *John* cannot be both the subject and the object (or the agent and the theme) of the verb *hit*. In this account, the types of arguments a verb must take are specified in the lexicon in the form of selectional restrictions. Theta roles roughly represent the semantic role that an argument plays in a clause. Thus, in the lexical entry for *hit* is the information that its subject is assigned an agent thematic role, and theme is assigned to its object. The projection principle requires that these selectional restrictions of verbs are observed at all levels of linguistic representation (importantly, before and after movement applies). Stated formally, the projection principle is as follows: the theta criterion holds at D-structure, S-structure and LF. The theta criterion stipulates that a) a lexical NP must occupy one and only one theta position, and b) every theta role of a given verb must be assigned exactly once. Consider 45):

45) Joe_i was pushed t_i by Sally.

Push assigns the thematic role of *theme* to the object NP *Joe* at D-structure. At S-structure, the thematic role is assigned to *Joe* via the trace of the moved NP.

2.6.2. Studies of normal acquisition

The literature on the acquisition of the passive indicates some differential performance depending on the task demands. Information about passives in production is sparse; passive constructions are rare in the spontaneous speech of children, as in that of adults.

However, most of the data places comprehension of a full passive with agent between three to four years of age, with comprehension of truncated, agentless passives somewhat before that (Sinclair and Bronckart, 1972; deVilliers and deVilliers, 1973; Maratsos, 1974; Baldie, 1976). There is some evidence that young children may utilize a nonlinguistic strategy for comprehending passives (although this does not in itself preclude a grammatical analysis by the child). Strohner and Nelson (1974) found that two- to three-year olds relied on a "probable event" strategy, with slightly older children (four- to five-year olds) demonstrating correct performance on passives, and thus showing evidence of being able to analyze the sentence syntactically.

2.7 SUMMARY OF ACQUISITION OF CORE PRINCIPLES OF GRAMMAR

To sum up our discussion of the acquisition of the grammatical principles above, several points can be made. First, the adult versions of various grammatical principles do not emerge full-blown in all cases. Some aspects of grammar appear to either mature or develop earlier than others (e.g. while knowledge of c-command appears early, binding and other principles which depend on c-command may be mastered later). Second, while constraints on coreference in particular may be mastered somewhat later in childhood, knowledge of certain aspects of structure (the c-command relationship, recursion of some sort in NP and VP) appear very early (e.g. two- to three-years of age). Third, following Hyams (1987) the analysis here is that the peripheral aspects *of a given construction* will be acquired later its the core properties. Thus, recursion in VP occurs early on, with knowledge of appropriate complementizers for particular verbs evident later in development. Finally, all of the properties examined above (with the possible exception of the ten-year-old ceiling on subject control) appear to be mastered in comprehension tasks by the early school years. Thus, knowledge of these core principles can be investigated in a population of school-aged children.

We now turn from principles of grammar which are presumed to part of the core, to an examination of another aspect of the grammar: verbal inflection.

2.8 ACQUISITION OF INFLECTION

Inflection is discussed here as a distinct aspect of the grammar which has been of interest to theoreticians as well as psycholinguists for many years. While many have recognized the somewhat special status of inflection within the grammar, there are many attempts to "cut the grammatical pie" in such a way as to capture the role of inflectional morphology outside of the syntactic principles discussed earlier. Thus, there is the traditional view of the grammar having a division between morphology (or morphosyntax) versus syntax. Another historical distinction has been made between major transformations or major movement rules (such as the passive) versus minor movement rules (such as affix hopping, which allows attatchment of verbal morphology to the verb [Emmonds, 1976]). More recently, there has been a distinction proposed concerning the syntax of major lexical categories versus functional categories (Pollack, 1990), with the latter including material which would be in INFL (inflection; Guilford and Noonan, 1989). All of these theoretical views are an attempt to correctly capture theoretically important distinctions within the grammar and to account for the interaction of morphology with syntax.

There is also a distinction which, while not motivated by grammatical theory, is nevertheless popular in psycholinguistic literature, particularly that dealing with adult aphasia. This is the "open-class" versus the "closed-class" dichotomy, with the latter including determiners, prepositions, and inflectional morphology. (e.g. Bradley, Garrett and Zurif; 1980). Interestingly, Braine (1976)'s pivot-open grammars of early childhood, while not exactly corresponding to the traditional open/closed class distinction for adults, nevertheless also tries to characterize what is different about those word classes which admit few new members and which appear to play a special role in the grammar.

One approach which may be particularly useful here is the core-periphery distinction. As discussed briefly earlier in this chapter, the periphery of the grammar varies from language to language, but is presumed to be those properties which involve relaxation of or exceptions to the settings of UG, as well as the particular grammatical features which make each language unique. Hyams (1987) suggests that one of the hallmarks of peripheral aspects of grammar is that they do not appear until somewhat later in the acquisition process. In fact, children acquiring English do not produce verbal inflectional morphology until much later than is noted for their counterparts learning other, more richly inflected languages. For example, the children in Brown's (1973) study acquired "third person regular" at a rank of 9.66 out of the fourteen morphemes examined in his study of spontaneous speech (at a mean age of 2-9); regular past /-ed/ was ranked at 9.00. On a formal task (the CYCLE-R; Curtiss and Yamada, to appear), we have the following ages for comprehension of tense/aspect inflectional morphology: /-ing/ at age 5, /-ed/ at age 6, and "will" at age seven. Agreement morphology is similarly late on the CYCLE, with verb singular and plural not passed until age 6 and 8 respectively. Hyams contrasts the late mastery of English morphology with with her own data concerning the acquisition of agreement by Italian children (at about age 2).

To account for this disparity in timing, Hyams proposes a parameter which is set according to whether a bare verbal stem is a well-formed lexical item in the language at hand. In English, a bare verb root is a well-formed word, and thus English speaking children do not need to learn verbal morphology to satisfy lexical well-formedness conditions (unlike children learning Italian or Spanish). Thus, children learning English acquire verbal inflectional morphology relatively late in the acquisition process not because they are grammatically delayed compared to children learning other languages, but because they are not forced to learn morphology to satisfy this particular parameter.

For English, inflectional morphology is a relatively peripheral aspect of the grammar which is learned later in the acquisition process. There is an exception to the late acquisition of verbal morphology in English, and that is the acquisition of /-ing/. Hyams attribute the relatively early appearance of this piece of morphology as being due to the child learning each progressive form as a separate lexical item (so that verb X is separate in the lexicon from the verb X+ing).[6]

Note that this approach allows us to make language-specific predictions about what will happen following brain damage in children. Thus, while in English, verbal morphology might be somewhat vulnerable given its peripheral status in the grammar, it might not be vulnerable for children learning a language where inflection plays a more central role. In fact, Levy, Amir and Shalev (1989) found no impairment in inflectional morphology in their left-hemisphere damaged case who was acquiring Hebrew.

2.9 HYPOTHESES

In this chapter, we have reviewed the current syntactic analyses of the constructions which crucially involve various core principles and modules of grammar. In addition, while there is no clear consensus on the exact theoretical explanation of the special status of inflection in English, it appears for a number of reasons that this component of the grammar might be vulnerable in the face of FLHD.

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[6] Borer (1990) notes that V + *ing* constructions differ in many ways from "normal" verbs (e.g. normal verbs don't occur as a subject, don't have a "property" reading but do take complements). Thus, there are various distributional differences between V + *ing* and other verb forms, and these differences may represent an important linguistic distinction that exists even in the adult grammar. Further, Radford (1986) proposes that *ing* verbs are actually unmarked for tense; thus, they are acquired outside of mastery of systematic tense morphology.

. In contrast, it seems plausible that the core principles of syntax might be relatively resistant to damage. This work assumes a theoretical view in which acquisition of syntax requires unique and special acquisition mechanisms that are not shared by other linguistic or cognitive domains. Thus, for phylogenetic reasons this knowledge should be housed in the brain in such a way as to be resistant to damage.

Given the reviews of the neurolinguistic literature, the overview of grammatical theory and the acquisition data, it is now possible to state several hypotheses about the grammatical ability of the FLHD individuals.

H1: Early focal left hemisphere damage will result in deficits on standardized tests assessing lexical as well as morphosyntactic knowledge. However, in depth asssessment of grammatical performance will reveal:

H1a: Acquisition of core properties of syntax will generally not be impaired if key areas of the left hemisphere are damaged early in development (before the end of the hypothesized critical period, or before age 5).

H1b: Acquisition of inflection in English will be impaired following focal left hemisphere damage at any point in childhood.

H2: Age at onset will affect the nature and extent of deficits in the acquisition of grammar, with an increasing age at onset related to greater deficits.

H3: Performance of focally lesioned subjects will vary according to demands of the tasks used to assess grammatical knowledge, implicating processing deficits rather than deficits in underlying linguistic representations.

CHAPTER 3

METHODOLOGY

3.1 SUBJECTS

Subjects for this study came from a number of medical facilities in the Southern California area. They were recruited either by direct referrals from physicians or were selected after reading medical histories from a list of possible candidates provided by physicians. The subjects had to meet the following criteria: 1) early focal left hemisphere seizure activity or focal damage evident at birth or which occurred during the first 5 years of life; 2) no evidence of right hemisphere pathology (note that JL is somewhat of an exception to this; this will be discussed further in Chapter 4); 3) no family history of learning problems or language disorders; 4) no familial left-handedness; 5) no reports of generalized cognitive deficits. With regard to the last criterion, there was typically no IQ data on the subjects, so this criterion was met on an informal basis (e.g. assessment of the children's teachers). It should be noted that all subjects except for FC (who had gross motor impairments) were placed in regular elementary school classrooms; however, four of the six subjects had received some special educational help (in the form of a resource teacher or learning specialist).[1]

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[1] There is IQ data only on SR, as general psychological testing had not been deemed needed for the other subjects for either medical or educational reasons. A psychological evaluation at age 12 found him to be "mildly mentally retarded" (full scale IQ = 66; VIQ = 69, PIQ = 67). However, he is also described as having good performance on "selective language tests", age-appropriate arithmetic and reading recognition skills, and age-appropirate attentional and concentrational skills on tasks where he was given lots of structure. It was also noted that his performance may have been influenced by his low tolerance of frustration and some emotional difficulties with regard to his peers at school, and it was recommended that he be retested when these

Table 1: Neurological status of FLHD subjects

Subject	Age at onset	Site of damage	Hemiparesis/seizures
1. WB	0;2	Left parietal-occipital hemmorhage with some frontal extension	Mild paresis of right arm. Long history of seizure medication
2. SR	0;7	Left temporal lobe	Long history of seizure medication
3. MB	2;2	Left temporal lobe seizures; no evidence of structural damage	None
4. NA	3;10	CVA involving internal middle cerebral artery on left after repair of tetralogy of Fallot	Mild paresis of right arm
5. FC	5;0	Malformation of vein of Galen noted at 0-2; CT at 5-0 indicated aneurysm with hemmorhage in left temporal lobe involving internal capsule and thalamus	Long history of seizures and medication
6. JL	4;5	Left temporal lobe seizures; at 8-0 had hemmorhage of anterior tip of left temporal lobe and "minimal" contusion of right temporal lobe	Long history of seizures and medication

All subjects who met the above criteria were contacted; two families declined to participate, and the rest were included in the study. Information about the neurological

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problems were resolved. Thus, in his case a generalized cognitive deficit cannot be ruled out; however, he performs similarly to the other subjects (as we shall see) and is thus included here.

status of the experimental subjects is summarized in Table 1. Site of damage refers to evidence regarding structural damage on x-ray computed tomography (CT) unless otherwise noted.

To address Hypothesis 2, which deals with the effect of age at onset of symptoms of brain damage, the subjects were divided into three groups. The groups were based on the time of onset, and would allow some between-group comparisons (although the limitation of the small number of subjects is a limiting factor in interpreting the data. Group I is composed of subjects with damage during the first year of life. Group II has subjects with damage from age two to four years. Group III has subjects with damage from ages four to five years. Each group has two subjects each, one with focal damage and one with focal seizure activity but no discernable damage.

Each FLHD subject was matched to a non-impaired control subject whose age was within three months of their chronological age (CA) at first testing. Information regarding brain-damaged and control subjects is presented in Table 2.

Table 2: Subject information

Group	Subject	Sex	Age at testing	Control	Sex	Age at testing
I	1. WB	M	7;6 to 7;9	SF	M	7;9
I	2. SR	M	13;2	KY	M	13;2
II	3. MB	M	5;9 to 5;10	SS	M	5;9
II	4. NA	M	6;3	SM	F	6;3
III	5. FC	M	9;9 to 10;2	JP	F	10;0
III	6. JL	M	12;7 to 12;8	CL	M	12;5

3.2 ASSESSMENT PROCEDURES

The assessment procedures used with each subject were of two kinds: those used to establish general levels of linguistic functioning; those designed to evaluate specific linguistic knowledge in depth.

The assessment battery is detailed below.

3.2.1 Normative data

The normative tests were used in an initial session to establish: a) the presence or absence of obvious language disorders or delays, and b) to determine that the subjects were able to perform appropriately on formal tasks, and c) to allow comparison of lexical vs. morphosyntactic performance. The tests used for that purpose are presented as follows:

1. Curtiss-Yamada Comprehensive Language Evaluation (CYCLE; Curtiss and Yamada, 1985)

2. Peabody Picture Vocabulary Test-Revised, Form L (PPVT-R; Dunn and Dunn, 1981)

3. Producing Word Associations Subtest, Clinical Evaluation of Language Functions (CELF; Semel and Wiig, 1980)

4. The Boston Naming Test (Goodglass, Kaplan and Weintraub, 1983)

The CYCLE was used to evaluate general linguistic performance of the experimental subjects relative to their chronological peers. (It was also used as part of the experimental battery; see 3.2.2). Two sub-batteries of the CYCLE were used here: the CYCLE-R (Receptive Battery) and the CYCLE-E (Elicitation Battery). Both the CYCLE-E and the CYCLE-R are normed for ages two to nine years. The CYCLE-R is a compilation of comprehension subtests, utilizing primarily a picture- sentence matching task (with object manipulation tasks used for the locative preposition and some pronoun tests). The CYCLE-R items test knowledge of a variety of syntactic and morphological items. In each subtest of the CYCLE-R a particular construction type is tested five times. The picture stimuli are simple line drawings (see Appendix A for examples of pictures and stimuli sentences and a list of each of the subtests of the CYCLE-R and CYCLE-E; Appendix B lists sample stimuli from each of the subtests used in the linguistic battery). Each test sentence has, in addition to the picture which represents the correct response, three decoys containing the same objects or people in different relationships, ensuring that the subject must comprehend and respond to the key construction and to the entire sentence. Four out of five correct responses is considered "passing" for any given item. To pass an entire age level, the subject must pass 80% of the items at that level.

The CYCLE-E is an elicited production task, with pictures used to focus attention and cue the desired response. Thus, the examiner starts the desired utterance and the subject must "finish" it (see Appendix A for example item). It tests a variety of grammatical constructions. Each construction is tested twice. Two out of two correct responses is considered passing a given subtest. A subject must pass 80% of the items at a given level to have "passed" the level.

Three other tests were used as formal measures of fluency and lexical knowledge. The PPVT-R (Dunn and Dunn, 1981) is a picture pointing vocabulary test normed to age 18. The Producing Word Associations subtest of the CELF is a measure of word fluency ("Tell me all the kinds of animals you can think of"). Word fluency tasks are a common component of neuropsychological batteries, and are assumed to represent ability to retrieve words by semantic category. The CELF has norms by grade level, approximately spanning the years from 5 to 17. The Boston Naming Test (Goodglass et al., 1983) is a confrontation naming test using simple line drawings as stimuli. The test was originally designed for use with adult aphasics; norms for children were drawn from Guilford and Nawojczyk (1988).

The control subjects were not given the normative battery, as these tests have published norms to which the performance of the FLHD subjects can be compared.

3.2.2 Evaluation of morphosyntactic knowledge: The experimental battery

To evaluate the morphosyntactic knowledge of the subjects, a variety of tasks were used. It is often difficult test to knowledge of a particular type of construction using one method. For example, passives are rare in spontaneous speech, not comprehended in a picture-pointing task until middle childhood, but easily tested early on in an object manipulation task. In addition, children with brain damage often have nonlinguistic performance deficits (e.g. visual field cuts, memory deficits, etc.) which can influence performance on one task but not another. Unfortunately, the current state of the art is such that determining which task is the "best" for a given population is difficult at best; thus, the battery included several types of tasks with different response requirements.

The tasks included in the experimental morphosyntactic battery were as follows:

1. Comprehension:
    a. Animal enactment
    b. CYCLE-R (specific subtests)
2. Elicited production:
    a. Animal description
    b. CYCLE-E (specific subtests)
3. Language sample
4. Judgement task

Appendix B describes the specific tests from the CYCLE-E and CYCLE-R used in the assessment of knowledge of the particular grammatical constructions discussed in Chapters 4 through 6. All of the other tests are described below (and complete lists of types of structures tested are presented in Appendix C). The tasks were given in randomized order, with the exception of the the animal description task, which always preceded the enactment task. This was done to ensure that production on the description task was not influenced by remembering stimuli from the enactment task.

3.2.2.1 Animal enactment task: This object-manipulation comprehension task is similar to those used by numerous researchers (Sheldon, 1974; Tavakolian, 1978; Solan, 1981; Goodluck, 1981). This task tests for comprehension of particular syntactic structures. The task begins with a pretest of knowledge of the names of the characters to be used, as well as knowledge of an appropriate label for the action that child observed. If a child did not know a particular character, he was told the appropriate name, and was retested at the end of the pretest for that name. At this point, two subjects still did not know *Pokey*; for these two subjects (MB and NA, the youngest FLHD subjects) all items which included that character were changed to include other characters that they did know. Likewise, if the child had difficulty in acting out a particular verb, the action was demonstrated for them. All children were able to act out the verbs by the end of the pretest.

In the actual test, the child was presented with a sentence and told to use the figures provided by the examiner to act it out (see Appendix D for list of test items). In constructing the items for this task, every attempt was made to allow the subjects to produce possible incorrect as well as correct responses. Thus, for sentences such as 47):

47) The deer looked at himself.

a deer, a bear, and a mirror were placed in close proximity to the subject, allowing for correct (deer looks in mirror) as well as incorrect (deer looks at bear) responses.

Use of a particular construction by the examiner was made as felicitous as possible (e.g. providing two horses that could be talked about to appropriately motivate the use of a restrictive relative clause). Further, the sentence was repeated as often as needed if the child either did not respond or appeared confused. Three tokens of each construction type were included in the randomized battery. The battery was typically presented in three parts of 21 items each.

This particular test does require knowledge of numerous lexical items (although all children were able to comprehend the labels in isolation at the end of the pretest). It also assumes that children know the theta grids associated with particular verbs; however, no errors violating the theta requirements of these verbs were made (i.e. no errors were observed where the child omitted a required argument of a verb). The demands on short-term memory were minimized by repeating the stimuli as needed. Thus, all factors which might cause errors (outside of errors based on actual inability to comprehend the syntactic structures) were minimized as much as possible.

The subjects were required to score at least 80% correct to be attributed with knowledge of any of the specific areas of the grammar included on the test.

3.2.2.2 Animal description task: This is an elicited production task, designed to examine the child's ability to produce a variety of target syntactic structures. In this task, the child is told that it is his or her turn to talk, and say what the examiner is doing with the animals.

Before the actual test sentences, the child was pretested to make sure he had labels for each of the characters and for each of the actions. The child's word for a character's name or for an action was always accepted as correct (e.g. the robots were called *robots*, *Muscles* (the store name) and *monsters* by various children; some children didn't know the character *Pokey* and just called him *the horse*; *push* was sometimes interpreted as *shove* or *bump*). Occasionally a child was not able to produce a label for an action; in this case, he was told a label, and was asked again at the end of the pretest for the label (all children were able to come up with a label on the second try).

In part I, the task is simple description, with any relevant comment or description accepted as a valid response. If the child hesitated, he was cued with "Tell me about what you see; start with (subject of the sentence)." Part II is adapted from the procedures used by Hamburger and Crain (1984) to elicit object relative clauses; a third party (a parent or sibling) was asked to hide their eyes, with the examiner hiding a penny under one of two identical animals. The examiner involved one of the animals (the one with the penny) in an enactment scheme. The child then described the ongoing action to the third person ("Pick up the (animal) that ..."). If the child had trouble starting the sentence, he was cued, "Tell her which one has the penny. Say, 'Pick up...'". In Parts I and II three tokens of each type of item were presented. Appendix C lists examples of each type of item used in this test. Three tokens of each construction type were included in the randomized battery. The battery was typically presented in its entirety.

Like the enactment task, this task requires ability to retrieve the needed lexical items (although all children were able to come up with the labels in isolation at the end of the pretest). It also assumes that children know the theta grids associated with particular verbs; however, no errors violating the theta requirements of these verbs were made. Note that, in part II, use of a particular construction was made as felicitous as possible (e.g. providing two horses that could be talked about to appropriately motivate the use of a restrictive relative clause). Further, the action was continued by the examiner until the child produced a sentence. This was done to lessen the short-term memory load.

3.2.2.3 Judgement task: In this task, which had items relevant to binding and control, the children were asked to say whether a sentence sounded "like a good sentence-- like how a grown-up would sound"[2]. The children were then introduced to the task in three pre-tests, roughly along the lines of McDaniels et al. (1987). First, they were told that some of the sentences they would hear would be "good", and they were given two stimuli accompanied by ongoing action carried out by the figures used in the act-out test. Next, they were told that some of the sentences they would hear would not be good. They were then given three examples of sentences with appropriate lexical items accompanying the action but with wrong word order, as in:

48) bump the bear was the girl by.

In the second pretest, the figures were removed. The child was asked to make the same judgement (was the sentence "good" or "bad"). These eight sentences

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2 In retrospect, it might have been more appropriate to ask only if the sentence "sounded good". Children are often able to appreciate that adult utterances can sound different from their own (e.g. they do not accept as correct adult mimicry of their misarticulations), while producing in their own utterances something which is very different from the adult target.

contained some grammatically correct sentences, some grammatically correct but semantically anomalous sentences, and some ungrammatical sentences (with incorrect word order or missing constituents, or agreement error). If errors were made, they were explained to the child, and the next item was given. The only error made by any of the subjects was on a semantically anomalous item. These items were included to further emphasize the importance of attending only to the "grammaticality" of the sentences. If they made such and error, the examiner returned to the appropriate sentence at the end of the session to readminister the item. All children were able to do the task by the end of the second pretest.

The third pre-test involved introducing the child to the probes which would be used on the test stimuli. They were told "Sometimes I will ask you about who did some of these things." They were given two sentences, and then given the probes as in 49):

49) The bear hits the elephant.

a) "Was that a good sentence or a bad sentence?"

b) "Who got hit?"

For the actual test items, probes continued ("Could it have been (referent other than the answer to b) above)?" Thus, the subjects were asked to consider other referents which may not have been allowed by the adult grammar, but which might be possible in the FLHD subjects' grammars. In Appendix C, the items probed for are listed after each item.

The probes were included to circumvent the typical difficulty with judgement tasks (e.g. that ungrammatical stimuli are judged to be grammatical without an explanation of the basis of the judgement). However, it is noted that the probes were in the passive; thus, interpretation of this data required waiting until all of the linguistic testing was done to ensure that the children were "passive proficient" and thus comprehending the probe sentences. As will be seen, all subjects were able to demonstrate comprehension of the passive construction on the enactment task, and thus their probe data were included in the data pool.

The actual test items were then administered in a single session. One token of each type of construction was presented. Sentences were repeated to avoid undue demands on short-term memory if the subject hesitated or if they asked for a repetition (this happened 7 times across all FLHD subjects and 4 times across the normal controls). To be scored as correct, the response had to include: a) the appropriate judgement of grammaticality, and b) appropriate responses to the probes (with coreference that as allowed by the adult grammar).

It is clear that the judgement task requires metalinguistic abilities not involved in the other tasks. It is interesting that Hamburger and Crain (1984) felt judgement task to be easier than an act-out or a picture-pointing task, and thus more representative of true ability. McDaniels et al. (1987) assumed judgement tasks to be more accurate because they allow evaluating responses to ungrammatical constructions (which might be "grammatical" for the child but which would be the type of data not available from the comprehension responses. In any case, considerable nonlinguistic factors are at play, including the possibility that children have a tendency to "just say yes" in complying with adults while taking the task (Grimshaw and Rosen, 1990).

3.2.2.4 Language samples: The language sample data came from taped conversations between the the investigator and the subject. The topics were school, family, games and hobbies, favorite TV programs and movies, and the subject's most recent birthday. In addition to conversation, a narrative was elicited (samples from each of the FLHD subjects are in Appendix D). The subjects were read the story of *Curious George rides a bike* (Rey, 1941) at the beginning of the first session. They were then asked to retell that story to another person (parent, sibling or friend) at the end of that session. These data were used to supplement the conversational data. One hundred utterances transcribed from the sample compose the corpus. These utterances were as contiguous as possible, but exclude sentences with unintelligible portions, responses of "yes" and "no", and automatic or formulaic utterances (e.g. "you got me", "I don't know"). The samples were then scanned for constructions relevant to the principles discussed in the next chapter, including:

a) examples of lexical misuse, or lexical retrieval problems.

b) examples of the relevant syntactic structures

c) all instantiations of agreement and tense verb morphology (for the analysis of inflection).

For b) and c), both grammatical and ungrammatical examples were tallied, to determine the extent to which each subject had control over the relevant section of the grammar.

3.3 DATA COLLECTION

The testing situation varied somewhat for each subject, depending on geography and the age of the subject. The experimental subjects were tested at least two years post onset, with two children (SR and WB) tested seven or more years post onset. At least two, but no more than five, visits were made to the home of the child. The visits ranged from one to three hours[3], and were completed within a one to three month period (with the exception of FC, whose data collection stretched over a five month period due to difficulties related to his foster home placement). Formal tasks were alternated with conversation. Sessions with the control subjects were similarly arranged, although three of the subjects were assessed in their school rather than in their home, with the data collected from all control subjects within three visits scheduled within a month.

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[3] This time was not spent at a desk "working". Time spent at particular tasks was interspersed with conversation (spontaneous speech samples) and breaks and snacks as needed.

3.4 STATISTICAL ANALYSES

A variety of statistical analyses were used to evaluate the group data; these are described individually in chapter 4. The Sign Test was used most frequently to compare the pairs of experimental and control subjects for each of the tasks.

CHAPTER 4

TEST RESULTS

4.1 OVERVIEW

This chapter presents the test results relevant to the hypotheses in Chapter 2. Overall performance on standardized tests and group comparisons are presented in section 4.2. Results on tasks assessing specfic aspects of core grammar will be presented in section 4.3. Finally, the data regarding inflection will be presented in section 4.4.

JL was the only subject with additional focal damage to the right hemisphere. However, as his patterns of performance are very similar to those of the remaining subjects who did not evidence damage to the right hemisphere, his data are included in the group analyses as well as in sections evaluating the performance of the subjects individually.

4.2 PERFORMANCE ON STANDARDIZED TESTS AND GROUP COMPARISONS

4.2.1. Tests of lexical knowledge

The data on the performance of the FLHD subjects on standardized measures of lexical knowledge are presented in Table 3. There are three measures of lexical performance: PPVT-R (picture-pointing vocabulary comprehension), Word Fluency (from the CELF; requires generating words by semantic category), and the Boston Naming test (confrontation naming). Group numbers (I - III) refer to age of onset (see chapter 3). Finally, age at testing and (for consistency) age scores on tests are represented as year;months, although some of the tests report the scores using a slightly different notation (years-months).

Table 3: Age and grade-level scores on standardized tests of lexical knowledge

Group	Subjects and CA	PPVT-R (form L)	Word Fluency[1]	Boston Naming Test[2]
I	1. WB (7;6 to 7;7)	7;7	Grade 8 (30)	7;5 (30)
I	2. SR (13;2)	7;6	Above Grade 12 (36)	6;5[3] (24)
II	3. MB (5;9 to 5;10)	4;6	Grade 4 (23)	below 5;0 (18)
II	4. NA (6;3 to 6;4)	6;2	Grade 1 (15)	Below 5;0 (24)
III	5. FC (9;9 to 10;2)	5;10[4]	Grade 1 (13)	6;5 (27)
III	6. JL (12;7 to 12;8)	9;10	Grade 8 (30)	7;5 (30)

1 Norms are for expected grade level achievement;grade levels represent the maximum "criteria for grade level" as given in the manual. Raw scores are given inparentheses.

2 Norms are taken from Guilford and Nawojczyk, 1988. Age scores were originally given as ranges; here, ranges were calculated for each age group of one standard deviation above and below the mean. The age score attributed to these subjects is the oldest age level for which the subject's score falls within the +/- one standard deviation range. The lowest age norms were 5;0; thus, some subjects report with "below 5;0". Raw scores are given in parentheses.

3 Testing done by neuropsychologist at age 12;7.

4 Testing done by speech pathologist at age 9;6.

As can be seen, with the exception of WB, all subjects evidence some degree of lexical impairment on at least one measure. All subjects but WB appear to have difficulty with confrontation naming (Boston Naming) even if performance is relatively unimpaired on other lexical measures. The mean delay (in years below expected age level was 2.11 years for the PPVT-R; for the Boston Test the mean delay was 2.83 years (although on both measures there is a great deal of variability). On the Word Fluency measure, however, all subjects but one (FC) performed at or above expected grade levels. Thus, while they had deficits on formal tests which "get harder", the FLHD subjects were able to retrieve appropriate lexical items within a given semantic category.

In addition to deficits in formal test performance at least two subjects (FC and MB) give evidence of word-finding deficits in their spontaneous speech samples. FC typically just "trails off" in utterances, but resumes the utterance if the obviously missing word is supplied.

50) (FC) *He's going to get ready for the ... the...*
(CJ) The what?
(FC) (NR)
(CJ) The fruit, the pizza, what?
(FC) (NR)
(CJ) I think he's getting ready for the pizza, don't you?
(FC) (nods; long pause) *He wants pizza.*

MB uses generic, vague terms, as in the following:

50) (MB) *And then he open the, the bird thingy...*

51) (MB) *And then the big giant, the big giant, one can... uh, uh, uh, the thingy Gargamel?*

Thus, the subjects do demonstrate lexical deficits, although (except for FC) the FLHD subjects showed surprising integrity on the Word Fluency measure. We will return to these findings in Chapter 5, and now consider the performance of the FLHD subjects on the morphosyntactic tests in the normative battery.

4.2.2 Tests of morphosyntactic knowledge

Performance on formal tests of morphosyntactic knowledge is presented in Table 4.

Table 4: Performance on standardized tests of grammatical knowledge (years and months performance delayed in parentheses).

Group	Subjects and CA	CYCLE-R[1]	CYCLE-E[1]
I	1. WB (7;6 to 7;7)	6 1/2 (1)	61/2 (1)
I	2. SR (13;2)	8 (1)[2]	7 (2)
II	3. MB (5;9 to 5;10)	4 1/2 (1)	2 1/2 (3)
II	4. NA (6;3 to 6;4)	5 1/2 (0;6)	5 1/2 (0;6)
III	FC (9;9 to 10;2)	6 (3)	5 (4)
III	JL (12;7 to 12;8)	5 1/2 (3;6)	5 1/2 (3;6)

1Norms are available in half-year increments

2 Note that the ceiling of the test is only at age "9+"; delay scores indicate difference between this ceiling and the age level attained.

All subjects demonstrate a deficit in performance on formal tests in this area, with a tendency for comprehension (mean delay = 1.67) to be either equal to or slightly beter than elicited production (mean delay = 3.08 year). The degree of the deficit varies from subject to subject (for NA the deficit is only 6 months on both the CYCLE-R and CYCLE-E; for JL there is a 3 1/2 year deficit on both measures).

In the next section we will examine some task and group comparisons relevant to the hypotheses of Chapter 2.

4.2.3 Overview of the grammatical data

4.2.3.1: Task comparisons: Recall that the measures used for the collection of the syntactic data included two comprehension measures (the Act-out and the CYCLE-R, the latter being primarily a picture pointing test), two elicited production measures (the elicitation, a sentence generation task, and the CYCLE-E, a sentence completion task) and a metalinguistic (judgement) task.

Table 5 presents the results of the overall performance of both groups by task type.

Table 5: Mean percent correct on experimental tasks

	Controls	FLHD subjects
Enactment	93%	81%
Judgement	90%	49%
Elicitation	98%	91%
CYCLE-R	NG	80%
CYCLE-E	NG	68%

The Sign Test was used to compare individual pairs of experimental subjects and their controls for each of the tasks. Performance was significantly different for the two groups on the enactment and the judgement task ($p < .05$) but not for the elicitation task ($p = .12$). The elicitation task was apparently the "easiest" for both groups. The CYCLE batteries ranked in the middle of the distribution for the FLHD subjects. It should be noted that one FLHD subject rejected two grammatical sentences as being ungrammatical, and would not interpret the referents for this sentence (these data were ommitted from the analysis).

As can be seen from the table, the performance of the FLHD subjects was significantly below that of the controls on all of the tasks, but difference between the groups is most noticeable for the judgement task. A discussion of the type of errors made, and about the role of the judgement data in interpreting the results, is warranted.

First, it appears that performance on the judgement task will be worse than that of other tasks for a specific aspect of the grammar. This is particularly likely to be the case for the FLHD subjects. Thus, some interpretation of these differences will need to be made, as there will be (as we shall see) instances of good performance on at least one comprehension task or production task, but poor performance on the judgement task.

One interpretation is that the judgement task is simply more sensitive, forcing the subjects to consider both grammatical and ungrammatical possibilities for each structure. However, if they do not have knowledge of a given principle, they should simply accept all possible referents as grammatical (all ungrammatical as well as grammatical sentences referents should be accepted), reject all referents, or perform at chance. This is, in fact, not the case. The FLHD subjects in particular are treating the grammatical and the ungrammatical possibilities offered by the probes as being quite different from each other. The data for these two error types (rejecting grammatically possible referents and accepting ungrammatical referents) are summarized in Table 6.

Table 6: Mean percent of errors on the judgement task

	Controls	**FLHD subjects**
Reject grammatical stimuli	**5.00%**	**8.83%**
Accept ungrammatical stimuli	**13.50%**	**45.17%**

Thus, it is not the case that the subjects treat the grammatical and ungrammatical stimuli in a similar fashion. Instead, the subjects much more frequently accept as grammatical those probe possibilities which are grammatical. It is the ungrammatical stimuli which are more difficult to judge appropriately, especially for the FLHD subjects, whose performance approaches chance for these stimuli.

Given their difficulties with the ungrammatical item, the FLHD subjects in particular appear to have a response bias to "just say yes" or say that probes are OK when they are not ($z = 8.76$; $p < .0001$). Thus, given ungrammatical referents, the FLHD subjects will attempt to find an interpretation that may not preferred but will allow them to accept the stimuli.

To further test the hypothesis that the FLHD subjects had a tendency to "just say yes" and comply with the task, 5 adult subjects were asked to interpret ungrammatical sentences of the type used in the judgement task for reflexives. They were told that they had to act-out the sentences, even if they seemed strange or if they were unsure. All subjects were (with some complaining) nevertheless able to find an interpretation for the ungrammatical sentences. Thus, it is possible that the FLHD subjects (and the controls) accepted ungrammatical referents in order to comply with the examiner (because they felt they, like the adults, had to do the task.

There is additional evidence that the judgement task is problematic for the FLHD subjects for non-structural reasons. Three of the FLHD subjects (WB, SR and JL) made an error suggestive of processing difficulties rather than an incorrect structural analysis. They interpreted the pronoun in 54) as corefent with the subject:

54) $Gumby_i$ tells him_i that the robot will jump over the fense.

Thus, they allowed an interpretation where Gumby tells himself something, a somewhat unlikely intepretation (e.g. all other items had the subject of a *tell* sentence telling something to someone else). This error is more easily explained if the subjects have some inherent difficult with the task (e.g. keeping the sentence in memory, comprehending the passive, etc.)

The tendency to "just say yes" in order to comply with the perceived demands of the task, when coupled with possible deficits in other domains (e.g. short term memory), make the judgement data somewhat suspect in terms of what they reveal about the underlying knowledge of the FLHD subjects. The general assumption here is generally to accept good performance (e.g. 90% correct or better) on a given task as evidence of intact, adult grammatical knowledge of a given principle (and perhaps, evidence of maturity in dealing with nonlinguistic task demands). Thus, the judgement data will largely play a supplemental role in the discussions that follow; if the subject is able to perform well on the judgement data, then this consistutes additional evidence that they have access to this principle of grammar. However, given the patterns of performance discussed above, if the judgement performance is poor due to over-acceptance of ungrammatical referents, but performance on another task is good, the subjects will be assumed to have performed poorly on the judgement data for other, nongrammatical, reasons.

Some final methodological notes concerning the length of the sentence stimuli and the picture choice arrays on the CYCLE-R are warranted. First, an analysis of the effect of sentence length was done for the enactment and the judgement tasks to ensure that it was not the case that longer sentences were more problematic. No significant difference was found ($p > .05$) on the judgement task, and for the enactment task longer sentences were in fact easier ($p = .0031$). This may reflect the fact that most of the shorter sentences contained pronouns and anaphors, which were the aspect of the grammar found to be the most problematic for the FLHD subjects.

Second, the picture arrays of the CYCLE-R vary in format from 2 - 4 pictures, depending on the subtest. Of some concern was the possibility that the number of picture choices in the array might have affected performance in some consistent way. A Sign Test was performed to rule out this possibility. With the scores corrected for chance, significant differences were not found between arrays (p values ranged from .1094 to .3438 on the various comparisons).

4.2.3.2: Group comparisons: While a primary focus of this research is on the individual patterns of performance by each of the subjects, some group comparisons are also presented here. The performance of the FLHD subjects was compared to that of the controls for each of the specific core syntactic property is studied as well as for inflection. Paired t-tests were used for the comparison. Note that the CYCLE data are not included here as they were not given to the normal control subjects; the data to verbal complements is also excluded, in that these are derived exclusively from spontaneous speech. Table 7 presents these results.

Table 7: Group performance and comparisons for specific aspects of grammar

Aspect of grammar	Assessment procedure		
	Act-out	Judgement	Elicitation
Recursion in NP: relative clauses			*
Binding A		*	
Binding B	**		
Binding C			
Control		*	
NP movement/ the passive			

* significant at $p < .05$ two tailed
** significant at $p < .01$ two tailed

As can be seen from the table, the FLHD subjects do differ from the controls on some measures (with the differences always being that the controls performed better than the FLHD subjects, but do not do so consistently for a given aspect of grammar, nor on a particular type of task. It is interesting that on formal tests of grammatical knowledge, where the index is a gross measure of overall performance level, all subjects show at least a slight delay in performance expected for their age; however, on the experimental battery (the tests used here to assess specific aspects of syntactic knowledge) no consistent deficit is seen. Groups comparisons, then do not consistently support Hypothesis 1a; (that core syntactic knowledge will be intact following FLHD); however, group comparisons do not address the question of the structure of each individual subject's grammar. This will be the goal of section 4.3.

Two additional analyses were performed on the group data to examine the effects of age at onset.

4.2.3.3 Effect of age of onset: To test Hypothesis 2 which concerned the effect of age at onset of neurological damage, a Kruskal-Wallis test was performed comparing groups I, II and III on formal test scores, scores from the tests in the morphosyntactic battery with regard to knowledge of core aspects of syntax, and on scores with regard to the spontaneous speech measures of inflection. No significant differences between the age groups were seen. These measures should be interpreted with some caution, however, given the small number of subjects in the study. Thus, it cannot be ruled out that the lack of significance is due to an "N" of two per group. In particular, Group III subjects did perform the worst on the CYCLE.

An additional analysis was run to ensure that age at time of testing was not a significant factor in group performance comparisons. Given that this study included children of varying ages, it is important to establish that age at the time of testing was not a factor by which performance could be characterized (e.g. it was important to rule out the possibility that either the youngest or the oldest children did the worst in order to address questions concerning the effects of the age at onset of symptoms). In order to rule out a possible effect of age (CA) at testing as a variable in the results, a regression analysis was done for each measure (e.g. Control-act out, Control-judgement, Control-elicitation, etc.). No relationship between CA and any linguistic score was found ($p > .01$ for all measures). Thus, linguistic performance could not be predicted on the basis of CA, and it was not the case that the youngest subjects did the worst. The implications of these findings will be discussed in Chapter 5.

4.3 CORE PRINCIPLES OF SYNTAX

In this section individual subject data relevant to Hypothesis 1a will be presented; namely, data from tasks designed to evaluate their knowledge of core principles of grammar. The principles of interest are: recursion (in NP and VP), the Binding principles, interpretation of PRO and control, and NP movement (in passives).

A few points should be noted about the representation of the data in the sections that follow. The data are generally presented in terms of percentages of correct responses, with the total number of items per task given at the top of each column. One exception to this is the judgement/probe task, where responses are usually given as "+" or "-" (since there is often only one item of this type used). The control subjects were not given the CYCLE; thus, this column will be blank for them. Finally (as will be noted where relevant) the controls sometimes demonstrated 100% correct performance on a task; in this case, their scores are not presented individually in the table.

4.3.1 Recursion

4.3.1.1 Recursion in NP: relative clauses: There are three types of relative clauses used in the tasks investigating knowledge of recursion in NP:

52a) (SS type) The horse that dances jumps over the cage.

b) (OS type) The bear hits the elephant that knocks over the fence.

c) (00 type) The deer bumps the horse that the robot tickles.

Recall that before age 5 comprehension of OS and OO relatives may be incorrect, with the matrix subject being interpreted as coreferential with the embedded subject in some types of stimuli, and that active vs. stative verbs as well as the number of full lexical NP's in the sentence have been found to affect processing in normal children (Goodluck and Tavakolian, 1982); see Appendix B and C for a list of all stimuli types relevant to this and the following sections). The data will be presented for all OS, OO and SS sentences in the following tables; we will return to the issue of the number of NP's in the discussion of the error types.

Table 8 presents the comprehension data on relative clauses (in terms of accuracy and types of errors encountered). Note that the control subjects performed with 100% accuracy on the comprehension and judgement tasks; the tables include only the FLHD subjects. Note that the object relative clause stimuli on the enactment varied in the number of lexically full NP's they contained to address the reported effect (this point will be returned to in the discussion of the error types found).

Table 8: Comprehension and judgement data on relative clauses

	Enactment			CYCLE-R		
(type)	SS	OS	OO	SS	OS	OO
(# items)	(6)	(12)	(3)	(5)	(5)	(5)
1. WB (7;6 to 7;7)	100%	100%	100%	100%	60%	20%
2. SR (13;2)	100%	100%	100%	100%	NG	100%
3. MB (5;9 to 5;10)	100%	75%	67%	100%	NG	NG
4. NA (6;3)	100%	100%	100%	100%	NG	NG
5. FC (9;9 to 10;2)	100%	92%	100%	100%	100%	0%
6. JL (12;7 to 12;8)	100%	92%	67%	100%	100%	60%

NG = not given due to age when expected to comprehend

Looking at the table above, it is clear that the children were able to interpret SS relatives; however, as Tavakolian (1981) noted, an SS relative can be analyzed as conjoined clauses as opposed to an embedded structure, with the child appearing to have comprehended correctly (e.g. 52a) could be interpreted as *the horse dances and (the horse) jumps over the cage*). Thus, the comprehension data from the S-relatives is not sufficient to determine the status of recursive structures. The data from the O-relatives are needed to more clearly evaluate the comprehension of relatives, and here the performance is less consistent.

Five of the subjects were able to interpret OS relatives correctly with some consistency on at least one comprehension task. FC and JL each made only a single error out of 12 OS item; neither error was interpretable as a consistently different sturctural analysis, as is evident by the responses below:

53) (FC) The bear hits the elephant that knocks over the tree (enacted as *the bear hits the elephant and elephant and bear hit tree*).

54) (JL) Gumby tickles the girl that bumps into the fence (enacted as *the girl tickles Gumby; the girl bumps into the fence*).

Example 53) is ambiguous in terms of the analysis of the relative clause (e.g., it could be that the subject was appropriately interpreted as being coreferent with the object of the matrix clause, but that FC just brought the character "along for the ride" [used both characters as the subject NP]). In JL's error in 54) appears to be a problem with short-term memory or attention, in that the order of mention of the first two NP's is reversed (JL "misheard" the location of the null element).

Thus, only MB appears to have impaired performance on OS relatives which is not attributable to non-structural factors. However, while three out of the twelve OS sentences were interpreted as having the matrix subject as the embedded subject, these errors were on sentences with three lexically full NP's. Given that even four- and five-year-old non-impaired children perform better with two versus three full lexically full NP's in a stimulus sentence (Hamburger and Crain, 1984), it is argued here that MB's grammar has OS relative clauses (cf. the 75% correct performance on the enactment overall, and the 100% correct performance on stimuli with only two lexically full NP's). His performance is less than perfect on these other stimuli due to extralinguistic factors relating to task demands.

With regard to OO relatives, three subjects (WB, NA and SR) made no errors on the tasks across the board. FC had 100% accuracy on this structure on the enactment task, but 0% correct on the CYCLE-R. Thus, he must be attributed with knowledge of the grammar of this structure or we have no explanation of his 100% accuracy on the enactment task. The remaining two subjects (MB and JL) do not demonstrate consistently correct performance on any comprehension task. However, as we shall see, JL produces OO relative clauses; thus, he must have relatives in his grammar, and his impaired comprehension performance with regard to OO relative clauses must also be attributed to extralinguistic factors. Thus, only MB's performance suggests a possible deficit in this area.

The production data concerning relative clauses are summarized in Table 9. In order to examine all possible data with regard to recursion in NP, the speech data also includes relativized NP's where the NP is not the subject or the object of a clause, as in 55):

55) (CAJ) And who is that, on the phone? Someone...

(FC) *Someone who needs a pizza.*

and "headless relatives", the precursors to true relative clauses produced earlier in development by normal children, as in 56):

56) (SR) *That is what I said.*

Table 9: Production data on relative clauses

Subject	Elicitation		CYCLE-E		Spontaneous speech			
(type)	OS	OO	OS	OO	rel NP	headless rels	OS	OO
(# items)	(3)	(3)	(2)	(2)				
FLHD:								
1. WB (7;6 to 7;9)	100%	33%	100%	100%				+
2. SR (13;2)	100%	0%	50%	100%		+		+
3. MB (5;9)	0%	0%	NG	NG				
4. NA (6;3)	100%	100%	0%	100%			+	+
5. FC (9;9 to 10;2)	67%	0%	0%	100%	+	-		
6. JL (12;7 to 12;8)	100%	0%	100%	0%	+		+	+

Controls:								
1. SF (7;9)	100%	100%					+	
2. KY (13;2)	100%	100%				+	+	+
3. SS (5;9)	100%	100%						
4. SM (6;3)	100%	+*			+			
5. JP (10:0)	100%	100%					+	
6. CL (12;5)	100%	100%					+	+

Key:
+ = produced a well-formed example
- = produced ill-formed example
NG = not given due to age
* = one response was off-target

As noted in Table 9, all FLHD subjects but MB produced some relative clauses in their spontaneous speech samples, and, specifically, produced object relatives on at least one elicitation task. Some of these were "headless" relatives of the type produced by normal children early in development, as in 56) above, or NP's with an accompanying relative clauses, as in 55) above. However, there were also full relatives, with most/all of the data from the speech samples being object relatives, as might be expected from the normative literature. e.g. OS rels:

57) (NA) *He's the one that lives by the church.*

And OO rels:

58) (NA) *Paces are things you work on.*

59) (LB) *Look at all the money they have there.*

These appear to be comparable to some of the constructions produced by the controls, such as:

60) (CL) *It's like a race car he's gonna put on a track.*

However, while the subjects did produce a variety of well-formed relativized structures, many of the subjects produced errors on the production tasks. These errors are characterized as follows:

a) word strings, as in:

61) (MB) Target: The horse that the camel is tickling --> *"The horse... the tickling the horse.*

b) frame violations, where the subject rejected the frame of an elicited production item and began a different clause:

62) (FC) Target: (Pick up) the bear that the girl is tickling --> *"Pick up the bear that is... the girl tickles the bear.*

c) presence of a resumptive pronoun, where the embedded sentence contained movement without deletion (an option legal in some languages):

63) (WB) It's the horse that the camel is tickling him.

d) failure to relativize, e.g.:

64) (FC) Cue: This is the boy...

Response: *"he washed his face"*

65) (FC) It's, it's a lady he helps Alice.

Although not in any of the samples of the normal controls here, this last type of error has been attested in the spontaneous speech of normal children (e.g. examples in Curtiss and Jackson, to appear). It should be noted that this was the only error found in the spontaneous speech data (from only one subject, FC, who also did produce a relativized NP in one other instance).

Table 10 below lists the distribution of these error types across the subjects.

Table 10: Distribution of error types on the relative clause production data

Subject	Error types: Word strings	Frame violations	Resumptive pronoun	Failure to relativize
1. WB		+	+	
2. SR		+	+	
3. MB		+		
4. NA	+			
5. FC		+		+
6. JL		+	+	

Table 10 shows that, while 5/6 of the FLHD subjects could produce relativized structures, they differed from the controls in that they produced ill-formed structures or avoided production of the particular target structure. Their errors were primarily on the elicited data; FC is the exception to this, as he failed to relativize one of his two relative constructions in spontaneous speech, as in example 65 above).

For the other subjects, elicited production tasks led the subjects to produce word strings (NA), constructions with resumptive pronouns (three subjects) or frame violations (5 subjects). However, 5 of the 6 FLHD subjects produced at least one well-formed relative in spontaneous speech, indicating that perhaps task demands on the elicitation tasks were such that the FLHD subjects were unable to formulate correct responses.

To summarize, when performance-related factors are factored out, five subjects were able to demonstrate performance suggesting they had subject and object relatives in their grammars. One subject (MB) did not produce any relatives; likewise, he did not demonstrate consistent comprehension performance with regard to OO relatives. Thus, he may be in the process of acquiring true relatives, but has not yet demonstrated adult-like competence in this area.

It should be noted that the FLHD subjects did differ from the controls in their variability across tasks, and were apparently affected by various performance factors in ways which did not affect the performance of the controls.

4.3.1.2 Recursion in VP: verbal complements: A fuller discussion of infinitival complements will be included in the discussion of PRO and control (section 4.3.3) and in the section on binding (section 4.3.2). A brief discussion will appear here concerning verbal complements in general by looking at infinitival as well as two types of non-infinitival complements: tensed (finite) complements and the complements of perception verbs (small clauses). In the previous section, we found that all of the subjects were able to comprehend/interpret structures with an IP or S embedded in NP (relative clauses); all subjects were but one were also able to produce relative clauses. However, verbal complements also constitute recursive structures, with the complement being either a tensed or infinitival S'.

Infinitival complements contain a phonologically null subject (discussed in Chapter 2), as in:

66) I [told you [PRO to go]].
VP IP

Tensed complements simply have the second IP embedded in the matrix VP:

67) I [told you [that you should go]]
VP IP

Following Stowell (1981), complements of perception and causative verbs are typically analyzed as "small clauses", nonsentential in that they lack INFL, but still containing an NP and VP sequence, as in:

68) You [made [[me] [do it]].
VP NP VP

The data with regard to verbal complements may be particularly helpful in a discussion of recursion in that while infinitival complements contain PRO as the subject of the embedded clause, tensed complements and small clauses have no relative pronouns nor phonologically null elements. Thus, the data on these types of constructions will be helpful in providing additional evidence as to the extent to which the grammars of the FLHD subjects allow for embedded S's and thus recursion without some of the complicating factors encountered in the relative clause data.[1]

The types of verbal complements found in the spontaneous speech of the subjects are listed below in Table 11. The following types of complements were examined:

a) tensed that-complements (with or without complementizer; *I think (that) he goes to my school.*

b) indirect discourse (*I said "you are it"; he goes "you're kidding"*

---

1 The original focus of the section of recursion was exclusively on relative clauses. However, after examining the spontaneous speech data, it because apparent that the corpora contained a wide variety of verbal complements, and thus additional and quite rich source of data with regard to the subject of recursion. Thus, for this section, there is only the spontaneous speech data and not the range of tasks used for the other construction types seen in this chapter.

c) small clauses (complements of perception and causative verbs; *I made it go; I see him go*)

d) wh-complements (also examined in the previous section as "headless relatives"; *I want what you have*)

e) infinitival complements (*I asked him to come here*)

Table 11: Verbal complements and small clauses found in spontaneous speech samples

	Type of complement				
	That comp	discourse	small clause	wh-comp	infin
Subjects:					
FLHD:					
1. WB (7;6 to 7;9)	+	+	+	+	
2. SR (13;2)	+	+		+	
3. MB (5;9 to 5;10)	+		+		
4. NA (6;3)	+		+		
5. FC (9;9 to 10;2)			+		+
6. JL (12;7 to 12;8)		+			+
Controls:					
1. SF (7;9)	+		+		
2. KY (13;2)		+	+		
3. SS (5;9)	+	+			+
4. SM (6;3)	+	+		+	+
5. JP (10;0)	+	+		+	+
6. CL (12;5)	+	+			

As can be seen above, all subjects used at least two types of complements examined here, and, importantly, no ill-formed complements were found. Appropriate complementizers were used and complements were appropriate to the conversation at hand.

The following are some examples of the relevant structures, with one from both a FLHD (a) example) and a Control subject (b) example.

69) tensed that-complements (with or without overt complementizer):

a) (NA) *I think its coming in.*

b) (SF) *I think she's laughing.*

70) discourse

a) (JL) *He'll yell "My mommy's gonna come."*

b) (SS) *She said "Cut it out".*

71) small clauses

a) (WB) *Don't let it hit our car.*

b) (KY) *...and they don't really let you do anything.*

72) wh-complements

a) (SR) *That is what I might think about.*

b) (SM) *That is why I always go out.*

73) infinitival complements

a) (FC) *The man's telling him to get over the gate.*

b) (JP) *They showed them how to do stuff.*

To summarize, we now have evidence from both relative clauses and verbal complements that the FLHD have recursion in both NP and VP. The question of how they deal with the empty element PRO will be returned to in section 4.3.3, but we have some "preview" evidence that at least two FLHD subjects can generate infinitival as well as finite complements. Thus, the grammars of the FLHD subjects allow for the generation of rich, complex utterances outside of the domain of the single clause.

4.3.2 Binding of overt NP's

We will now consider the data individually for each binding principle.

4.3.2.1 Principle A: Binding Principle A delineates the domain in which a reflexive must have a coreferent antecedent. Recall that young children show improving performance on tasks assessing knowledge of Principle A from ages 2 to four years (Wexler and Chien, 1985; Jacubowicz, 1985; McDaniel et al., 1989; Solan, 1987). McDaniel et al. note that at least some children apparently go through a stage where reflexives are allowed to be subjects of sentences before arriving at the adult grammar. Hyams (1989) has suggested that children do know the binding theory, but do not know the domain in which binding takes place. In any case, children are able to demonstrate adult-like knowledge of Principle A by somewhere between the ages of 5 to 7 years.

For this aspect of grammar, both the act-out and judgement/probe tasks evaluate whether the child "knows" that reflexives are locally bound. Elicited production tasks (CYCLE-E and elicitation) essentially probe the reverse situation; namely, that in a situation where a reflexive is called for, does the child demonstrate knowledge of the appropriate domain for binding the anaphor, and is the child able to produce the appropriate lexical items. The judgement task also includes ungrammatical sentences, allowing further probing of the conditions under which anaphors are in acceptable structural relationships in the child's grammar.

The performance of the subjects on tasks assessing knowledge of Principle A is presented in Tables 12 - 14. The comprehension errors were simple violations of A (reflexives were not bound locally). The judgement data allowed for two types of errors (presented in Table 13): non-local binding of reflexive, and allowing a reflexive to be the subject of the sentence.

Table 12: Performance on comprehension tests: Binding Principle A

	Enactment* Simple S	Enactment* Infinitive	CYCLE-R Simple S
Subjects:			
1. WB (7;6 to 7;9)	100%	100%	100%
2. SR (13;2)	100%	100%	100%
3. MB (5;9 to 5;10)	100%	100%	100%
4. NA (6;3)	100%	100%	100%
5. FC (9;9 to 10;2)	67%	33%	100%
6. JL (12;7 to 12;8)	100%	100%	100%

*All controls achieved 100% on this task

On the comprehension tasks, all subjects but one (FC) correctly interpreted reflexives as having local coreferents. FC was inconsistent in his performance, sometimes binding anaphors to nonlocal antecedents.

Table 13: Performance on judgement task: Binding Principle A

Subjects:	Judgement score (%)	Error non-local binding OK	OK as subject of S
FLHD:			
1. WB (7;6 to 7;9)	100%		
2. SR (13;2)	80%	+	
3. MB (5;9 to 5;10)	20%	+	+
4. NA (6;3)	60%	+	+
5. FC (9;9 tp 10;2)	40%	+	+
6. JL (12;7 to 12;8)	100%		
Controls:			
1. SF (7;9)	100%		
2. KY (13;2)	100%		
3. SS (5;9)	60%	+	
4. SM (6;3)	80%		+
5. JP (10;0)	100%		
6. CL (12;5)	100%		

On the judgement task, three subjects (WB, JL and NA) performed similarly to their controls; JL and WB made no errors, and NA, one of the youngest subjects, made errors typical for his age. MB, SR and FC all performed much worse than their controls. SR and FC made all their errors on the the ungrammatical sentence stimuli. This is important for SR, who performed correctly on the comprehension task but made an error here (although he also judged 4/5 sentences correctly). MB does perform worse than his control; however, in the literature it has been noted that some children do not master the reflexive until age 6 (e.g. McDaniels et al., 1989). Thus, it can not be ruled out that MB is performing worse than his control but is nevertheless at the lower end of the normal curve. However, FC is clearly performing well below levels expected for a 9 year old; also, performance on the judgement and comprehension task are consistent with each other, suggesting he does not yet consistently obey Principle A.

Table 14 summarizes the production data. The production errrors were use of pronouns instead of an obligatory reflexive (e.g. *He_i washed him_i"). Note that all the controls performed with 100% accuracy on the elicitation task.

Table 14: Performance on production tasks: Binding Principle A

Subject	Elicitation (6)	CYCLE-E (2)	Spontaneous speech
FLHD:			
1. WB (7;6 to 7;9)	100%	100%	
2. SR (13;2)	100%1	50%1	
3. MB (5;9 to 5;10)	100%	---2	
4. NA (6;3)	100%	100%	
5. FC (9;9 to 10;2)	100%1	100%1	+
6. JL (12;7 to 12;8)	100%		

Note:
1 Credit given for "hisself"
2 Not given due to age norms

As can be seen, all subjects produced the correct forms, with the exception of SR, who on the CYCLE-E produced the following (note there are only two relevant items on this task):

74) Cue: Here the mother is dressing the baby, but here she is dressing...(TARGET: *herself*)

SR: *her.*

In spontaneous speech, only one FLHD subject had an example of reflexive (although MB produced an emphatic reflexive in a by-phrase). The example from FC is:

75) *Cartoon [the cat] licks hisself, too.*

None of the controls produced any examples of true reflexives in spontaneous speech (although KY produced a single emphatic reflexive).

In summary, two subjects (WB and JL) clearly demonstrate knowledge of Principle A. NA's performance on the judgement task is similar to that of his control; elsewhere he performs well, and thus must be considered to have age-appropriate performance, if not complete mastery of Principle A.

Three subjects demonstrate uneven performance, and require further evaluation. The first is FC, who made errors in both comprehension and in the judgement task, although he produced reflexives on both tasks. It appears that, whil he has reflexives in his lexicon, and can retrieve them in sentences where a "to self" meaning is needed, he has either not yet learned which lexical items are anaphors (and thsu Principle A does not apply), or he simply has not yet acquired Principle A. This point will be returned to in the next section, but, in either case, FC is clearly delayed in this aspect of the grammar.

SR made a single error on the judgement task (allowing a reflexive as a subject), scoring 80% correct, and his error could reflect the response bias mentioned earlier with regard to this task (a tendency to accept ungrammatical sentences as grammatical). However, he also produced a pronoun in place of a reflexive in one response, suggesting that he, like FC, may not yet know which items are pronouns and which are anaphors. Finally, MB made more errors than his control on the judgement task (getting only 20% correct, as compared to 60% correct by his control SS). However, MB did not make errors on the other tasks; thus, it is assumed here that his knowledge of Principle A is appropriate for his age.

4.3.2.2 Principle B: Recall that the literature has suggested a relatively late acquisition of binding principle B, with 6 to 7 year olds allowing local c-commanding antecedents for pronouns. Thus, given the norms, we might expect relevant data on the question of knowledge of binding principles from only SR and JL, the two oldest FLHD subjects, as well as the oldest control subjects.

The comprehension data are presented in Table 15 below. In interpreting the data for Principle B, the FLHD subjects made two types of errors on the comprehension task which were not considered to reflect their knowledge of B per se. First is the "child as agent" response of WB (which, according to Hamburger and Crain, 1984, is a response made by normal young children):

76) The robot is washing him --> *WB picks up robot; WB washes robot.*

The second type of non-binding error made by the FLHD subjects was the "control" error (see section 4.3.4 on PRO/control for more information on the subjects knowledge of control facts). In these errors, the FLHD subjects demonstrated flawed performance because of misinterpretation of the control facts of verbs in infinitival sentences, as in this example from NA:

77) Gumby tells Pokey PRO to pat him --> *Gumby whispers to Pokey, Gumby pats Pokey.*

In either case, the "control" error does not represent a violation of Principle B.[2]

Because of the frequency of these errors which are not relevant to Principle B, in Table 15, the data from the enactment are presented with these responses excluded as "errors" in the final column. A "+" indicates that a particular type of error was made. The CYCLE-R tests pronoun knowledge with foils for number, gender and case; however, it does not test the domain for binding for pronouns and thus is not included here).

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[2] Note that in the example, if the child's knowledge of control leads him to interpret the verb as having subject control for tell, he is, in fact obeying Principle B in this example.

Table 15: Performance on comprehension tests: Binding Principle B.

(# items)	Enactment* (6)	Error types: local binding (T1)	control error (T2)	child as agent (T3)	% correct - errors T2 and T3
1. WB (7;6 to 7;9)	67%	+		+	80%
2. SR (13;2)	67%	+	+		80%
3. MB (5;9 to 5;10)	0%	+	+		17%
4. NA (6;3)	33%	+	+		50%
5. FC (9;9 to 10;2)	50%	+	+		60%
6. JL (12;7 to 12;8)	100%				

*Note that all controls achieved 100% on this task

The FLHD subjects as a group evidence poorer performance in comprehension; however, many of their errors are not related to violations of principle A per se. When other, non-binding violations are factored out, only MB, NA and FC demonstrate substantially poorer performance than their controls (less than 80% correct). However, with regard to MB and NA, it has been noted elsewhere in the literature that 5- and 6-year olds might be expected to make errors with regard to this aspect of the grammar; thus, MB and NA may have controls at the upper end of the normal distribution. Thus, for the moment we will leave open the question of their knowledge of Principle B.

In Table 16 the data on the judgement task are presented. All errors on this task were violations of Principle B.

Table 16: Performance on judgement task: Binding Principle B

(# items)	Score (2)
FLHD:	
1. WB (7;6 to 7;9)	+
2. SR (13;2)	-
3. MB (5;9 to 5;10)	-
4. NA (6;3)	-
5. FC (9;9 to 10;2)	-
6. JL (12;7 to 12;8)	-
Controls:	
1. SF (7;9)	+
2. KY (13;2)	+
3. SS (5;9)	+
4. SM (6;3)	+/-
5. JP (10;0)	+
6. CL (12;5)	+

On this task, 5/6 of the FLHD subjects perform more poorly than their controls. However, given the poor performance of the control subject SM, the performance of MB and NA (and their apparent lack of obedience of Principle B) may not be all that surprising for their age.

The production data are presented in Table 17. The error types are described as follows:

a) violations of B (producing a reflexive instead of a pronoun in a nonlocally bound environment, e.g. *Gumby tells Pokey to pat himself* meaning *Gumby tells Pokey* *to pat him* . This response is unattested in the normal population, although it has been found in comprehension (Chien and Wexler, 1987).

b) errors on case (e.g. producing *her/she*)

c) producing a name where a pronoun is called for (e.g. *Cookie Monster is washing Cookie Monster*).

Note that all subjects produced pronouns in their spontaneous speech samples, with the only error observed being those like b), case errors.

Table 17: Performance on production tasks: Binding Principle B

(# items)	elicitation (6)	Error type*	CYCLE-E (2)	Error type*	Spontaneous Speech
Subjects:					
FLHD					
1. WB (7;6 to 7;9)	100%		100%		+
2. SR (13;2)	100%		NG		+
3. MB (5;9 to 5;10)	100%		50%	case	+
4. NA (6;3)	67%	B	NG		+
5. FC (9;9 to 10;2)	0%	B,name	100%		+
6. JL (12;7)	50%	B	100%		+
Control data:					
1. SF (7;9)	100%				+
2. KY (13;2)	100%				+
3. SS (5;9)	100%				+
4. SM (6;3)	100%				+
5. JP (10;0)	100%				+
6. CL (12;5)	100%				+

*Key: Name = produces full names (violation of principle C)
B = violates B (allows local binding)
Case = produces a pronoun but of wrong case

In production, 3/6 FLHD subjects allowed violations of B on the elicitation task, although all used pronouns correctly in spontaneous speech, and only one error was made on the CYCLE-E (a case error of *her/she* made by the youngest child). The CYCLE-E may have elicited more correct responses by the nature of the contrast used in the cue (where the reflexive is used and stressed, as in:

78) Cue: Here the father is shaving **himself**, but here...

To summarize performance with regard to Principle B, we will first consider the controls. One of the controls (SM) made an error on the judgement task; all other performance was correct. Thus, it is either the case that normal children as old as six might not have mastered Principle B on this task, or that even the controls have the response bias noted earlier.

For the FLHD subjects, WB appears to have knowledge of Principle B as demonstrated by his performance on all tasks. SR makes errors on only the judgement task; however, this may simply reflect the earlier described response bias, and thus the evidence largely supports the hypothesis that he does know Principle B. However, MB, NA, FC and JL all have errors on the judgement task and at least one other task, indicating that they do not appear either to a) have knowledge of which items are anaphors and which are pronominal, or b) have Principle B. Given FC's apparent ability to interchange prnouns and anaphors, even on a production tak, this might suggest that, at least for him, he has not yet learned which lexical items are prnouns and which are anaphors.

4.3.2.3 Principle C: To review, recall that the literature reports that by age 5 - 6 most children have "outgrown" responses which violate Binding Principle C (and thus no longer allow illegal backwards coreference in constructions like 78 a) and b) below:

79) a) He washed Gumby.

b) Gumby tells him that the robot will jump over the fence.

However, according to McDaniels et al. even some adults find sentences like 79) b) above "tricky". Thus, we will examine the data separately for the two types of constructions above.

Because only two tasks presented relevant items for Principle C (comprehension task and the judgement task), the data are presented together in Table 18. Again, several error types were noted. First were the processing errors as described earlier, where the wrong referents for the NP's were selected or the order of the NP's was incorrect. Second were sentences on the judgement task which were interpreted as follows:

80) Gumby tells him that the robot will jump over the fence.

Probe: Who got told something?

(NA): *Gumby.*

Thus, the above response cannot be interpreted with relevance to Principle B; it is either a violation of B or simply another example of a processing error as noted above. Again, as in many previous points, we see that the current state of the art in terms of knowledge of processing constraints and extralinguistic factors calls for caution in interpreting teasing apart error types and analyzing performance, particularly in a brain-damaged population.

The final type of error was violation of Principle C itself.

Note that the judgement data are represented only as "+" or "-" as there was only one relevant item per column, while the act-out data is represented by percent correct responses.

Table 18: Comprehension data for Binding Principle C

	Knows C in simple clause		Error type	Knows C in embedded S		Error
	Enact.	Judge/ Probe		Enact.	Judge/ Probe	
(# items)	(3)	(1)		(3)	(1)	
FLHD:						
1. WB (7;6 to 7;9)	100%	+		67%	-	P,B
2. SR (13;2)	67%	-	C	67%	-	C
3. MB (5;9 to 5;10)	100%	-	C	0%	-	C,B
4. NA (6;3)	100%	-	C	0%	-	C
5. FC (9;9 to 10;2)	100%	+		67%	+	C
6. JL (12;7 to 12;8)	100%	+		33%	-	C,P,B

Subjects:						
1. SF (7;9)	100%	+		67%	+	C
2. KY (13;2)	100%	+		100%	+	
3. SS (5;9)	100%	+		67%	-	C
4. SM (6;3)	100%	+		67%	-	C
5. JP (10;0)	100%	+		0%	-	C
6. CL (12;5)	100%	+		67%	-	C

+ = passed all relevant items
- = failed all items
(B) = made error violating principle B
(P) = made processing error (mixing up order of NP's and or VP's/adjectives
(C) = made "C" type error as discussed above

The controls appeared to know C in simple clauses on both act-out and judgement tasks. However, 5/6 controls had difficulty with either the comprehension or judgement of the embedded S-type stimuli; thus, it appears that, as noted in previous studies, normal children have difficulty with these sentence types, and thus these will not be included in the evaluation of the FLHD subjects.

Three subjects (SR, MB, NA) had difficulty with the judgement task; SR also made an error on the enactment task. Thus, while we cannot rule out the possibility that MB and NA are influenced by their response bias (and/or are just slightly late in maturing in this area), SR s clearly not performing at expected levels for his age with regard to Principle C.

Spontaneous speech samples contained no examples of violations of Principle C.

4.3.4 Control and Interpretation of PRO

4.3.4.1 PRO in VP complements: First we will examine the data relevant to interpretation of PRO in VP complements, where the verb specifies in the lexicon whether it requires object control of PRO or subject control of PRO. As noted earlier, the literature has consistently indicated that children first interpret sentences with *ask*, *tell* and *promise* as having object control of PRO, only allowing subject control in the case of promise later in development (at age 7 or 8 years).

Table 19 presents the individual profiles of the subjects on the control items for PRO in complements. Note that the judgement data is presented only as "+" or "-" due to single response required for this task. The actout data is represented as percent correct responses.

Table 19: Interpretation of PRO in VP complements on the actout and judgement tasks

	Enactment		Judgement	
	tell	promise	tell	promise
(# items)	(3)	(3)	(1)	(1)
FLHD:				
1. WB (7;6 to 7;9)	100%	100%	-	-
2. SR (13;2)	100%	0%	+	-
3. MB (5;9 to 5;10)	100%	0%	-	-
4. NA (6;3)	100%	0%	-	-
5. FC (9;9 to 10;2)	100%	33%	+	+
6. JL (12;7 to 12;8)	100%	0%	-	-
Controls:				
1. SF (7;9)	100%	100%	+	+
2. KY (13;2)	100%	100%	+	+
3. SS (5;9)	100%	0%	+	+
4. SM (6;3)	100%	100%	+	+
5. JP (10;0)	100%	100%	+	+
6. CL (12;5)	100%	100%	+	+

Table 20 presents the production data for PRO in complements. Note that two subjects made errors in formulating sentences with *tell* which do not reflect knowledge of subject/object control in obligatory verbal complements:

81) (SR) *The camel... tells for her to go in.*

82) (MB) *The lion's telling, the bear, is jumping, jump over the fence.*

MB has a problem formulating the sentence either attributable to general formulation difficulty or has difficulty producing an untensed complement (probably not the case as he did produce two examples of *tell*-type infinitives). Note that the percentage correct for these subjects includes these errors.

Table 20: Production data on PRO in complements ("tell" vs."promise")

(# items)	Elitation (tell) (3)	CYCLE-E tell (2)	CYCLE-E promise (2)	Spontaneous Speech tell	Spontaneous Speech Catenatives
1. WB (7;6 to 7;9)	100%	NG	NG		+
2. SR (13;2)	67%	NG	NG		+
3. MB (5;9 to 5;10)	67%	NG	NG		+
4. NA (6;3)	100%	NG	NG		+
5. FC (9;9 to 10;2)	100%	100%	0%	+	+
6. JL (12;7 to 12;8)	100%	100%	100%	+	+
——					
1. SF (7;9)	100%				+
2. KY (13;2)	100%				+
3. SS (5;9)	100%				+
4. SM (6;3)	100%				+
5. JP (10;0)	100%				+
6. CL (12;5)	100%				+

Note:
NG = not given due to age or ceiling on performance
+ = well-formed example in spontaneous speech sample

For PRO in VP complements the data indicate that the youngest pair of subjects (MB and control SS, 5;10 and 5;9 respectively) appear to lack knowledge about obligatory subject controlled verbs. Thus, MB's performance is within normal limits. However, four other subjects have difficulty with tasks assessing knowledge of *promise* (SR, NA, FC and JL). These subjects can be seen to be delayed with respect to this aspect of the grammar.

Further, the performance on the judgement task by four subjects (WB, MB, NA and JL) reveals a pattern not attested elsewhere in the literature; namely, free interpretation of PRO for both *tell* and *promise*. However, this pattern was restricted to the judgement data, and reflects their overall response bias on this task.

The spontaneous speech data contain a variety of infinitival constructions with catenatives, verbs like *want* and *need*:

83) (MB) *And I want to get that Robot.*

84) (LB) *You have to get off the same plane.*

85) (SR) *I'm gonna make her take me.*

Thus, the FLHD subjects were clearly able to generate constructions similar to the early infinitival constructions produced by normal young children. There were only two examples of *tell* constructions (both by FLHD subjects), and no examples of *promise*:

86) (JL) *I tell her to go to bed.*

87) (FC) *The man's telling him to get over the gate.*

4.3.4.2 PRO in adjuncts: We will now examine performance on tasks assessing knowledge of PRO in adjuncts. The relevant structures are those in 46) and 88):

88) The elephant pushes the lion before PRO jumping over the fence. (Direct Object type)

89) The bear jumps over the girl before PRO bumping over the fence. (Prepositional Phrase type)

The data from these types of constructions (along with data on OS rels) will allow us to interpret the performance of the children studied here. Recall that the literature (Hsu and colleagues, eg. Hsu et al. 1985) suggests a series of stages for the mastery of PRO in adjuncts:

a) no control (PRO = arb; evidently not all children go through this stage.

b) subject control via a highest S strategy, with the matrix subject = embedded subject (children may comprehend PRO in adjuncts but perform incorrectly on OS relatives, where the matrix object must be coreferential with the embedded subject)

c) object control, due to the minimal distance principle (closest NP is the controller (children perform incorrectly)

d) object control, c-command followed but adjuncts are attached to VP instead of IP

e) mixed control; some VP attachment and some IP attachment of the adjunct

f) adult control: subject control of PRO in adjuncts with S attachment of the adjunct.

Table 21 presents the comprehension data for all of the subjects (next page). As can be seen, all controls but SM appear to have adult knowledge of control facts on this task; SM, one of the youngest subjects, is in Hsu et al.'s mixed stage, appropriate for his age. As for the FLHD subjects, two (WB and NA) appear to be in the adult stage. While MB performs worse than his control, he performs similarly to NA's control, who is older than MB. Thus, given this fact, and also given norms reported elsewhere, we must consider MB, who is in the mixed stage, to have age-appropriate performance. As for SR, FC and JL, they appear to be quite delayed in mastery of this aspect of grammar for this task (FC and JL are in the mixed stage, and SR has VP attachment of adjuncts.

Table 22) presents the judgement/probe data for this area (on page 107). Note that these data are the last with regard to PRO; there were no relevant production data.

Table 21: Interpretation of PRO in adjuncts: enactment data

	Construction type		
(# items)	DO adjunct (3)	PP adjunct (3)	OS relatives (6)[3]
1. WB (7;6 to 7;9)	100%	100%	100%
2. SR (13;2)	0%	100%	100%
3. MB (5;9 to 5;10)	67%	50%*	100%
4. NA (6;3)	100%	100%	100%
5. FC (9;9 to 10;2)	67%	67%	100%
6. JL (12;7 to 12;8)	67%	67%	100%

Controls:			
1. SF (7;9)	100%	100%	100%
2. KY (13;2)	100%	100%	100%
3. SS (5;9)	100%	100%	100%
4. SM (6;3)	67%	100%	100%
5. JP (9;9 to 10;2)	100%	100%	100%
6. CL (12;7 to 12;8)	100%	100%	100%

Note:* = one ambiguous response was thrown out from consideration (the sentence was acted out with PRO = both NP's doing the action)

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[3] Although in section 5.2.1 performance on several subtypes of OS relatives is discussed, here only comprehension data on OS relatives with only 2 full NP's was was used, as in:

i) Gumby hits the bear that hops up and down.

The data are restricted to only these examples of OS relatives because the FLHD perform more poorly on sentences with three lexically full NP's for reasons which may have nothing to do with the relative structure.

Table 22: Judgement/probe data for PRO in adjuncts

	DO-type adjuncts (1)	PP-type adjuncts (1)
FLHD:		
1. WB (7;6 to 7;9)	-	-
2. SR (13;2)	+	+
3. MB (5;9 to 5;10)	-	-
4. NA (6;3)	+	+
5. FC (9;9 to 10;2)	-	+
6. JL (12;7 to 12;8)	+	+
Controls:		
1. SF (7;9)	+	+
2. KY (13;2)	-	+
3. SS (5;9)	+	+
4. SM (6;3)	+	+
5. JP (10;0)	+	+
6. CL (12;5)	-	+

Note:
+ = correct performance
- = incorrect performance

First we will examine the data from the nonimpaired controls. The two oldest controls were able to accept interpretations of object-controlled PRO in the DO-type structures. Thus, this task may be too difficult for any of the children to demonstrate reliable interpretations; this is confirmed by the responses of five adults who were tested, one of whom allowed an ungrammatical response on the probe as well. Thus, for this aspect of the grammar, we will concentrate on the act-out data in the summary of the performance (note that there are no relevant data found in the spontaneous speech samples or in the CYCLE batteries).

In examining the data, it is clear that none of the subjects are in the first stages in the acquisition of PRO as proposed by Hsu et al. (1985). Thus, none have subject sontrol via a "highest S strategy; none have object control via the "closest NP" strategy. However, there was at least one subject in each of the remaining stages.

To summarize, on temporal adjuncts 5/6 controls had the adult grammar (subject control of PRO in adjuncts), and 1 (6 year-old) subject was in the "mixed"stage, consistent with reports in the literature. Two of the 6 FLHD subjects had the adult grammar with regard to PRO, and 1 (young) subject was in the mixed stage, appropriate to his age. Three subjects appear to be delayed in this area: SR (who has object control with VP attachment of adjuncts), and FC and JL (who are older, but still in the mixed stage.

Clearly, the FLHD subjects appear to deal with PRO in complements and adjuncts in both processing and production tasks, and are in the process of mastering control when it is not free. Some controls and some FLHD subjects do not yet know the peripheral facts concerning the unusual subject control property of particular lexical items such as *promise*, and in this there may be evidence of a delay in the two older FLHD subjects.

4.3.4 NP movement, linking of theta roles and the passive

For this construction, only four subtasks contained relevant items. No passive items were included in the animal description task because it was found to be nearly impossible to elicit passive (rather than an active voice construction) descriptions without changing the task significantly to focus on the patient and thus cue the passive. Thus, all of the data on the passive are pesented in Table 23 below. Note that the controls performed correctly on all act-out and judgement items; the table includes only the FLHD subjects. Note also that some subjects produced responses on the CYCLE-E which are considered to be frame violations; that is, the subject rejects the proferred sentence frame and starts a new utterance (in the active voice).

Table 23: Performance on passive items

(Task) (# items)	Enactment (3)	Judgement (1)	CYCLE-R (5)	CYCLE-E (2)	Spont. speech/ elicit.
Subjects FLHD:					
1. WB (7;6 to 7;7)	100%	+	100%	NG	
2. SR (13;2)	100%	+	0%	50%	+
3. MB (5;9 to 5;10)	100%*	+	100%	NG	NM
4. NA (6;3)	100%	+	40%	NG	+
5. FC (9;9 to 10;2)	100%	+	80%	+*	+
6. JL (12;7 to 12;8)	100%	+	60%	+*	+

Note:
* = One response was a frame violation; percentage correct was for remaining responses
NM = example from spontaneous speech was misssing appropriate morphology
\+ = correct performance

As can be seen, all of the subjects performed well on the enactment and judgement task. However, on the CYCLE-R, three subjects performed below acceptable criterion level. There was no consistent error pattern. It seems clear that there is something about the CYCLE-R task which appears to make it a more difficult comprehension measure for this aspect of the grammar. In any case, we must attribute the subjects with the appropriate grammar is they are producing and comprehending passives in other cirumstances (e.g. even even SR, who performed poorly on both the CYCLE-R and the CYCLE-E, produced a passive in spontaneous speech.

In production, there are many frame violations and nontarget resopnses. This preference for "avoiding the passive" has been noted previously in normal adult populations, and seems to indicate here the normal preference, as all subjects tested did produce at least one passive construction. Additionally, in an attempt to produce an OO relative, two subjects produced a passivized construction (resulting in an OS relative):

90) (NA) *Pick the bear that's wash...that's getting cleaned.*

91) (SR) *Pick up the bear that's getting cleaned.*

Thus, unlike what has been reported for adult aphasics, these FLHD subjects do not demonstrate a partricular deficit with A-chains and associate them with roles with syntactic positions. However, in production, it appears that at least some of these subjects tolerate (but do not prefer, perhaps) A-chaining and empty categories.

Given the infrequency of the passive in spontaneous speech, it is not too surprising that only two of the FLHD subjects, with one (MB) produced the appropriate word order but without the appropriate verbal morphology.

92) (JL) *...they're broken by that kid.*

93) (JL) *It got stolen.*

94) (JL) *It was called a pit bike.*

95) (MB) *... and then he was transform to cars.*

Similarly, only two controls produced passives:

96) (SS) *...so he got benched.*

97) (KY) *'Cause you get fined if you, like, get fined if you get in fights.*

4.4 INFLECTION

In this section we will examine one additional aspect of grammatical knowledge: inflection. Recall that one candidate for peripheral status in the grammar of English, according to Hyams (1987) is verbal inflection. There is also empirical evidence that Auxiliary verbs (including *be*) have traditionally been problematic for other populations at risk (e.g. language disordered children; Ingram, 1972); thus, we might expect difficulties in this population as well.

Here we will look at two types of morphological markers: those denoting subject/verb agreement and tense/aspect marking. Three three types of data will be considered: a) comprehension data (from the CYCLE-R): b) elicited production data (from the CYCLE-E) and c) data from the spontaneous speech samples.

4.4.1 Number agreement on verb and AUX

In considering the subjects' performance with regard to subject/verb agreement, two types of data are considered: singular/plural auxiliary *be* and verb singular/plural. The singular/plural distinction is marked with either the 0-morpheme or *-s*; thus, the bare verb stem is a grammatical possibility. For auxiliary *be*, overt marking of both singular and plural is required (*is/are*). As can be seen in Appendix C, the morphology is the only cue to the singular/plural distinction; the nouns form irregular plural (and thus take a 0-morpheme).

Table 24 presents the formal test data (CYCLE-R and CYCLE-E). As previously, CYCLE-R data is presented in percent correct responses; CYCLE-E data is represented in terms of "+", "+/-" and "-" as there are only two responses per subtest. Ages at time of testing are again given in parentheses.

Table 24: Agreement on verbs and aux *be*: CYCLE data

	CYCLE-R Aux be		CYCLE-R Verb		CYCLE-E Aux be		CYCLE-E Verb	
	S	P	S	P	S	P	S	P
(# of items)	(5)	(5)	(5)	(5)	(2)	(2)	(2)	(2)
(age level)	(6)	(6)	(6)	(8)	(5)	(5)	(5)	(4)
1. WB (7;6 to 7;9)	100%	60%	100%	0%	NG	NG	+	+/-
2. SR (13;2)	100%	40%	100%	0%	+	+	+	NG
3. MB (5;9 to 5;10)	NG	NG	NG	NG	+	+/-	-	-
4. NA (6;3)	80%	100%	60%	NG	+	+	+	NG
5. FC (9;9 to 10;2)	100%	40%	100%	0%	+	+	+	+
6. JL (12;7 to 12;8)	100%	100%	100%	0%	+	+	+	-

NG = not given (due to basal or ceiling effects due to age or performance of child)
+= passed test
-= failed test
+/- = passed 1/2 items on the subtest

With regard to aux *be*, it appears that aux singular (*is*) is mastered by all subjects in both comprehension and production; responses were consistently correct. Three of the of the FLHD subjects produced inconsistent responses on Aux plural (*are*). Interestingly, they all generally produce both *is* and *are* as appropriate; MB produced the single error on the CYCLE-E:

98) Cue: Here this deer is eating and here these deer...

(MB) *eating*.

MB's response indicates a missing aux, a response typical of younger children and one which clearly precludes addressing questions of agreement.

The fact that the subjects are able to produce plural aux be but do not consistently perform on the comprehension task indicate that the subjects have learned the singular/plural forms of *be*; however,it could be that their difficulty lies in the irregular plural noun.[4] Thus, they interpret the noun as singular (0-marked) at the same time they comprehend the auxiliary as being plural; thus, their around chance performance in the face of this apparently contradictory construction. This is less of a problem on the elicitation task, which sets up a singular/plural contrast in the task via contrastive stress and determiners marked for number:

99) Cue: These deer all like to do the same thing. See? Here this deer *is* eating. And here these deer ________ (*are eating*).

Thus it appears that the FLHD subjects do appear to have aux singular; aux plural appears to be problematic for three subjects. However, for two of these (MB and NA) the errors may not be entirely out of line; aux singular is at level 5 on the CYCLE-E and level 6 on the CYCLE-E. Thus, given the ages of MB and NA, we cannot rule out the possibility that they are performing at the lower limits of normal performance. Only WB's performance on aux singular on the comprehension task remains problematic

With regard to verb singular/plural marking, the formal test data presents a somewhat different picture. Verb singular was comprehended and produced by all but the two youngest subjects (verb singular items are at level 6 in comprehension and level 5 in production; if (again) we grant that MB (age 5) and NA (age 6) are having slight delays in development, these errors are not too out of line. Verb plurals, however elicited consistently incorrect performance by the four subjects taking the comprehension subtest. Thus, 0-marking on the verb was consistently interpreted as being singular. It could be that nouns like *deer* and *fish*, which have irregular plural forms, are interpreted as being singular (missing the plurals *-s*). This would explain the

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[4] This is consistent with a generalized lexical deficit (e.g. they simply do not have the irregular plural form in their lexicon.

consistent errors on the comprehension task with regard to verb purals, and would also explain the elicitation errors such as:

100) (WB) Cue: Every day this deer stands, and every day these deer...

(WB, MB, JL) *stands*.

Thus, while the five of the FLHD subjects make errors with verb plurals on one task or another, the influence of the irregular noun plural on performance cannot be entirely ruled out.

There is one remaining problem which is MB's responses on the Verb singular on the CYCLE-E:

101) Cue: ...everyday this fish...

(MB) *swim*.

Thus, he has largely switched his responses on verb singular and verb plural items. Thus, he either has no number marking on the noun, has interchangeable auxiliary morphology (also unmarked for number), or has some difficulty with the task.

An examination of the spontaneous speech data is warranted to further evaluate the extent to which the FLHD subjects have difficulties with number agreement. Here, the focus was broadened somewhat to include all non-third person forms of verbs and of aux *be*. The data also include instances of past tense verbs of aux as well as present tense (although this did not affect the data greatly; see below). (Note: all controls demonstrated 100% accuracy in their spontaneous speech samples with regard to third and non-third person singular and plural marking on aux be and verbs). Ages are again given in parentheses.

Table 25: Agreement: spontaneous speech data

	3rd singulars		Plurals	
	verb	aux	verb	aux
1. WB (7;6 to 7;9)	100%	100%	93%	92%
2. SR (13;2)	100%	100%	100%	100%
3. MB (5;9 to 5;10)	56%	100%	92%	100%
4. NA (6;3)	100%	100%	100%	100%
5. FC (9;9 to 10;2)	64%	100%	100%	100%
6. JL (12;7 to 12;8)	94%	100%	100%	100%

The FLHD subjects demonstrate variable performance, with MB and FC showing performance in the 55-65% accuracy. Most of the FLHD subjects did make errors, but their performance was largely correct (90%+; recall, however, that none of the controls made any errors).

The errors made in the spontaneous speech sample were as follows (errors represented as *erroredform/target*):

(WB) -*was/were* (1/12 obligatory contexts for *were*)

-*goes/go* (1/14 obligatory contexts for 0-non-3rd singular)

(SR) -none

(MB) -*0/-s* (4/9 obligatory contexts for 3rd person -*s*)

--*s/0* (2/25 obligatory contexts for 0-non 3rd singular)

(NA) -none

(FC) -*0/-s* (4/11 obligatory contexts for 3rd singular -*s*)

(JL) -*0/-s* (1/16 obligatory contexts for 3rd person -s)

Here, the only consistent difficulties appear to be primarily on producing third singular -*s*, although various other errors are scattered throughout the data (and again note MB's reversal of singular with plural marking, although note that these responses constitute a very small portion of his obligatory contexts. Interestingly, no subjects demonstrated 0% correct on any aspects of verb/aux singular/plural, indicating that all had some access to the appropriate lexical items and knew appropriate contexts for them in spontaneous speech.

To summarize, aux be singular (*is*) was mastered in all tasks. Aux be plural (*are*) was problematic in comprehension, but with production data largely correct. Verb singular ('s) was largely comprehended correctly (with the exception of MB); it was also elicited correctly for all subjects but MB. However, the spontaneous speech data indicated that MB and FC were not consistently marking verbs in obligatory contexts with this morpheme. Thus, MB may not have clearly attached a number feature to this item in the lexicon, while FC, able to comprehend it and produce it in a structured task, may have formulation difficulties which preclude good performance on spontaneous speech. In any case, they both appear to be performing below expected levels with regard to this morpheme. On verb plurals (0-marking), the subjects perform poorly on formal tasks but well in spontaneous speech. Note, however, that verb plurals are unique in that to produce a correct utterance, the subject must add no overt morphology (in a sense, do nothing). Thus, the spontaneous speech data would look the same with regard to verb plurals for subjects who had no morphological system as well as for subjects who had mastered the paradigm; both would produce only the verb stem for verb plurals. Thus, for this aspect of the grammar, the spontaneous speech data cannot be considered definitive with regard to this structure, and we must assume performance to be delayed for most of the FLHD subjects.

4.4.2 Tense/aspect

In this section, both CYCLE data and spontaneous speech data will be again considered. For the CYCLE-R, the subject is given a pretest where he is taught that the pictures depict part of the same story, and given a context for each picture. The type of picture choice is the same for each item: there is one picture of ongoing action, one of a completed action, and one of an action about to take place. The CYCLE-E sets up a contrast between two pictures, as in the example:

102) Cue: Here the boy is getting *ready* to wash his face. But here the boy..

(Target: is cleaning his face/is washing it.)

Table 26 presents data from the following subtests of CYCLE-R: -ing, -ed, gonna, and will (all of the relevant subtests from the CYCLE-R battery). As before, CYCLE-R data is presented in percent correct responses. Again, ages of the FLHD subjects is given in parentheses. Scores in parentheses indicate items which are normed at or above the subjects' chronological age; obviously, these cannot be considered as evidence of delay in this aspect of grammatical knowledge

Table 26: Performance on the tense/aspect subtests of the CYCLE-R

	ing	ed	gonna	will
(# items)	(5)	(5)	(5)	(5)
(age level)	(5)	(6)	(6)	(7)
1. WB (7;6 to 7;9)	100%	100%	100%	(20%)
2. SR (13;2)	NG	0%	0%	60%
3. MB (5;9 to 5;10)	80%	NG	NG	NG
4. NA (6;3)	100%	(20%)	(20%)	(0%)
5. FC (9;9 to 10;2)	80%	60%	0%	0%
6. JL (12;7 to 12;8)	80%	20%	60%	20%

Note:

NG = not given due to age constraints

Here, the problems in comprehension appear on all T/A markers except for *-ing*. As noted earlier, however, this might not be surprising in that there is evidence of a somewhat special status of *-ing* within the grammar, perhaps related to learning *V* + -

ing forms as a single lexical item. The subjects varied somewhat; NA performed with 100% accuracy on *-ing*, while FC and WB made *-ing* errors, but had a particular strategy with regard to *will* (interpreted as *-ed* 80% and 60% of the time respectively.

For the remaining morphological errors, some of the errors appear to be attributable to age at the time of testing. However, three of the older subjects (SR, FC and JL) have difficulty with all other tense/aspect markers on this test. An error analysis indicates that the most common foil chosen on error responses was the picture depicting *-ing* (74% of all errors).

Table 27 presents the CYCLE-E data on the following tense/aspect markers (part of the original CYCLE battery): *be + -ing*, passive past participle *-en*, *be + gonna/will*, and passive past participle. As before, the CYCLE-E responses are noted as "+", "+/-" or "-", as there are only two items on the subtests. There were several types of errors on the CYCLE-E; these are noted in the table and were as follows:

a) wrong tense marker for picture (= WP):

103) Cue: Here the girl is getting ready to open the present. But here, the girl...

(WB) *opened it* (target = is opening it)..

b) missing morphology (= MM)

104) Cue: Here the girl is getting ready to open the present. But here the girl...

(MB) open... the present. (target = has opened it)

c) off-task or "I don't know" responses (OT)

105) Cue: ...here the boy

(SR) *is running from the cat.* (target = is being pushed by the girl).

Table 27: Performance on the tense/aspect subtests of the CYCLE-E

(age level)	ing (5)	past participle *-en* (6)	will/ gonna (7)	passive past participle (8)
1. WB (7;6 to 7;7)	- WP	+	+	NG
2. SR (13;2)	+	- MM	-/+ MM	- MM, OT
3. MB (5;9 to 5;10)	+	NG	NG	NG
4. NA (6;3)	- MM	- MM	+	NG
5. FC (9;9 to 10;2)	- WP	-/+ MM	- MM, OT	-/+ MM
6. JL (12;7 to 12;8)	-/+ WP	- MM	+	+

As can be seen, the data on tense/aspect morphology as elicited on the CYCLE-E is inconsistent. Interestingly, 3/4 of the erroneous responses on the *be + -ing* involved descriptions not appropriate to the stimulus picture; there were not ungrammatical, but possibly revealed difficulties with responding appropriately to the task due to non-linguistic factors. Only NA made a "missing morphology" error on this form. FC and SR had some "off-task" responses; all others responses were in error due to missing morphological markers. Thus, errors on obligatory tense/aspect morphology was inconsistent but widespread throughout the data.

The spontaneous speech data with regard to tense/aspect morphology are presented in Table 28. The following tense/aspect markers were evaluated, with responses indicating percentage correct (morphologically complete and well-formed) responses out of those required (in obligatory contexts): regular past, irregular past (including marking on auxiliary be and have), -ing, gonna, will, and 3rd person singular/present -s. This last marker does carry a dual function of marking agreement for person/number as well as indicating present tense; thus, although this was discussed earlier, it is included again here. Note that "--" indicates that there were no relevant data (no obligatory context as determined for a particular form).[5]

Table 28: Tense/aspect morphology in spontaneous speech

	Regular past	Irregular past	-ing	gonna	will	3rd pers sing/ present
FLHD:						
1. WB (7;6 to 7;90	50%	94%	100%	100%	67%	86%
2. SR (13;2)	100%	100%	100%	100%	100%	100%
3. MB (5;9 to 5;10)	38%	79%	100%	--	--	50%
4. NA (6;3)	91%	95%	100%	--	--	75%
5. FC (9;9 to 10;2)	50%	100%	100%	100%	--	75%
6. JL (12;7 to 12;8)	83%	71%	75%	100%	100%	94%
Controls:						
1. SF (7;9)	89%	88%	100%	100%	100%	100%
2. KY (13;2)	100%	100%	100%	100%	100%	100%
3. SS (5;9)	100%	100%	100%	100%	100%	100%
4. SM (6;3)	71%	83%	100%	100%	100%	100%
5. JP (10;0)	100%	100%	100%	100%	100%	100%
6. CL (12;5)	100%	100%	100%	100%	100%	100%

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5 It is acknowledged here that "obligatory context" can sometimes be difficult to determin; in general, the temporal frame of the narrative was used to make these determinations. There were several instances where it was not clear what the obligatory context was; these verbs were not included here.

Looking at the spontaneous speech data, some interesting facts become apparent. First, the controls subjects as well as the FLHD subjects made errors involving omission of obligatory verbal morphology with respect to past tense (in particular, note the performance of SM, age 6). However, the degree of error was greater in the FLHD subjects as compared to their matched controls.

The types of errors found in the samples were of two sorts, both attested in normative data. The first type was the "missing" morphological error, one error also found in the elicited production data. Note that these errors involved both regular and irregular forms, and resulted in bare verb stems. Some examples of this type of errors are:

FLHD subjects:

106) (FC) *Because I taste it before.* (*taste/tasted*)

107) (JL) *But last night at a babysitter, her go to her bedroom* (*go/went*).

108) (MB) ... *Papa Smurf, he change him good with his magic potion* (*change/changed*).

Control subjects:

109) (SM) *We haven't use this. (use/used)*

110) (SM) *I paint it pink* (*paint/painted*).

A second type of error was overregularization of irregular forms, seen on the past tense forms (sometimes in addition to the irregular form, as in 13):

FLHD subjects

111) (MB) *The thingy knocked down, and the bird almost falled*) .

112) (WB) *You slepted all night*?

The third type of error was the use of a form inappropriate to the context (morphology was present, the verb was well-formed, but not conforming to obligatory context)

113) (JL) *He jumped my mom, he wants to go to the bathroom, so he went inside the pool. (wants/wanted)*

Controls:

114) (SF) *And the flag came down from it and you pull the flag... (came/comes)*

This type of error might just be related to discourse factors (keeping track of the overall tense of a narrative, and occurred relatively infrequently.

To summarize, the FLHD subjects demonstrated difficulties with tense/aspect morphology across tasks. Some of their errors were related to task demands on the formal tasks (e.g. the "wrong picture" response on the CYCLE-E). However, many of their errors involved "bare stem" productions of verbs in elicited and spontaneous sproductions. While the controls also demonstrated errors in spontaneous speech with regard to tense/aspect morphology, errors were found in samples from only two subjects, and were restricted to past tense forms. Thus, this aspect of grammatical knowledge seems to have been particularly vulnerable following FLHD, although the error types are not atypical of normal subjects.

Several additional points should be made. First, the errors were again, inconsistent from task to task, again implicating processing difficulties as opposed to representational deficits. However, significant amounts of errors were present in spontaneous speech, unlike the data examined relevant to the core properties of syntax. Second, the FLHD subjects primarily demonstrated errors which have been clearly attested for younger normal children: over-regularization of past tense morphology and over-reliance on 0-marking (clearly a grammatically viable option within the English morphological paradigm). Thus, it was not the case that they had demonstrated abnormal knowledge in this area; rather, they had apparently not yet learned or mastered the appropriate verbal morphology, and produced a bare stem instead of a fully inflected form. This exception to this is MB, who switched verb singular/plural:

in his case, it was as if he had both forms in his lexicon but the forms were unmarked for agreement. This is not typical of unimpaired children, and may reflect one instance in which knowledge of grammar is abnormal in this particular case.

CHAPTER 5

SUMMARY AND DISCUSSION

5.1 SUMMARY OF HYPOTHESES

We will now return to all the hypotheses and summarize the findings of this dissertation.

H1: Early focal left hemisphere damage will result in deficits on standardized tests assessing lexical as well as morphosyntactic knowledge.

The FLHD subjects were found to be variable in their performance on the standardized battery. With regard to performance on the lexical battery, one subject (WB) demonstrated age-level performance or above on all three tests. One other subject (NA) was able to comprehend words appropriately, but appeared to have trouble retrieving words to name pictures. The remaining four subjects performed below age-expected levels on tests of comprehension and on naming. Thus, these results are consistent with the findings of Aram et al. (1985) and Rankin et al. (1981): namely, early FLHD (or, as these researchers point out, early damage to either hemisphere) is associated with deficits on formal tests of lexical knowledge.

However, the results of the Word Fluency test reveals some surprising integrity in lexical knowledge. Five out of six subjects were able to generate words within a specific semantic category, indicating that, while they might know fewer vocabulary items, or might be unable to retrieve enough words on a confrontation naming task, there was evidence from the Word Fluency measure that their lexicons were organized in a fashion similar to that found for normal children.

Thus, performance on the lexical measures was somewhat variable, with the subjects demonstrating abilities ranging from no measurable deficit to performance severly impaired across the board.

Performance on the standardized morphosyntactic measures (the CYCLE batteries) indicated deficits in all subjects, with the deficits ranging from a few months to several years below expected levels. The deficits were seen in both comprehension and production; if there was a difference in the amount of the delay between the two scores, it was always the case that the production score was worse. The pattern of comprehension exceeding or being equal to production is the one typically reported in the literature; thus, in terms of relative comprehension versus production abilities there is no evidence of unusual or deviant patterns in the performance of the FLHD subjects. However, the FLHD subjects did not always evidence simple patterns of delay (e.g. perform like a younger unimpaired child). For example, on the CYCLE-R, FC passed levels 6 and 8, but not level 7. Thus, in this respect the FLHD subjects do not simply have a clear developmental delay, but rather uneven performance overall.

The obvious question to ask at this point is: on the formal tests of morphosyntax, what did the FLHD subjects make their errors on? To answer this question, we can look at some of the scores generated by the CYCLE-R which attempt to categorize performance by specific components of the grammar. The data largely suggest that the subjects just made a number of errors across test type. Four of the six FLHD subjects did poorly on the Syntax tests (all but WB and FC failed 25% to 30% of the tests they took). Likewise, four subjects did poorly on the Morphology tests (all but WB and SR failing 43% to 50% of these tests). Two subjects did poorly on the semantic tests (which include quantifiers and other lexical items); MA and JL failed 42% and 25% respectively. Thus, it seemed to be the case that the subjects just failed too many morphosyntactic tests across the board to get appropriate age scores. No single structure was consistently problematic; for example, for MB, prepositions appeared especially problematic (he failed 50% of these tests, while all other subjects scored 80% or above). For SR, pronouns were especially difficult (he failed 71% of these tests, while all other subjects achieved 100% correct). Thus, the patterns appeared somewhat idiosyncratic.

To summarize, most subjects appear to have deficits on formal/standardized measures of morphosyntactic ability as assessed by comprehension and elicited production tasks. This is, like the lexical findings, consistent with the findings of others (e.g. Aram et al. 1985;1986;1988), although the degree of the deficit varies from subject and may be related to age at onset.

H1a: Acquisition of core properties of syntax will generally not be impaired if key areas of the left hemisphere are damaged early in development (before the end of the hypothesized critical period, or before age 5).

The data here indicate that the subjects were largely able to demonstrate knowledge appropriate to their age level on at least one task for some aspects the aspects of the grammatical core examined here. All subjects demonstrated evidence of recursion within their grammars; most were able to demonstrate appropriate interpretation of PRO in complements, all demonstrate appropriate interpretation of passives.

However, there were exceptions to this; namely, there were aspects of the core which were problematic for some (but not all) FLHD subjects. The most noticeable deficits in performance were with regard to the Binding Principles. One subject (FC) demonstrated no knowledge of either A or B, suggesting that perhaps he had not yet learned which items were anaphors and which were pronouns. An additional subject (SR) demonstrated poor performance with regard to Principles A and C; one subject (JL) did poorly with tasks assessing knowledge of Principle B. The two youngest subjects also performed poorly on Principles B and C with respect to their controls; however, for these subject, who were within age limits established elsewhere in the literature, it cannot be ruled out that they are within the lower limits for their age.

Why these constructions in particular should have been at risk for some subjects but not others is not completely clear. It could be that even slight variation in the amount and foci of brain damage is sufficient to account for the variability in deficits observed here. Further, if we assume that some of the problems reflect deficits in the lexicon for certain syntactic facts (e.g. the control facts specified lexically for some verbs, or the specification of the type of nominal for reflexives and pronouns), it could be postalated that much of lexical knowledge (both for semantic information and syntactic specifications) is impaired for these children.

This study does not rule out the possibility that the FLHD subjects will not "catch up" with respect to their ability to obey the Binding Principles at some later point in time. It does, however, at least implicate at least a *delay* in acquisition of this aspect of the grammar.

H1b: Acquisition of inflection will be impaired following focal left hemisphere damage at any point in childhood.

Acquisition of some aspects of inflection was found to be impaired for the FLHD subjects. In fact, two aspects of the grammatical periphery were found to be impaired: a) the peripheral aspects of the grammatical constructions examined here (e.g. the particular lexical facts with regard to subject vs. object control verbs, the control of passive morphology, the appropriate overt complementizer), and b) tense/aspect morphology and agreement (verb singular marking). The spontaneous speech data as well as the formal test data confirmed the vulnerability of the periphery following focal left-hemisphere damage.

H2: Age at onset will affect the nature and extent of deficits in the acquisition of peripheral aspects of grammar, with an increasing age at onset related to greater deficits in the periphery.

This hypothesis was not confirmed by the data relating to knowledge of the specific aspects of the grammar examined here, nor for the formal test data. However, as cautioned earlier, the small number of subjects in this study must be considered as the failure to find significant differences between the group. As noted earlier, it does appear that those FLHD subjects in Group III (damage after the age of 4 years) perform more poorly on overall scores on the CYCLE-R and CYCLE-E. It is not clear at this point whether this reflects their ability to deal with the nonlinguistic demands related to the formal task are compromised by the brain damage or with the linguistic structures tested on the CYCLE. This is a question which awaits further research to be answered.

In addition to the small sample size, there might be another reason for the failure to find an effect of age at onset: it is possible that none of the subjects studied here sustained brain damage late enough to test the critical period window or the effects of lateralization having been complete. Lenneberg (1967) originally proposed the onset of puberty as the time limit for the equipotentiality of the hemispheres of the brain. While lateralization of linguistic function is usually thought of as being completed around age 5 in the normal brain, this does not preclude a damaged brain from shifting function to a different foci if the damage takes place early enough in childhood.

Age at onset might not be as crucial with regard to the lexical tests. Recall that the oldest subjects (SR, FC, JL) performed the worst on the formal measures of vocabulary comprehension and production. We have noted earlier that brain damage is associated with an inability to learn new material; thus, it should not be surprising that focal left (and, possibly right) hemisphere damage may affect ability to perform on formal vocabulary tests in a way which becomes more striking over time. Older children evidence a greater gap as compared to their peers, regardless of the age at onset, due to the increasing expectations for the amount of information they are expected to have learned.

H3: Performance of focally lesioned subjects will vary according to demands of the tasks used to assess syntactic knowledge, implicating processing deficits rather than deficits in underlying linguistic representations.

It is clear that there was great variability of the FLHD subjects' performance, both across tasks and within the same task. Frequently we saw that, while impaired in performance on a given task, an individual FLHD subject was able to demonstrate correct responses on a different task or in spontaneous speech for the same structure. Thus, the results implicate consistent processing deficits with less consistent representational deficits. In the cases where there was inconsistent performance, we must postulate intact underlying representations in order to account for their computation of the correct structural representation consistently on at least one of the task, or to account for their ability to generate the appropriate structures in spontaneous speech.

These findings are relevant to a number of additional issues, which are considered below.

5.2 BRAIN LATERALIZATION AND NEURAL PLASTICITY

The performance of the FLHD subjects was largely intact for the aspects of the core examined here with the exception of the Binding Principles and with teh exception of apparently delayed (but apparently on course) development of interpretation of PRO in adjuncts. The remaining core appears largely intact, and if we propose that knowledge of core aspects of syntactic principles is that aspect of grammar which is genetically endowed, and we assume the traditional link between the "language" areas of the left hemisphere and grammatical knowledge, how is it that this aspect is preserved in light of damage to the proposed substrate?

A number of possibilities are apparent. First, it has been proposed that the anterior aspect of the left hemisphere does not play the same role in subserving language in children and adults. Thal et al. (1989) have suggested that in children the key dichotomy is anterior/posterior, not left/right as in the adult brain. They propose that posterior cortex in children might be responsible for the support of most aspects of grammar and lexical production, with the right hemisphere contributing heavily to lexical comprehension, until such time as linguistic functions become automaticized (perhaps in pre-adolescence). If this is the case, the FLHD subjects studied here did not sustain damage to the actual regions of the brain subserving language. Thus, this model would explain why the core was largely preserved: its initial substrate is outside the locus of brain damage studied here. It does not explain why such aspects of the grammar such as inflectional morphology were compromised, unless we hypothesize that aspects of the grammar which must be "learned" in the classical sense are vulnerable to any brain damage (as proposed earlier). This question awaits data from left and right posterior as well as left posterior damaged subjects.

A second possibility is that the anterior portions of the left hemisphere are specialized for syntax, but that the immature brain is plastic enough to allow certain linguistic functions (the core) but not others (the periphery) to shift representation to the right hemisphere or to other areas of the left hemisphere. Following Witelson (1987) it is proposed that those aspects of knowledge which depend on general cognitive skills (e.g. learning?) may demonstrate a lower level of function following early lesions. This might be due to the less effective mediation of the "equikinetic brain" of such general abilities. Thus, inflectional morphology might be compromised, as might apparent obedience to Binding (again, reflecting perhaps a lexical deficit). However, specific cognitive functions (the core) which depend on focal representation might respond better to relocation, and as such benefit from the plasticity of the immature brain.

Finally, the notion of the critical period for language acquisition is relevant here. If we assume that the critical period for language acquisition is from 0 to about 5 years of age, the data here are somewhat problematic in that the FLHD subjects all suffered their damage during this time and were thus able to shift support of linguistic functioning to the right hemisphere during the critical period, when the plasticity of the neural tissue still was such that such a shift could occur. However, if we assume that the critical period for acquisition of core principles of syntax extends until puberty (as in Lenneberg's 1964 formulation of the equipotentiality hypothesis, as opposed to Krashen's subsequent revision of this hypothesis), there is no inconsistency. In this case, none of these subjects were a true test of the critical period hypothesis, as their damage and subsequent reorganization took place well before puberty.

There is some new evidence which supports the idea that dramatic changes in brain function take place later than originally thought. Chugain et al. (1987) noted that the cerebral metabolic rate for glucose increases steadily throughout early development, but slowly begins to decline at about 8 to 10 years of age, corresponding to the phase of synaptic elimination and a decrease in dendrites (dendritic pruning; Huttenlocher, 1979). Chugani et al. speculate that the change in glucose uptake patterns at this age is related to the end of the critical period for language acquisition. This would be consistent with our findings of the intact knowledge of much of the core found here; these subjects were still within the critical period for acquisition of language.

Finally, when discussing the critical period, it is important to delineate what exactly the period is critical for. The findings of the dissertation make it clear that there might be different windows of time for the completion of acquisition of different components of the grammar.

5.3 LANGUAGE PERFORMANCE AND TASK VARIABILITY

> "Performance tasks vary in what kinds of linguistic knoweldge they exploit... No given performance task, with its special knowledge requirement, can full reflect the entire range of underlying competence." (Valian, 1979. p. 19)

As noted earlier, the FLHD children studied here demonstrated inconsistent performance on tasks assessing their knowledge of grammar. However, other than Binding (and for some, PRO in adjuncts) they generally demonstrated performance that was within normal limits on at least one task. Thus, it appears here that FLHD leads to processing deficits which inconsistently affect their ability to do metalinguistic or other tasks. The processing deficits may be related to either extralinguistic factors or to processing difficulties limited specifically to the processing of language. We have not detailed the general neuropsychological status of the cases studied here, but it has been documented widely that brain damage can to many parts of the brain can affect a variety of cognitive abilities, including memory and attention (Fuster, 1985). With regard to brain damage and linguistic processing, Brookshire (1973) has suggested the presence of auditory processing deficits in adult aphasics which are relevant here. He notes that some patients have auditory systems characterized by a "slow rise time", tending to miss the initial portion of an auditory stream. Others seem to demonstrate "noise build up", making more errors on "complex" sentences and on the ends of longer messages. Still others are characterized by what Brookshire terms "intermittent auditory imperception", with processing deficits which come and go amidst periods of apparently unimpaired performance. While I have not attempted to characterize the "perceptual" errors of these subjects, it does appear on the surface as if some demonstrated the intermittent difficulties described above, leading to unexplainable lapses in performance across tasks. In any case, we take response inconsistency here to be representative of a processing deficit rather than a deficit in linguistic knowledge. Further, it is interesting that the error patterns did not reveal better performance for the group as a whole on a given task type, but rather individual and different patterns for each subject. This is in contrast to the clearer dissociations of comprehension vs. production shown in patients with Alzheimer's disease (Kempler, 1984; Kempler, Curtiss and Jackson, 1987).

The hpothesis that the underlying deficit observed in the test performance of FLHD subjects is a processing deficit is consistent with several studies of both normal as well as language imparied children. First, Golinkoff and Hirsh-Pasek (1987) and Hirsh-Pasek and Golinkoff (1987) note methodological difficulties with studies of comprehension related to nonlinguistic requirements. First, comprehension tasks requires action of some sort. It requires willingness on the subject's part to play the game. It requires specific rubrics for interpreting pictures, keeping sentences in memory long enought to act them out (cf. the difficulties of the FLHD subjects in retaining sentences with multiple NP's in memory). They note that traditional studies of language comprehension (taken as a reflection of underlying linguistic knowledge) even with normal children indicate acquisition of particular structures at later ages than when they may actually have the relevant linguistic knowledge.

Chiat and Hirson (1987) in their study of the spontaneous speech of a developmentally dysphasic child propose processing constraints (in their case, of certain phonological details) which underlie their subject's impaired output. Kamhi, Catts, Koenig and Lewis (1984) in their study of language-impaired subjects note that comprehension and non-symbolic abilities develop in tandem, while language production abilities appear to develop independently of both comprehension and these other cognitive abilities. Thus, their subjects demonstrated difficulties in one type of task while proficiency in another.

Thus, the task differences observed here may typify an abnormal language processor, or may just reflect an exaggeration of the task-related differences observed in any normal children. In any case, there appears to be additional support for the idea that inconsistencies in performance are linked to processing rather than consistent representational deficits of the core.

5.4 THE NATURE OF EARLY LANGUAGE IMPAIRMENT: DELAY VERSUS DEVIANCE

The findings of this dissertation support a conclusion that the data from FLHD subjects did not indicate any aspect of their syntactic knowledge which can be considered deviant. Thus, this is consistent with studies of language-impaired subjects (e.g. Curtiss, Katz and Tallal, to appear; etc.). The only manner in which their grammatical knowledge can be considered truely different from that of younger children is their uneven performance; that is, while they do not construct grammars outside of the possibilities for human languages, and while their errors are typically those also attested to occur with normal subjects, they do demonstrate linguistic profiles which are developmentally uneven. That is, subjects may have mastered parsing OS relatives but not demonstrate adult knowledge of Binding Principle A (as with subject FC).

5.5 QUESTIONS FOR FUTURE RESEARCH

A number of concerns await future research. First is the importance of investigating knowledge of other functional (versus major lexical) categories (e.g. look at other items which have theoretical ties to inflection. In this way, it could be determined if the deficit with regard to inflectional morphology was part of a larger deficit explainable on the basis of a specific theoretical distinction.

A second question to be addressed concerns the final attainment of the adult grammar. While this dissertation sought to evaluate the linguistic knowledge of FLHD subjects during the developmental years, it remains to be seen whether or not the subjects evaluated here will ever attain the adult grammar in the areas in which they showed normal but slightly delayed performance (e.g. performance with respect to Binding Principle B). Thus, it would be of interest to evaluate these subjects or others like them in early adulthood to determine if they eventually were able to demonstrate competence in the areas in which they demonstrated deficits in childhood. This would be of interest for all of the types of data collected here, in that it is possible that their deficits with regard to the grammatical periphery would eventually disappear due to the protracted acquisition which nevertheless resulted in attainment of adult-like competence.

A third question relates to the choice of subjects. While damage to the left hemisphere is assumed to underlie most language problems in adults, we have not yet documented the specific grammatical effects of damage to either hemisphere of the brain. Thus, it could be the case that damage to either hemisphere could lead to the types of deficits found here. Assessment of the knowledge of children with early right hemisphere damage would allow us to address this question, and deepen our understanding about the brain-language relationship early in childhood.

A fourth question generated by this work relates to the lexical deficit. The primary focus of this work was on morphosyntax rather than on the lexicon. However, in the formal test data we were presented with an intriguing picture of impaired performance on tests of single word comprehension and production (confrontation naming), but with a hint of normally organized and accessed lexicon (resulting in appropriate performance on the word-fluency measure. This suggests that future work on the lexical knowledge of focally brain damaged children could address the question as to the nature of their apparent lexical deficit. Specifically, is their lexical deficit largely semantic or morphosyntactic in nature? With respect of semantic information, is it the case that, given their difficulty in learning new material, they simply are unable to learn the appropriate number of lexical items expected for their age, but are able to integrate and organize what they learn into the appropriate semantic field? A lexical analysis of their spontaneous speech samples would also provide data relevant to the question of their lexical integrity.

Finally, information concerning the nonlinguistic cognitive abilities of FLHD subjects would be relevant to questions concerning the independence of language from other aspects of cognition during development. It is possible that the variability of the test performance of these subjects can be linked to specific nonlinguistic cognitive factors (e.g. memory, attentional factors or even overall nonlinguistic intelligence). While this is outside the scope of this project, information regarding some of these nonlinguistic cognitive abilities would complete the picture of what is impaired in this type of brain damage, and what the relationship is between linguistic and nonlinguistic cognitive abilities during development.

5.6. SUMMARY

This dissertation has focused on the grammatical knowledge of children following focal left hemisphere damage early in life. To summarize, it was found that) most of the subjects demonstrated deficits on formal tests of lexical knowledge, and all demonstrated deficits on formal tests of morphosyntactic knowledge. The deficits varied in severity across subjects. With respect to morphosyntax, their patterns of performance were not simply that of a developmental delay in that they did pass some "older" items and yet fail some of the "younger" items. Further, it appeared that different structures were problematic for different children, with all subjects failing too many tests overall to attain an appropriate age level on these tests.

On experimental measures the FLHD subjects were found to demonstrate knowledge of some of the core principles of syntax investigate here (recursion in NP and VP, NP movement in passive constructions, and, for some subjects, PRO in adjuncts). The areas of the grammar where the FLHD subjects demonstrated fairly consistent deficits were the Binding Theory, with some subjects having an apparent dealy in interpreting PRO in adjuncts and one subject had no evidence of knowledge of relative clauses. At least for Binding, it is hypothesized that a possible basis for this deficit relates to a lexical problem; these items are simply not specified in the lexicon for type of nominal. Likewise, interpetation of PRO with the verb *promise* is taken to reflect a deficit in lexically-specified grammatical information about control.

Knowledge of certain aspects of verbal inflection also appear to be compromised following FLHD. Spontaneous speech data support the patterns observed on the formal test data. It was also found that the performance of the FLHD subjects differs significantly from that of the controls in terms of the variability of the FLHD subjects across tasks.

Finally, age at onset does not appear correlated with degree of deficit on either the formal test data or on the experimental tasks, although the issue of age remains a somewhat unanwered question given the sample size.

This dissertation is a first step towards re-examining the data from brain-injured children in a way which is motivated by theoretical distinctions which can help us to more thoughtfully evaluate the nature of their linguistic deficits. Further, it is apparent that methodological choices can have important consequences for how we view the gramamtical knowledge of these children, and for all individuals who might reveal something about the way that linguistic knowledge and the brain are intertwined in development as well as in the mature state.

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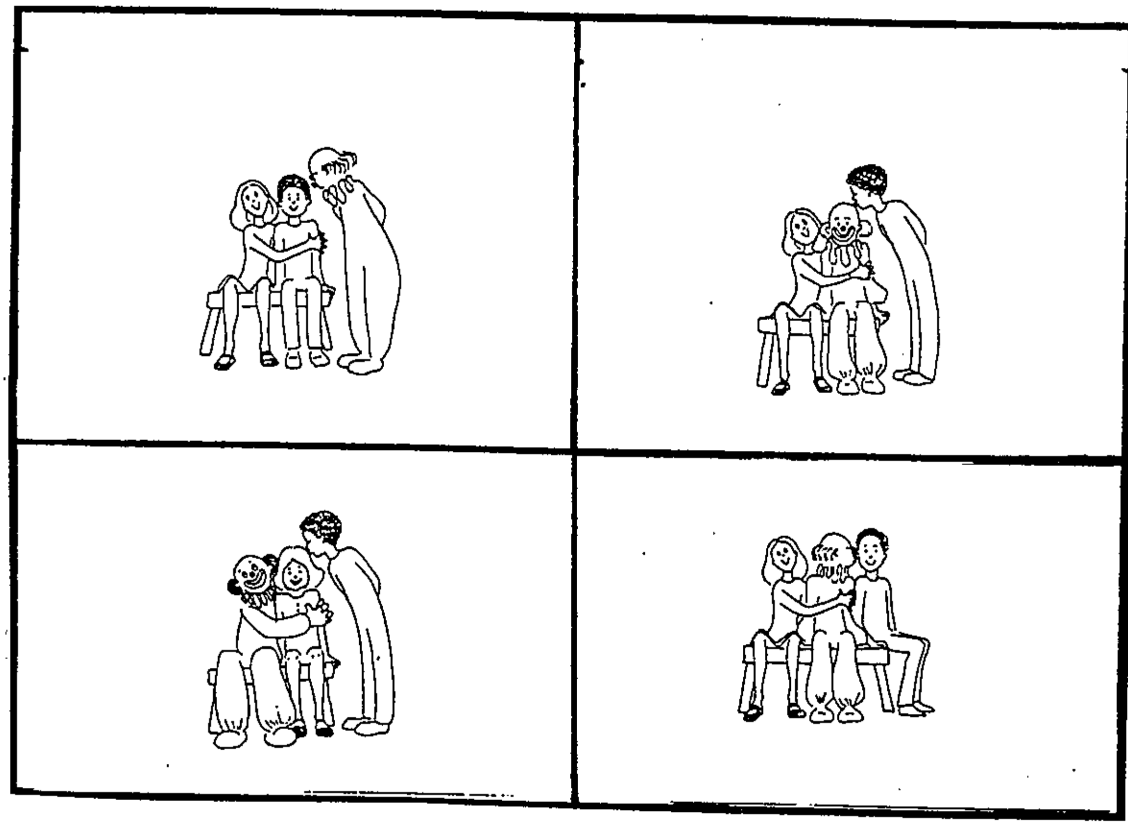
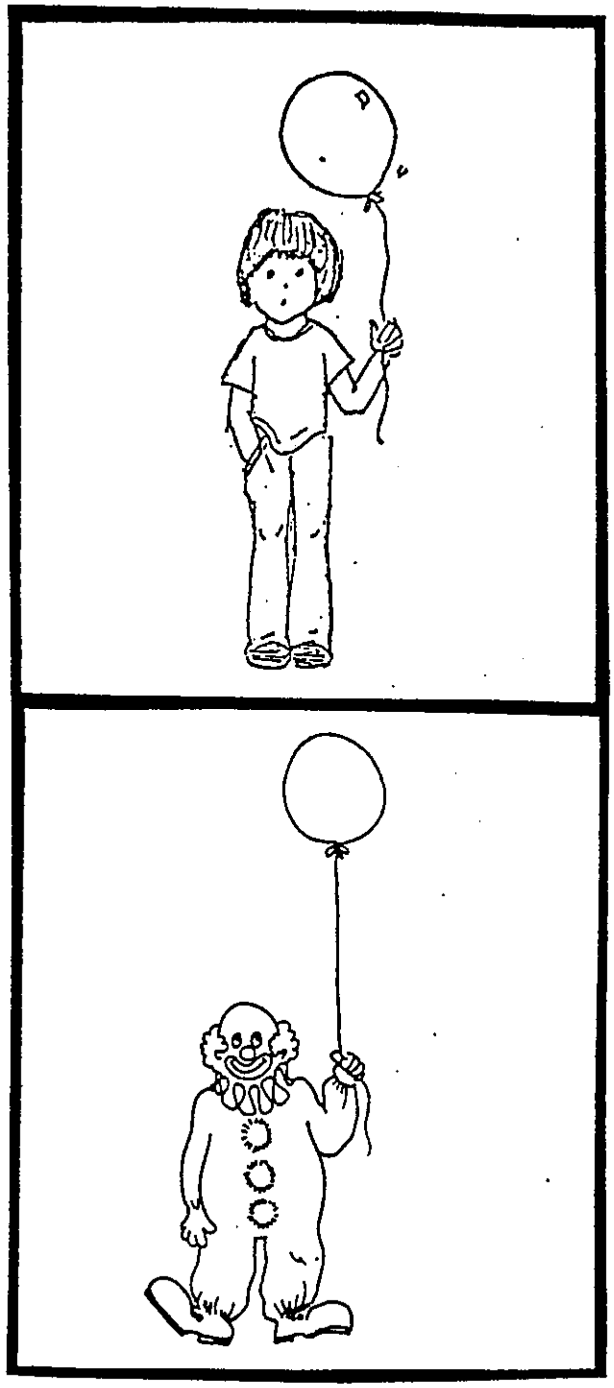
APPENDIX A: SAMPLE CYCLE-R AND CYCLE-E ITEMS



CYCLE-R: Object relatives with relativized object
"The girl is hugging the clown that the boy is kissing."



CYCLE-E: Relativized object
"A boy is holding one balloon. A clown is holding the other balloon. This is the balloon________"
(Target: "that the clown is holding; the clown has"

CYCLE-R AND CYCLE-E TESTS BY AGE LEVEL

CYCLE-R

Level 2 (not given to any of the subjects)

Level 3

Simple modification
Complex modification
Dysjunction
Lexicon: Action II
Lexicon: Description II
Lexicon: Reference III
Locative prepositions: In front of/in back of I
Locative prepositions: In front of/in back of II
Object pronouns: me/you
Possession

Level 4

Comparatives with -er
Active voice word order
Double embedding I
Lexicon: Action III
Lexicon: Description III
Locative prepositions: Under/next to I
Noun singular/plural
Superlatives with -est
Third person object pronouns
Wh-subject questioning
Passive voice word order
Quantifiers: None
Subject (S-S) relative clauses

Level 5

Before and after I
Case-marking prepositions: to
Complex negation
Locative prepositions: Under/next to II
Locative prepositions: In front of/in back of III
Passive voice word order II
Possessive adjectives
Quantifiers: Many
Reflexive pronouns
Tense and aspect: -ing
Wh-object questioning

Level 6

Aux-be pluralAux-be singular
Case-marking prepositions: For
It vs. other third person pronouns
Locative prepositions: Under/next to III
Third person subject pronouns
Tense and aspect: -ed
Tense and aspect: gonna
Verb singular

Level 7

Before and after II
Case-marking prepositions: By
Case-marking prepositions: From
Case-marking prepositions: With
Double-embedding II
Possessive morpheme 's
Subject relatives ending in NV
Subject vs. object pronouns
Tense and aspect: will

Level 8

Object clefting
Object (O-S) relative clauses
Story comprehension
Verb plurals

Level 9+

Complex semantics
Negative passive
Object relatives (O-O) with relativized object
Relative pronouns with double function

Level 2

Locative prepositions: On
Noun singular
Active voice word order
Simple negation

Level 3
Comparative -er
Locative prepositions: In back of
Possessive adjectives: His, her
Direct object-indirect object
Superlative -est
Tense/aspect: -ed
Subject pronouns: He
Case-marking prepositions: To
Simple declaratives

Level 4

Subject pronouns: They, she
Modals: Can/may, do
Future conditionals
Quantifiers: Any
Possessive morpheme: 's
Verb plural
Negative modals: Don't

Level 5

Noun plurals
Aux-be plural
Aux-be singular
Locative prepositions: in front of
Verb singular
Tense/aspect: Be + -ing
Case-marking prepositions: of
Embedded negation
Negative modals: Won't

Level 6

Negative past modals: Couldn't
Past participles: -en
Relativized subjects
Case-marking prepositions: With

Level 7

Case-marking prepositions: From

Past tense modals: Could
Reflexive pronouns: Herself, himself
Tense/aspect: Be + gonna/will
Negative past tense modals: Wouldn't
Relativized objects
Subject pronouns: It [-animate]
Counterfactual conditionals

Level 8

Case-marking prepositions: By, for
Passive past participle: Been + -ed
Passive voice word order

Level 9+

Promise/ask/tell
Negative past tense modals: Shouldn't
Past tense modals: Would

APPENDIX B:
CYCLE TESTS USED IN THE MORPHOSYNTAX BATTERY

Recursion in NP: Relative clauses

CYCLE-R:

Subject (S-S) relatives

The boy who is mad is pulling the girl.

Object (O-S) relatives

The girl is chasing the clown who is happy.

Object relatives (O-O) with relativized object

The girl is kissing the boy that the clown is hugging.

CYCLE-E:

Relativized subjects

One of these girls painted a picture. One of these girls opened a present. This is the girl __________ (Target: *that opened the present, who opened the present*)

Relativized objects

A boy is holding one balloon. A clown is holding another balloon. This is the balloon __________ (Target: *that the clown is holding, the clown has*)

Binding: Principle A

CYCLE-R:

Reflexive pronouns

The boy is washing himself.

CYCLE-E:

Reflexive pronouns

Here the mother is dressing the baby. But here the mother is dressing __________
(Target: *herself*)

Binding:Principle B

CYCLE-E:

Subject pronouns

I'm going to tell you about this girl. She is eating. Now you tell me about this boy.

__________ (Target: *He is eating, he's doing it, too*)

PRO and Control: Complements

CYCLE-E:

Tell

Amy told Mark to feed the dog. Exactly what did Amy say? __________
(Target: *Feed the dog.*)

Promise

Craig promised Tammy to take out the garbage. Exactly what did Craig say?
__________ (Target: *I'll take out the garbage tomorrow*)

NP movement and the passive

CYCLE-R:

Passive II

The boy is being pushed by the girl.

CYCLE-E:

Passive Voice Word Order

Here the girl is chasing the boy. But here the girl __________

Target: *is being chased by the boy; is getting chased.*

Verbal morphology and aux

CYCLE-R:

Tense/aspect -ing

The man is sewing the shirt.

Tense/aspect -ed

The girl painted the picture.

Tense/aspect will

Someone will tie the shoe.

Tense/aspect gonna

The boy is gonna eat his dinner.

CYCLE-E:

Tense/aspect -ed

Here the boy is getting ready to pour the juice. But here the boy already __________ (Target: *poured the juice, poured it*)

Tense/aspect be + -ing

Here the girl is getting ready to open the present. But here, the girl __________ (Target: *is opening it, is opening the present*)

Tense/aspect be + gonna/will

Look, this boy has a dirty face, and he's reaching for the soap. What's about to happen? __________ (Target: *He's gonna wash his face; he will get clean*)

APPENDIX C:
SAMPLE ITEMS FROM THE TEST PROTOCALS

I. ANIMAL ENACTMENT TASK

Training items

Active S
  Gumby kisses the bear.

Passive

Simple S
  The bear was bumped by the girl.

Reflexives

Simple S
  Gumby is patting himself.

Infinitival complement
  Pokey tells the deer to look at himself.

Pronouns

Simple S
  The robot is washing him.

Infinitival complement
  Gumby tells Pokey to pat him.

Backwards anaphora

Simple S
  He washed Gumby.

That-complement matrix pronoun
  Gumby tells him that the robot will jump over the fence.

Relative clauses

SS relative, stative verb
  The girl that has a present jumps over the fence.

SS relative, active verb
  The elephant that hops up and down goes into the house.

OS relative, 2 NP's, 2 active verbs
  Gumby hits the bear that hops up and down.

OS relative, 2 NP's, 1 active verb, 1 stative verb
  The horse bites the girl that has a present.

OS relative, 2 active NP's; 1 inactive NP
  The bear hits the elephant that knocks over the tree.

OS relative, 3 active NP's

The girl kicks the horse that jumps over the bear.

OO relative
The girls kicks the bear that the cowboy hits.

Control

Tell + infintival complement
The lion tells the bear to jump over the fence.

Promise + infinitival complement
The girl promises Gumby to go into the cage.

Adverbial complements

DO + adverbial temporal
The elephant pushes the lion before jumping over the fence.

PP + adverbial temporal
The camel stands near the bear before hopping up and down.

II. ANIMAL DESCRIPTION TASK
(target structures)

Part 1: Binding and Control

Training items

Active voice (Training items)
  Gumby kisses the bear.

Pronouns

Simple S
  The robot is washing him.

Infinitival complements
  Gumby tells Pokey to pat him.

Reflexives

Simple S
  Gumby is patting himself.

Infinitival complements
  Pokey tells the deer to look at himself.

Control

Tell + infinitival complements
  The lion tells the bear to jump over the fence.

Part 2: Object relatives

OS relatives
  Pick up the cowboy that is tickling the bear.

OO relatives
  Pick up the bear that the girl washed.

III: JUDGEMENT/PROBE TASK

Training items

1. The tree are green.
2. The babies is crying.
3. Climbing the lion is the tree up.
4. Is green grass the.
5. The boy is eating.
6. Is jumping over the fence.
7. Pushing the bear.
8. The girl is happy.

Reflexives

Simple

The bear is washing himself.

Judgement: Good or bad

Probe: Who got washed?

Could it be _____?

Could it be _____?

Infinitival complement

Pokey tells the deer to look at himself.

Judgement: Good or bad

Probe: Who got told something?

Could it be _____?

Could it be _____?

Ungrammatical simple

I am washing himself.

Judgement: Good or bad

Probe: Who got washed?

Could it be _____?

Could it be _____?

Ungrammatical long

The horse washes the deer before the gate bumps himself.

Judgement: Good or bad

Probe: Who got bumped?

Could it be _____?

Could it be _____?

Ungrammatical subject

Himself is jumping up and down.

Judgement: Good or bad

Probe: Who is jumping?

Could it be _____?

Could it be _____?

Pronouns

Simple S

Gumby is patting him.

Judgement: Good or bad

Probe: Who got patted?
Could it be _____?
Could it be _____?

Infinitival complement
Pokey tells the cowboy to wash him.
Judgement: Good or bad
Probe: Who got washed?
Could it be _____?
Could it be _____?

Backwards coreference

Simple S
She is looking at the girl.
Judgement: Good or bad
Probe: Who is looking?
Could it be _____?
Could it be _____?

That-complement matrix pronoun
Gumby tells him that the robot will jump over the fence.
Judgement: Good or bad
Probe: Who got told something?
Could it be _____?
Could it be _____?

Control structures

Tell
The lion tells the bear to jump over the fence.
Judgement: Good or bad
Probe: Who jumped over the fence?
Could it be _____?
Could it be _____?

Promise
The cowboy promises the robot to sit down.
Judgement: Good or bad
Probe: Who sat down?
Could it be _____?
Could it be _____?

DO + adverbial temporal
The robot tickles the bear before bumping into the tree.
Judgement: Good or bad
Probe: Who bumped the tree?
Could it be _____?
Could it be _____?

PP + adverbial temporal
The bear jumps over the girl before bumping into the cage.
Judgement: Good or bad
Probe: Who bumped the cage?

Could it be _____?
Could it be _____?

APPENDIX D:
EXCERPTS FROM THE SPEECH SAMPLES OF THE FLHD SUBJECTS

Note: In these excerts from the speech samples, the speakers are labeled as "E" for the examiner, and with the appropriate first initial for the child.

1. Sample from WB (CA = 7-6)

E: Money doesn't grow on trees. I wish it did. Be helpful, wouldn't it?

W: I wish it grew, um, right over there on the front lawn, on the back lawn.

E: What would you do if you had a money tree?

W: I'd run over and get all the money off. And put it in the bank.

E: And then... and then what?

W: And then, I'll keep it in the bank forever.

E: Would you buy anything with it?

W: Buy a new car.

E: Anything else?

W: Nothing else.

E: Nothing? How about Hot Wheels or...

W: I don't even know what Hot Wheels are.

2. Sample from SR (CA = 13-2)

E: What happened on your last birthday?

S: I'm supposed to go to Magic Mountain. I never got to yet.

E: Why?

S: My mom won't take me.

E: She wouldn't take you? She's incredibly mean!

S: I'm get, I want her to take me.

E: You know, I've never been there.

S: I'm gonna make her take me tomorrow. That's what I might think about. I might think about making her take me. I'll beg and beg tonight.

Until she says...

S: (Interrupts, speaking to his friend who is listening to us)
Yeah, if you spend... the only thing is, you spend the night. It's, the, /w/, whoever spends the night can go. It's the only thing. I'm leaving early.

3. Sample from MB (CA = 5-9)

E: What do you like [to eat]??

M: I (unintelligible) like cereal, and they, I don't like vegebles.

E: You don't like vegetables and you don't like cake.

M: No.

E: Do you like fruit?

M: I like grapes.

E: Uh-huh.

M: Or not, only, only jui... not orange juice, white milk or juice.

orange

E: Uh-huh.

M: Or I like, uh, or I eat, sometimes I eats, uh, tuna and rice.

E: Tuna and rice.

M: Uh-huh.

E: I like rice a lot. Rice is good for you.

M: Sometimes I see the Transformers.

E: Do you? On TV?

M: Yeah, but you know what happens?

E: What?

M.: All the Megdoplex tacks the, the bad-guy robots. Megdoplex could bad guy. And he could swing...I remember I saw two of the good robots, and the, one of them, and then they 'tack him and then he was transform to cars.

swing the

4. Sample from NA (CA = 6-3)

E: I noticed something about your teeth.

N: I know.

E: What happened?

N: What?

E: What happened?

N: They fa... fell out.

E: They fell out. Well, that's good because I see some big adult teeth underneath.

N: I, not, these are coming in, straight in. I already lost this. I got to lose this one but I got this out. I think it's coming in.

E: Then you will get your adult teeth.

N: And I got this out.

E: Oh.

N: It never growed in.

5. Sample from FC (CA = 10-1)

E: Tell me about your eyes. What happened when you went...

F: (Interrupts) The doctor, um, had, I had surgery on my eyes. The doctor did it.

E: What happened? What was that like?

F: He put me to sleep.

E: Did you dream?

F: No.

E: No, a different kind of sleep, I bet. Then what?

F: Um, after he's finished with my surgery, he woke me up.

E: After he's finished with your surgery he woke you up. Uh. and then how did you feel? Did you feel sleepy? Did it hurt? How did it feel?

F: No, um... un, I gotta wake, um, they, they show, they let me see Messy Tessie.

E: Messy Tessie. I know who that is. That's one of those Garbage Pail Kids, isn't it? No? What is it?

F: It's, it's a lady he helps Alice.

6. Sample from JL (CA = 12-7)

E: Can you tell me a little bit more about your family? I did meet Jennifer, who is right here.

J: Yeah. There's one people who lets me use his radio.

E: What's his name?

J: Justin.

E: Justin.

J: I mean Jason.

E: Jason. And he is the one who's seventeen, right?

J: Yeah. And Justin's fourteen.

E: Fourteen, OK.

J: He's the one I hate.

E: Well, I guess that's pretty typical. Where are they today?

J: Jason, at his friends, somewheres, near the beach somewhere.

E: Oh, yeah?

J: 'Cause he always goes there. They buy pizza. He works at Sizzler for a job.

4.3.1 Overall comparison of performance of control subjects vs. FLHD subjects

Recall that the measures used for the collection of the syntactic data included two comprehension measures (the Act-out and the CYCLE-R, the latter being primarily a picture pointing test), two elicited production measures (the elicitation, a sentence generation task, and the CYCLE-E, a cloze task) and a metalinguistic (judgement) task.

The performance of the FLHD subjects and their controls was compared using paired t-tests. Note that the CYCLE data are not included here. Table 3 presents the data for the t-tests for each aspect of grammar investigated here, with the results presented by type of assessment procedure. As the data with regard to verbal complements are derived from sponaneous speech, these data will not be included in this section.

Table 3: Matched pairs t-tests for specific aspects of grammar

Aspect of grammar	Assessment procedure			
	Act-out	Judgement	Elicitation	CYCLE-E
Recursion in NP: relative clauses			*	
Binding A		*		
Binding B	**			
Binding C				
Control		*		
NP movement the passive				XX

* significant at $p < .05$ two tailed
** significant at $p < .01$ two tailed
XX not enough data for analysis

As can be seen from the table, the FLHD subjects do differ from the controls on some measures, but do not do so consistently for a given aspect of grammar, nor on a particular type of task. It is interesting that on formal tests of grammatical knowledge all subjects show at least a slight delay in performance expected for their age, while on the experimental battery (the tests used here to assess specific aspects of syntactic knowledge) no consistent deficit is seen. Groups comparisons, then do not consistently support Hypothesis 1a; however, group comparisons do not address the question pf tje structure of each individual subject's grammar. This will be the goal of the following chapter (Chapter 5).

Two additional analyses were performed on the group data which focus on the effects of age at onset and the effect of age at testing.

4.3.2 Effect of age of onset

As Hypothesis 2 concerned the effect of age of the onset of neurological damage, an ANOVA was performed comparing groups I, II and II on all relevant scores. No significant results were found between the groups. Thus, Hypothesis 2 was not supported: age at onset of damage did not affect acquisition of grammatical knowledge (syntactic or morphological knowledge). A certain amount of caution must be used in interpreting the results due to the small number of subjects; future research of this sort will be required to determine if the groups continue to demonstrate insignificant differences in performance. This point will be returned to in the discussion in Chapter 6.

4.3.3 Effect of age at time of testing

Given that this study included children of varying ages, it is important to establish that age at the time of inclusion in the study was not a factor by which performance could be characterized (e.g. it was important to rule out the possibility that the youngest children did the worst in order to address questions concerning the effects of the age at onset of symptoms). In order to rule out a possible effect of age (CA) as a variable in the results, a regression analysis was done for each measure (e.g. Control-act out, Control-judgement, Control-elicitation, etc.). No relationship between CA and any linguistic score was found ($p > .01$). Thus, linguistic performance could not be predicted on the basis of CA at time of testing, and it was not the case that the youngest subjects did the worst. This is a finding especially relevant for theories which propose that specific linguistic principles *mature*, in that there was no significant relationship between chronological age and performance on this battery. This will also be discussed further in Chapter 7.

4.3.4 Overall performance on specific test modalities

One question of interest in doing these group comparisons is the extent to which one or other of the tasks can be seen to be "easier" for either the control or FLHD subjects. Table 4 presents the overall percent correct on the three experimental tasks. Matched t-tests were used to analyze overall task performance differences between the controls and the FLHD subjects.

Table 4: Overall percent correct on experimental tasks

	Controls	FLHD subjects
Act-out task**	94.67%	78.67%
Judgement task*	85.57%	67.50%
Elicitation task	98.17%	90.16%

** Significantly different at $p < .01$ two-tailed
* Significantly different at $p < .05$ two-tailed

The act-out task was the area in which performance differed most significantly between the two groups, with the elicitation task (apparently the "easiest" for both groups) showing no significant difference. The judgement task was clearly the most difficult of the three tasks for both groups.

4.3.5 Comparison of performance across test modalities: Consistency of performance

One final concern addressed here is the extent to which performance on any given syntactic structure is the same across tasks. This question is relevant to hypothesis 3, which proposed that the FLHD subjects in particular would have performance which varied according to the task type, implicating processing deficits rather that representational deficits. No significant correlation was found for the controls or the FLHD subjects for performance on the same type of structures across tasks. Thus, not only did task type influence performance for the FLHD subjects; it also affected the performance of the normal control subjects, who as a group did performed better on the act-out, judgement and elicitation tasks overall.

This is less surprising than might be expected if you consider the task requirements imposed by each of the assessment procedures. Each task allows for probing syntactic knowledge under slightly different conditions. During comprehension tasks (the enactment task and the CYCLE-R), the subjects are required to listen and interpret the structures at hand while faced with several possibilities of the correct interpretation (eg. the alternative characters on hand for the enactment task, and the foil pictures in the case of the CYCLE-R). During the judgement task, the subjects are presented with sentences about which they make grammaticality judgements as well as answering probe questions about the possible referents for NP's. The judgement task includes structures that are ungrammatical for adults as well as grammatically correct structures, assessing the extent to which the children's judgements allow for possibilities which are "outside" the limits of the adult grammar of English.. The production tasks require the children to formulate appropriate structures that describe a stimulus situation (the description task) or picture (CYCLE-E), or which appropriately fit into ongoing conversation. Thus, each task has its own set of extralinguistic as well as linguistic requirements, and it would be surprising if performance of brain-damaged individuals was equivalent across all domains.

4.4 SUMMARY

The group comparisons in this chapter are relevant to a number of the hypotheses in Chapter 1. Each of these is reviewed in turn.

Hypothesis 1: Early focal left hemisphere damage will result in deficits on standardized tests of lexical and grammatical knowledge. This hypothesis was supported by the formal test data.

Hypothesis 2: Age at onset will affect the nature and extent of the deficits in knowledge of grammar. This hypothesis was not supported by the data, although it is important to remember the relatively small N in the study.

Hypothesis 3: Performance of the FLHD subjects will vary according to task type. This hypothesis was supported, with the interesting additional note that the performance of the controls, who did better overall on the judgement, act-out and elicitation tasks, nevertheless also showed some variability in their performance. Further, specific tasks were "easier" for both groups (e.g. the elicitation task).

In addition, the group comparisons revealed that age at time of testing was not a variable affecting performance.

In Chapters 5 and 6 the performance of the subjects individually for each section of grammar will be considered. This will be the data relevant to the remaining (key) hypotheses (1a and 1b); namely, those hypotheses which address the abilities , and review the underlying reasons for differences in performance within subjects across assessment procedures.

CHAPTER 5

CORE PRINCIPLES OF SYNTAX

5.1 OVERVIEW

In this section the data relevant to Hypothesis 1a will be presented; namely, data from tasks designed to evaluate the subjects' knowledge of core principles of grammar. The principles of interest are: recursion (in NP and VP), the Binding principles, interpretation of PRO and control, and NP movement (in the passive).

A few points should be noted about the representation of the data in the sections that follow. The data are generally presented in terms of percentages of correct responses, with the total number of items per task given at the top of each column. The exception to this is the judgement/probe task, where responses are usually given as "+" or "-" (since there is often only one item of this type used). The control subjects were not given the CYCLE; thus, this column will be blank for them. Finally (as will be noted where relevant) the controls sometimes demonstrated 100% correct performance on a task; their data is not presented in the table in this case.

5.2 RECURSION

5.2.1 Recursion in NP: relative clauses

Recall that there are three types of relatives used to investigate this aspect of syntactic knowledge:

1) (SS type) The horse that dances jumps over the cage.

2) (OS type) The bear hits the elephant that knocks over the fence.

3) (00 type) The deer bumps the horse that the robot tickles.

Recall that initially (before age 5) comprehension of OS and OO relatives may be incorrect, with the matrix subject being interpreted as coreferential with the embedded subject in some types of stimuli, and that there was evidence that active vs. stative verbs as well as the number of full lexical NP's in the sentence were found to affect processing in normal children (Hamburger and Crain, 1982; see Appendix D for list of all stimuli types). The data will be presented for all OS, OO and SS sentences in the following tables; however, we will return to the issue of the number of NP's in the discussion of the error types.

For this construction type it appeared to be especially useful to separate the production data from the comprehension/judgement data, as different patterns of performance were observed for each type. Thus, Table 1 presents the comprehension data on relative clauses (in terms of accuracy and types of errors encountered). Note that the control subjects performed with 100% accuracy on the comprehension and judgement tasks; the tables include only the FLHD subjects' data. Also it should be remembered that the object relative clause stimuli on the act-out varied in the number of lexically full NP's they contained, as this has been found to have an effect on the performance of nonimpaired children (Hamburger and Crain, 1982); this point will be returned to in the discussion of the error types found.

Table 1: Comprehension and judgement data on relative clauses

Subject	Act-out			CYCLE-R			Judgement/Probe	
	SS (6)	OS (12)	OO (3)	SS (5)	OS (5)	OO (5)	SS (1)	OS (1)
1. WB	100%	100%	100%	100%	60%	20%	+	+
2. SR	100%	100%	100%	100%	NG	NG	+	+
3. MB	100%	75%	67%	100%	NG	NG	+	+
4. NA	100%	100%	100%	100%	NG	NG	+	+
5. FC	100%	92%	100%	100%	100%	0%	+	+
6. JL	100%	92%	67%	100%	100%	60%	+	+

Key:

NG = not given due to age (below expected age norms)

Looking at the table above, it is clear the the grammars of all of the children allow for recursion of S. There were no errors in comprehending subject relative clauses. Both

OS and SS relative clauses were judged/interpreted correctly on the judgement task. Object relatives tasks (OS and OO) elicited more errors; however, all of the errored responses occurred on stimuli containing three full NP's. This was attributed to some difficulty with processing three full NP's in previous studies of normal children. I will argue here that most if not all of the errors made by the FLHD subjects constitute processing errors rather than specific linguistic deficits.

Looking at the types of error responses on OS and OO relatives, several types of errors were noted. First, there was the (previously reported) pattern of the embedded subject being coreferent with the subject of the matrix clause (cf. Goodluck and Tavakolian, 1981), as evidenced by MB:

4) The cowboy bumps the bear that jumps into the house (interpreted as *the cowboy bumps the bear; the cowboy jumps into the house*)

However, the subjects also made two other types of errors not attested by the literature and not found in the control data. The first is interpreting OO relatives as OS relatives, as in the case of WB and JL:

5) (JL) The girl kicks the bear that the cowboy hits (interpreted as *the girl kicks the bear; the bear hits the cowboy.*)

This second strategy would appear to an unusual structural analysis; however, it is proposed here that they are more accurately analyzed as belonging to the final group of errors, termed here processing errors, where the subjects respond as if they had heard a different stimuli sentence altogether, as in:

6) (JL) Gumby tickles the girl that bumps into the fence (interpreted as *Gumby gets tickle by the girl; Gumby bumps into the fence*).

7) (MB) Gumby kisses the elphant that the bear washes (intepreted as *Gumby kisses the elephant; the bear washed self*).

Several facts indicate that these are not problems with embedded structure but rather reflect processing difficulties. First, these responses are the exception rather than the rule; all subjects interpreted at least some of the OO and OS relatives correctly. Secondly, they occurred on sentences containing three full NP's, already noted to be difficult for nonimpaired young children. Third, any subject who made more than one error (WB, MB, and JL) made at l least two types of error. Thus, it was not the case that they had an alternative strategy or analysis which could be seen to underlie their responses.

As can be seen above, two of the subjects (SR and NA) made no comprehension errors, while four made errors attributable to processing difficulties, perhaps related to overloaded short-term memory. The processing difficulties were not clearly related to specific grammatical structures or to constistent but incorrect grammatical analyses. Thus, while performance varied somewhat according to task demands, all of the subjects were able to comprehend/interpret relative clauses, including relatives in which the grammatical role of the head of the matrix and the subject of the embedded clauses differ.

Now we examine the production data concerning relative clauses, which are summarized in Table 2. In order to examine all possible data with regard to recursion in NP, the speech data also includes relativized NP's (where the NP is not the subject or the object of a clause):

8) C: And who is that, on the phone? Someone...

(FC) *Someone who needs a pizza.*

and "headless relatives", the precursors to true relative clauses produced earlier in development by normal children:

9) (SR) *That is what I said.*

Table 2: Production data on relative clauses

Subject	Elicitation		CYCLE-E		Spontaneous speech			
	OS (3)	OO (3)	OS (2)	OO (2)	rel NP	headlessSS rels	OS	OO
FLHD:								
1. WB	100%	33%	100%	100%				+
2. SR	100%	0%	50%	100%		+		+
3. MB	0%	0%	NG	NG				
4. NA	100%	100%	0%	100%			+	+
5. FC	67%	0%	0%	100%	+	-		
6. JL	100%	0%	100%	0%	+		+	+

Controls:								
1. SF	100%	100%					+	
2. KY	100%	100%				+	+	+
3. SS	100%	100%						
4. SM	100%	+*			+			
5. JP	100%	100%					+	
6. CL	100%	100%					+	+

Key:
+ = produced a well-formed example
- = produced ill-formed example
NG = not given due to age
* = one response was off-target

As noted in Table 2, all FLHD subjects but MB produced some relative relative clauses in their spontaneous speech samples, and, specifically, produced object relatives on at least one elicitation task. Some of these were "headless" relatives of the type produced by normal children early in development, as in 9) above, or NP's with an accompanying relative clauses, as in 8) above. However, there were also full relatives, with most/all of the data from the speech samples were object relatives, as might be expected from the normative literature. e.g. OS rels:

10) (NA) *He's the one that lives by the church.*

And OO rels:

11) (NA) *Paces are things you work on.*

12) (LB) *Look at all the money they have there.*

These appear to be comparable to some of the constructions produced by the controls, such as:

13) (CL) *It's like a race car he's gonna put on a track.*

However, while the subjects did produce a variety of well-formed relativized structures, many of the subjects produced errors on the production tasks. These errors are characterized as follows:

a) word strings, as in:

14) (MB) Target: The horse that the camel is tickling --> *"The horse... the tickling the horse.*

b) frame violations, where the subject rejected the frame of an elicited production item and began a different clause:

15) (FC) Target: (Pick up) the bear that the girl is tickling --> *"Pick up the bear that is... the girl tickles the bear.*

c) presence of a resumptive pronoun, where the embedded sentence contained movement without deletion (an option legal in some languages):

16) (WB) It's the horse that the camel is tickling him.

d) failure to relativize, e.g.:

17) (FC) Cue: This is the boy...

Response: *"he washed his face"*

18) (FC) It's, it's a lady he helps Alice.

Although not in any of the samples of the normal controls here, this last type of error has been attested in the spontaneous speech of normal children (e.g. examples in Curtiss and Jackson, accepted for publication). It should be noted that this was the only error found in the spontaneous speech data (from only one subject, FC, who also did produce a relativized NP in one other instance).

Table 3 below lists the distribution of these error types across the subjects.

Table 3: Distribution of error types on the relative clause production data

Subject	Error types: Word strings	Frame violations	Resumptive pronoun	Failure to relativize
1. WB		+	+	
2. SR		+	+	
3. MB		+		
4. NA	+			
5. FC		+		+
6. JL		+	+	

Thus, while the FLHD subjects could produce relativized structures, they differed from the controls in that they produced ill-formed structures. It is important to note that these errors were primarily on the elicited data; FC is the exception to this, as he failed to relativize one of his two relative constructions in spontaneous speech, as in example 18 above).

For the remaining subjects, elicited production tasks led the subjects to produce word strings (NA), constructions with resumptive pronouns (three subjects) or frame violations (5 subjects). However, 5 of the 6 FLHD subjects produced at least one well-formed relative in spontaneous speech, indicating that perhaps task demands on the elicitation tasks were such that the FLHD subjects were unable to formulate correct responses.

To summarize, the data from all tasks are presented in Table 4.

Table 4: Comparison of relative clause data across tasks

Subject	SS rel/ relativized NP			OS rel			OO rel	
	Comp	Prod	Judg	Comp	Prod	Judg	Comp	Prod
1. WB	+		+	+	+	+	+*	+*
2. SR	+		+	+	+*	+	+	+*
3. MB	+		+	+*	-	+	+/-	-
4. NA	+		+	+	+*	+	+	+
5. FC	+	+	+	+*	+/-	+	+*	+*
6. JL	+	+	+	+*	+	+	+/-	+*

(Type of relative)

Note:
+ = 100% correct on all tasks
+* = some task variability, but still 100% correct on at least one task
+/- = variability on all tasks, but some correct responses
- = no correct responses

In summary, all subjects are able to comprehend and produce recursive structures in NP (as evidenced by performance on SS rels and ability to produce even simple relativized NP's (e.g. in response to a question in conversation). Three subjects show some task variability, but generally seem to be able to produce and comprehend OS and OO relatives (WB, SR, and NA). MB, the youngest subject, may differ from the adult grammar at this point; at age 5, his correct performance only where ES = MS is not far from that expected for his age, however (some of the norms have placed mastery of O rels at about age 4 years). This leaves FC and JL, who do evidence inconsistently poor performance with various O relatives. FC performs well (if task-variably) with OO relatives, but has some difficulty in producing OS relatives. JL performs well (if task-variably) with OS relatives; he has inconsistent performance with comprehension of OO relatives regardless of task types. Thus, all subjects have recursion; three have difficulty with interpretation of empty elements and/or in producing structures with a null NP in the appropriate place (for one subject, this is age appropriate). These subjects thus use a resumptive pronoun or avoiding the structure altogether. In one case (FC) there appeared to be an inconsistent failure to overtly relativize the second clause in the sentence, with the relative "that" missing.

Two additional points are worth mentioning here. First, no uniform pattern of task performance was seen across all subjects, either for structure type or task type. The best constructions exemplyfying this lack of consistency across subjects which to judge this were OS relatives with two NP's and OO relatives, structures tested on all four tasks in three of the left hemisphere subjects. For WB, performance on the CYCLE-R was the poorest. For JL and FC, however, this was not the pattern displayed (FC made the most errors on the CYCLE-E for OS rels, but most errors on the animal description and the CYCLE-R for OO relatives, for example). Second, there were many examples where performance on one elicitation task was not representative of performance on the other elicited production task. The same was true for performance on comprehension tasks. The best example of this is FC, who comprehended 3/3 of the OO relatives on the animal enactment taks, but 0/5 OO relatives on the CYCLE-R. He produced 2/2 OO relatives on the CYCLE-E but none on the animal description task.

5.2.2 Recursion in VP: verbal complements

While a discussion of infinitival complements will be included in the discussion of PRO and control (section 5.4) and in the section on binding (section 5.3), a brief discussion will appear here concerning verbal complements in general by looking at infinitival as well as two types of non-infinitival complements: tensed (finite) complements and the complements of perception verbs (small clauses). In the previous section, we found that all of the subjects were able to comprehend/interpret structures with an IP or S embedded in NP (relative clauses); all subjects were but one were also able to produce relative clauses. However, verbal complements also constitute recursive structures, with the complement being either a tensed or infinitival S'.

Infinitival complements contain a phonologically null subject (recall the discussion in Chapter 2), as in:

19) I [told you [PRO to go]].
VP IP

Tensed complements simply have the second IP embedded in the matrix VP:

20) I [told you [that you should go]]
VP IP.

Following Stowell (1983), complements of perception and causative verbs are typically analyzed as "small clauses", nonsentential in that they lack INFL, but still containing an NP and VP sequence, as in:

21) You [made [[me] [do it]].
VP V* NP VP

The data with regard to verbal complements may be particularly helpful in a discussion of recursion in that while infinitival complements contain PRO as the subject of the embedded clause, tensed complements and small clauses have no relative pronouns nor phonologically null elements. Thus, the data on these types of constructions will be helpful additional evidence as to the extent to which the grammars of the FLHD subjects allow for embedded S's and thus recursion without some of the complicating factors encountered in the relative clause data.[1]

The types of verbal complements found in the spontaneous speech of the subjects are listed below in Table 5. The following types of complements were examined:

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1 The original focus of the section of recursion was exclusively on relative clauses. However, after examining the spontaneous speech data, it because apparent that the corpora contained a wide variety of verbal complements, and thus an additional and quite rich source of data with regard to the subject of recursion. Thus, for this section, there is only the spontaneous speech data and not the range of tasks typical for the other construction types seen in this chapter.

a) tensed that-complements (with or without complementizer; *I think (that) he goes to my school.*

b) indirect discourse (*I said "you are it"; he goes "you're kidding"*

c) small clauses (complements of perception and causative verbs; *I made it go; I see him go*)

d) wh-complements (also examined in the previous section as "headless relatives"; *I want what you have*)

e) infinitival complements (*I asked him to come here*)

Table 5: Verbal complements and small clauses found in spontaneous speech samples

Subject	Type of complement				
Subjects:	That compl	discourse	small clause	wh-comp	infin
FLHD:					
1. WB	+	+	+	+	
2. SR	+	+		+	
3. MB	+		+		
4. NA	+		+		
5. FC			+		+
6. JL		+			+
Controls:					
1. SF	+		+		
2. KY		+	+		
3. SS	+	+			+
4. SM	+	+		+	+
5. JP	+	+		+	+
6. CL	+	+			

Thus, all subjects used at least two of the types of complements examined here. It should be noted that no ill-formed complements were found; appropriate complementizers were used and complements were appropriate to the conversation at hand.

The following are some examples of the relevant structures, with one from both a FLHD (first example) and a Control subject listed.

- tensed that-complements (with or without overt complementizer):

22) (NA) *I think its coming in.*

23) (SF) *I think she's laughing.*

- discourse

24) (JL) *He'll yell "My mommy's gonna come."*

25) (SS) *She said "Cut it out".*

- small clauses

26) (WB) *Don't let it hit our car.*

27) (KY) *...and they don't really let you do anything.*

- wh-complements

28) (SR) *That is what I might think about.*

29) (SM) *That is why I always go out.*

- infinitival complements

30) (FC) *The man's telling him to get over the gate.*

31) (JP) *They showed them how to do stuff.*

To summarize, we now have evidence from two general types of constructions, both relative clauses and verbal complements, that the FLHD have recursion in both NP and VP. The question of how they deal with the empty element PRO will be returned to in section 5.4, but we have some "preview" evidence that at least two FLHD subjects can generate infinitival as well as finite complements. Thus, the grammars of the FLHD subjects allow for the generation of rich, complex utterances outside of the domain of the single clause.

5.3 BINDING OF OVERT NP'S

We will now consider the data individually for each binding principle.

5.3 Principle A

Recall that young children show improving performance on tasks assessing knowledge of Principle A from ages 2 to four years (Wexler and Chien, 1985; Jacubowicz, 1985; McDaniel et al., 1989; Solan, 1987). McDaniel et al. note that at least some children apparently go through a stage where reflexives are allowed to be subjects of sentences before arriving at the adult grammar. Hyams (1989) has suggested that children do know the binding theory, but do not know the domain in which binding takes place. In any case, children are able to demonstrate adult-like knowledge of Principle A by somewhere between the ages of 5 to 7 years.

For this aspect of grammar, both the act-out and judgement/probe tasks evaluate whether the child "knows" that reflexives are locally bound. Elicited production tasks (CYCLE-E and elicitation) essentially probe the reverse situation; namely, that in a situation where a reflexive is called for, does the child demonstrate knowledge of the appropriate domain for binding the anaphor, and is the child able to produce the appropriate lexical items. The judgement task also includes ungrammatical sentences, allowing further probing of the conditions under which anaphors are in acceptable structural relationships in the child's grammar.

The performance of the subjects on tasks assessing knowledge of Principle A is presented in Tables 6 - 8 and is summarized in Table 9. The comprehension errors were simple violations of A (non-local binding of reflexives was allowed). The judgement data allowed for two types of errors (presented in Table 7): local binding of reflexive, and allowing a reflexive to be the subject of the sentence.

Table 6: Performance on comprehension tests: Binding Principle A

Subject	Enactment*		CYCLE-R
	Simple S	Infinitive	Simple S
1. WB	100%	100%	100%
2. SR	100%	100%	100%
3. MB	100%	100%	100%
4. NA	100%	100%	100%
5. FC	67%	33%	100%
6. JL	100%	100%	100%

*Note that all controls achieved 100% on this task

On the comprehension tasks, all subjects but one (FC) correctly interpreted reflexives as having local coreferents. FC was inconsistent in his performance, sometimes binding anaphors to nonlocal antecedents.

Table 7: Performance on judgement task: Binding Principle A

Subjects:	Judgement score (%)	Error	
		non-local binding OK	OK as subject of S
FLHD:			
1. WB	80%		+
2. SR	80%	+	
3. MB	0%	+	+
4. NA	60%	+	+
5. FC	40%	+	+
6. JL	100%		
Controls:			
1. SF	100%		
2. KY	100%		
3. SS	60%	+	
4. SM	80%		+
5. JP	100%		
6. CL	100%		

On the judgement task, two subjects (JL and NA) performed similarly to their controls; JL made no error, and NA, one of the youngest subjects, made errors typical for his age. MB shows no evidence of Principle A on this task; however, this is consistent with what the literature reports for his age. WB appears to be in McDaniels et al (1989) third stage, with his only error being that he accepts reflexives as subjects (akin to the emphatic form). Given WB's age (7), and the norms from the McDaniel study, his performance can still be considered appropriate for his age. Thus, five out of the six subjects performed appropriately for their age on this task, with on subject clearly knowing A and four other subjects in various stages of acquisition. However, FC continues to perform poorly, especially when considering his age (9 to 10).

Table 8 summarizes the production data. The production errrors were use of pronouns instead of an obligatory reflexive (e.g. *He$_i$ washed him$_i$"). Note that all the controls performed with 100% accuracy on the elicitation task.

Table 8: Performance on production tasks: Binding Principle A

Subject	Elicitation (6)	CYCLE-E (2)	Spontaneous speech
FLHD:			
1. WB	100%	100%	
2. SR	100%[1]	50%[1]	
3. MB	100%	---[2]	
4. NA	100%	100%	
5. FC	100%[1]	100%[1]	+
6. JL	100%		

Note:
[1] Credit given for "hisself"
[2] Not given due to age norms

As can be seen, all subjects produced the correct forms, with the exception of SR, who on the CYCLE-E produced the following (note there are only two relevant items on this task):

32) Cue: Here the mother is dressing the baby, but here she is dressing...(TARGET: *herself*)

SR: *her.*

In spontaneous speech, only one FLHD subject had an example of reflexive (although MB produced an emphatic reflexive in a by-phrase). The example from FC is:

33) *Cartoon [the cat] licks hisself, too.*

None of the controls produced any examples of true reflexives in spontaneous speech (although KY produced a single emphatic reflexive).

In Table 9 below, performance is summarized across all task types for performance with regard to Binding Principle A.

Table 9: Summary of performance: Binding Principle A

Subject	Knows A (local binding of reflexives) on comp	Knows A on judgement/ probe (not including subject constraint)	Knows subj. constraint on judg/ probe	Produces reflexives
Subjects: FLHD:				
1. WB	+	+	-	+
2. SR	+	+/-	+	+/-1
3. MB	+	-	-	+
4. NA	+	+/-	-	+
5. FC	+*	+/-	-	+
6. JL	+	+	+	+

Controls:				
1. SF	+	+	+	+
2. KY	+	+	+	+
3. SS	+	+/-	+	+
4. SM	+	+	-	+
5. JP	+	+	+	+
6. CL	+	+	+	+

Note:
+ = 100% on all tasks of this type
+* = some task variability, but still 100% correct on at least one task
+/- = variability on all tasks of this type, but still 100% correct on at least one task
- = no correct responses
1 Only error was on elicited task

In summary, (see Table 9 below) 4/6 controls and 1/6 FLHD subjects demonstrated consistent performance across all tasks, indicating they had knowledge of Principle A. Of the subjects making errors, 2/2 (youngest) controls and the two youngest FLHD subjects made errors on the judgement task only. This is consistent with reports elsewhere of children under 7 (e.g. McDaniel et al, 1989). It is as if the parsing ability of the very young and of some FLHD subjects is sufficiently "fragile" that, when challenged with less desirable grammatical choices, they are able to nevertheless find them (inconsistently) grammmatically possible responses.

This leaves 3/5 FLHD subjects who made at least some errors across tasks, one of whom is WB, who accepted reflexives as subjects, not inappropriate performance for his age (7). SR demonstrated some difficulty on one task with producing reflexives, but did well on another. Only FC (age 9) appears to have substantial difficulty with reflexives on a number of tasks; yet, he is able to produce them! With the exception of FC, who did not evidence knowledge of principle A at age 10 for the comprehension task, the FLHD subjects can be seen as performing within normal limits on two tasks assessing knowledge of principle A (act-out and production tasks) but as more susceptible to ungrammatical interpretations on a judgement task which forces them to consider ungrammatical (and perhaps less preferred but ultimately accepted) antecedents for reflexives.

4.3.2 Principle B

Recall that the literature has suggested a relatively late acquisition of binding principle B, with 6 to 7 year olds allowing local c-commanding antecedents for pronouns. Thus, given the norms, we might expect relevant data on the question of knowledge of binding principles from only SR and JL, the two oldest FLHD subjects, as well as the oldest control subjects.

The comprehension data is presented in Table 10 below. In interpreting the data for Principle B, the FLHD subjects made two types of errors on the comprehension task which were not considered to reflect their knowledge of B per se. First is the "child as agent" response of WB (which, according to Hamburger and Crain, 1984, is a response made by normal young children):

34) The robot is washing him --> *WB picks up robot; WB washes robot.*

The second type of non-binding error made by the FLHD subjects was the "control" error (see section 5.4 on PRO/control for more information on the subjects knowledge of control facts). In these errors, the FLHD subjects demonstrated flawed performance because of misinterpretation of the control facts of verbs in infinitival sentences, as in this example from NA:

35) Gumby tells Pokey PRO to pat him --> *Gumby whispers to Pokey, Gumby pats Pokey.*

Because of the frequency of these errors, they are presented in Table 15 below, with the final column representing percent correct with these other types of errors factored out. (Note that the CYCLE-R tests pronoun knowledge with foils for number, gender and case; however, it does not test the domain for binding for pronouns and thus is not included here).

Table 10: Performance on comprehension tests: Binding Principle B.

Subject	Enactment* (6)	Error types: local binding (T1)	control error (T2)	child as agent (T3)	%cor - errors T2 and T3
1. WB	67%	+		+	80%
2. SR	67%	+	+		80%
3. MB	0%	+	+		17%
4. NA	33%	+	+		50%
5. FC	50%	+	+		60%
6. JL	100%				

*Note that all controls achieved 100% on this task

Thus, it is the case that the FLHD subjects evidence poorer performance in comprehension; however, many of their errors are not related to violations of principle A per se. When other, non-binding violations are factored out, only FC and MB substantially poorer performance (less than 80% correct). However, all FLHD subjects but JL allowed violations of B (local binding of pronouns) at least once on this task. In Table 11 the data on the judgement task are presented. All errors on this task were violations of principle B.

Table 11: Performance on judgement task: Binding Principle B

Subjects: FLHD	Score (4)	Allow local binding
1. WB	100%	
2. SR	75%	+/-
3. MB	50%	+/-
4. NA	50%	+/-
5. FC	100%	
6. JL	75%	+/-
Controls:		
1. SF	100%	
2. KY	100%	
3. SS	100%	
4. SM	75%	+/-
5. JP	100%	
6. CL	75%	+/-

On this task, 3/6 of the FLHD subjects perform more poorly than their controls (SR, MB, FC). However, note that even the 12-year-old control performs with only 75% accuracy on this task. Evidently the judgement task forces the most violations of B in all subjects.

The production data are presented in Table 12. The error types are described as follows:

a) violations of B (producing a reflexive instead of a pronoun in a nonlocally bound environment, e.g. *Gumby tells Pokey to pat himself* meaning *Gumby tells Pokey to pat him*. This response is unattested in the normal population.

b) errors on case (e.g. producing *her/she*)

c) producing a name where a pronoun is called for (e.g. *Cookie Monster is washing Cookie Monster*).

Note that all subjects produced pronouns in their spontaneous speech samples, with the only error observed being those like b), case errors.

Table 12: Performance on production tasks: Binding Principle B

Subjects: FLHD	elicitation (6)	Error type*	CYCLE-E (2)	Error type*	Spontaneous Speech
1. WB	100%		100%		+
2. SR	100%		NG		+
3. MB	100%		50%	case	+
4. NA	67%	B	NG		+
5. FC	0%	B,name	100%		+
6. JL	50%	B	100%		+
Control data:					
1. SF	100%				+
2. KY	100%				+
3. SS	100%				+
4. SM	100%				+
5. JP	100%				+
6. CL	100%				+

*Key: Name = produces full names (violation of principle C)
B = violates B (allows local binding)
Case = produces a pronoun but of wrong case

In production, 3/6 FLHD subjects allowed violations of B on the elicitation task, although all used pronouns correctly in spontaneous speech, and only one error was made on the CYCLE-E (a case error of her/she made by the youngest child). It is as if the elicitation task "forces the hand" of the FLHD subjects, causing them to produce violations not typical in utterances made in spontaneous speech. The CYCLE-E may have caused more correct responses by the nature of the contrast used in the cue (where the reflexive is used and stressed, as in:

36) Cue: Here the father is shaving **himself**, but here...

Table 13 summarizes the performance of the subjects for the tasks assessing knowledge of Principle B.

Table 13: Summary of performance: Binding Principle B

Subject	Knows B (no local binding on comp tasks)	Knows B on judgement task	Produces pronouns
FLHD:			
1. WB	+/-	+	+
2. SR	+/-	+/-	+
3. MB	-	+/-	+/-*
4. NA	+/-	+/-	+/-
5. FC	+/-	+	+/-*
6. JL	+	+/-	+/-*

Controls:			
1. SF	+	+	+
2. KY	+	+	+
3. SS	+	+	+
4. SM	+	+/-	+
5. JP	+	+	+
6. CL	+	+/-	+

Note:
Knows B = pronouns are not locally bound in simple and infintival clauses.
Produces pronouns = on elicitation task or on CYCLE-E
+ = performs with 100% accuracy on relevant tasks
+/-* = performs inconsistently, but with 100% accuracy on at least one task
+/- = performs inconsistently
- = no correct responses on relevant task

In summarizing the performance of the subjects, first we will consider the performance of the control subjects. Four out of six of the controls passed all items, indicating they "knew" Principle B on all tasks. Two out of six controls (including the twelve year old) made some errors on the judgement task wherein pronouns could have local binding. Thus, while previously published norms indicated that Binding Principle B was late in being acquired or mastered in comparison with Principle A, this data suggests that even as late as 12 years of age children allow violations of B on the judgement task.

The FLHD subjects all allowed violations of B on one task or another, with little consistency across tasks. Given the performance of the controls, however, this cannot be held to be a deficit in this area. The one way in which the FLHD subjects differed from the controls is in their production on the structured elicitation task of reflexives for pronouns. This error suggests that perhaps their difficulties with binding relate to their knowledge of individual pronouns and reflexives; they may not have yet figured out which are anaphors and which are pronouns.

4.5.3 Principle C

To review, recall that the literature reports that by age 5 - 6 most children have "outgrown" responses which violate Binding Principle C (and thus no longer allow illegal backwards coreference in constructions like 37 a) and b) below:

37) a) He washed Gumby.

b) Gumby tells him that the robot will jump over the fence.

However, according to McDaniels et al. even some adults find sentences like X) b) above "tricky". Thus, we will examine the data separately for the two types of contstructions above.

Because only two tasks presented relevant items for Principle C (comprehension task and the judgement task), the data are presented together in Table 14. Again, several error types were noted. First were the processing errors as described earlier, where the wrong referents for the NP's were selected or the order of the NP's was incorrect. Second were sentences on the judgement task which were interpreted as follows:

which there were violations of Principle B, as in the following response:

38) Gumby tells him that the robot will jump over the fence.

Probe: Who got told something?

(NA): *Gumby.*

Thus, the above response cannot be interpreted with relevance to Principle B; it is either a violation of B or simply another example of a processing error as noted above.

The final type of error was violation of Principle C itself.

The comprehension data are presented below in Table 14. Note that the judgement data is represented only as "+" or "-" as there was only one relevant item per column, while the act-out data is represented by percent correct responses.

Table 14: Comprehension data for Binding Principle C

Subject	Knows C in simple clause		Error type	Knows C in embedded S		Error
	Enact. (3)	Judge/ Probe (1)		Enact. (3)	Judge/ Probe (1)	
FLHD:						
1. WB	100%	+		67%	-	P,B
2. SR	67%	-	C	67%	-	C
3. MB	100%	-	C	0%	-	C,B
4. NA	100%	-	C	0%	-	C
5. FC	100%	+		67%	+	C
6. JL	100%	+		33%	-	C,P,B

Subjects:						
1. SF	100%	+		67%	+	C
2. KY	100%	+		100%	+	
3. SS	100%	+		67%	-	C
4. SM	100%	+		67%	-	C
5. JP	100%	+		0%	-	C
6. CL	100%	+		67%	-	C

+ = passed all relevant items
- = failed all items
(B) = made error violating principle B
(P) = made processing error (mixing up order of NP's and or VP's/adjectives
(C) = made "C" type error as discussed above

The controls appeared to know C in simple clauses on both act-out and judgement tasks. 2 FLHD subjects (SR and NA) did allow backwards coreference violating C on one or both tasks at the level of the simple clause. All of the FLHD subjects and 5/6 control subjects have difficulty with one or both tasks with the longer stimuli. Thus, on first inspection, two subjects (SR and NA) do not appear to be functioning within normal limits in this aspect of grammar, while NA, JL and FC are performing similarly to their controls. However, there is an interesting difference in the type of errors made by the two subject groups. The controls' only errors were violations of C. The FLHD subjects also produced responses that were clear violations of C, but also produced processing errors and "B" violations. Both of these latter types of errors indicate that there might be some difficulty in keeping the appropriate lexical items in memory long enought to do the task (i.e. the "B" violations don't even make sense-- it seems unlikely that Gumby would tell himself something in the context of this task). For this aspect of grammar, then, while some of the FLHD subjects appear to have largely normal performance on the basis of the number of errors, they do produce responses not found in the control population.

Spontaneous speech samples contained no examples of violations of Principle C.

5.4 CONTROL/INTERPRETATION OF PRO

5.4 PRO in VP complements

First we will examine the data relevant to interpretation of PRO in VP complements, where the verb specifies in the lexicon whether it requires object control of PRO or subject control of PRO. As noted earlier, the literature has consistently indicated that children first interpret sentences with *ask, tell* and *promise* as having object control of PRO, only allowing subject control in the case of promise later in development (at age 7 or 8 years).

Table 15 presents the individual profiles of the subjects on the control items for PRO in complements. Note that the judgement data is presented only as "+" or "-" due to single response required for this task. The actout data is represented as percent correct responses.

Table 15: Interpretation of PRO in VP complements on the actout and judgement tasks

Subject	Act-out tell (3)	Act-out promise (3)	Judgement tell (1)	Judgement promise (1)
FLHD:				
1. WB	100%	100%	-	-
2. SR	100%	0%	+	-
3. MB	100%	0%	-	-
4. NA	100%	0%	-	-
5. FC	100%	33%	+	+
6. JL	100%	0%	-	-
Controls:				
1. SF	100%	100%	+	+
2. KY	100%	100%	+	+
3. SS	100%	0%	+	+
4. SM	100%	100%	+	+
5. JP	100%	100%	+	+
6. CL	100%	100%	+	+

Table 16 presents the production data for PRO in complements. Note that two subjects made errors in formulating sentences with *tell* and *promise* which do not reflect knowledge of subject/object control in obligatory verbal complements:

39) (SR) *The camel... tells for her to go in.*

40) (MB) *The lion's telling, the bear, is jumping, jump over the fence.*

MB has a problem formulating the sentence either attributable to general formulation difficulty or has difficulty producing an untensed complement (probably not the case as he did produce two examples of *tell*-type infinitives). Note that the percentage correct for these subjects includes these errors.

Table 16: Production data on PRO in complements ("tell" vs."promise")

Subject	Elitation (tell) (3)	CYCLE-E tell (2)	CYCLE-E promise (2)	Spontaneous Speech tell	Catenatives
1. WB	100%	NG	NG		+
2. SR	67%	NG	NG		+
3. MB	67%	NG	NG		+
4. NA	100%	NG	NG		+
5. FC	100%	100%	0%	+	+
6. JL	100%	100%	100%	+	+
1. SF	100%				+
2. KY	100%				+
3. SS	100%				+
4. SM	100%				+
5. JP	100%				+
6. CL	100%				+

Note:
NG = not given due to age or ceiling on performance
+ = well-formed example in spontaneous speech sample

For PRO in VP complements the data indicate that the youngest pair of subjects (MB and control SS, 5-10 and 5-9 respectively) appear to lack knowledge about obligatory subject controlled verbs. Thus, MB's performance is within normal limits. One other FLHD subject (SR) displays a normal but delayed pattern similar to MB's; however, SR is considerably older. FC shows close to adult performance, with some lag in complete acquisition of *promise*. However, the performance on the judgement task by four subjects (WB, MB, NA, and JL) reveals a pattern not attested elsewhere in the literature; namely, reversal of interpretation of *tell* and *promise* constructions. Thus, these subjects interpreted *tell* as having subject control and *promise* as having object control. This error was restricted to the FLHD subjects and only found on the judgement task. Again, we see evidence that the FLHD subjects, while having normal or at worst, normal but slightly delayed, performance on other tasks can be "forced" to violations on the judgement task. The judgement data aside, some of the FLHD subjects did show a clear delay in acquisition of the lexical facts for verbs taking a VP complement.

The spontaneous speech data contains a variety of infinitival constructions with catenatives, verbs like *want* and *need*::

41) (MB) *And I want to get that Robot.*

42) (LB) *You have to get off the same plane.*

43) (SR) *I'm gonna make her take me.*

Thus, the FLHD subjects were clearly able to generate constructions similar to the early infinitival constructions produced by normal young children. There were only two examples of *tell* constructions (both by FLHD subjects), and no examples of *promise*:

44) (JL) *I tell her to go to bed.*

45) (FC) *The man's telling him to get over the gate.*

5.4.2 PRO in adjuncts

We will now examine performance on tasks assessing knowledge of PRO in adjuncts. The relevant structures are those in 46) and 47):

46) The elephant pushes the lion before PRO jumping over the fence. (DO type)

47) The bear jumps over the girl before PRO bumping over the fence. (PP type)

The data from these types of constructions (along with data on OS rels) will allow us to interpret the performance of the children studied here. Recall that the literature (Hsu and colleagues, eg. Hsu et al. 1985) suggests a series of stages for the mastery of PRO in adjuncts:

a) no control (PRO = arb; evidently not all children go through this stage.

b) subject control via a highest S strategy, with the matrix subject = embedded subject (children may comprehend PRO in adjuncts but perform correctly on OS relatives, where the matrix object must be coreferential with the embedded subject)

c) object control, due to the minimal distance principle (closest NP is the controller (children perform incorrectly)

d) object control, c-command followed but adjuncts are attached to VP instead of IP

e) mixed control; some VP attachment and some IP attachment of the adjunct

f) adult control: subject control of PRO in adjuncts with S attachment of the adjunct.

Table 17: Interpretation of PRO in adjuncts: enactment data

Subjects FLHD:	DO adjunct (3)	Construction type PP adjunct (3)	OS relatives (6)[2]
1. WB	100%	100%	100%
2. SR	0%	100%	100%
3. MB	67%	50%*	100%
4. NA	100%	100%	100%
5. FC	67%	67%	100%
6. JL	67%	67%	100%

Controls:			
1. SF	100%	100%	100%
2. KY	100%	100%	100%
3. SS	100%	100%	100%
4. SM	67%	100%	100%
5. JP	100%	100%	100%
6. CL	100%	100%	100%

Note:
*** = one ambiguous response was thrown out from consideration (the sentence was acted out with PRO = both NP's doing the action)**

Note that all controls but SM appear to have adult knowledge of control facts on this task; SM, one of the youngest subjects, is in Hsu et al.'s mixed stage, appropriate for his age. As for the FLHD subjects, two (WB and NA) appear to be in the adult stage. MB is also in the mixed stage, appropriate for his age. While no abnovmal patterns were observed for the FLHD subjects on this task, three subjects appear to be quite delayed in

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[2] Although in section 5.2.1 performance on several subtypes of OS relatives is discussed, here only comprehension data on OS relatives with only 2 full NP's was used, as in:

i) Gumby hits the bear that hops up and down.

The data is restricted to only these examples of OS relatives because the FLHD perform more poorly on sentences with multiples full NP's probably linked to a processing problem (see section 5.2.1 for more details on this aspect of relatives).

mastery of this aspect of grammar for this task (FC and JL are in the mixed stage, and SR has VP attachment of adjuncts.

Table 18) presents the judgement/probe data for this area. Note that this is the of the data with regards to PRO; there were no relevant production data.

Table 18: Judgement/probe data for PRO in adjuncts

	DO-type adjuncts (1)	PP-type adjuncts (1)
FLHD:		
1. WB	+/-	+/-
2. SR	+	+
3. MB	+/-	+/-
4. NA	+	+
5. FC	+/-	+
6. JL	+	+
Controls:		
1. SF	+	+
2. KY	+/-	+
3. SS	+	+
4. SM	+	+
5. JP	+	+
6. CL	+/-	+

Note:
+ = correct performance
+/- = first response was correct but the subject also allowed other, ungrammatical interpretations of PRO

First we will examine the data from the nonimpaired controls data. Note that the two oldest controls were able to be pushed beyond their initial, preferred interpretation in to accepting interpretations of object-controlled PRO in the DO-type structures. Given this, it seems clear that this task is perhaps too difficult for any of the children to demonstrate reliable interpretations, and we will concentrate on the act-out data in the summary of the performance (note that there is no relevant data found in the spontaneous speech samples or in the CYCLE batteries).

In examining the data, it is clear that none of the subjects are in the first stages in the acquisition of PRO as proposed by Hsu et al. (1985). Thus, none have subject control via a "highest S" strategy; none have object control via the "closest NP" strategy.

However, there was at least one subject in each of the remaining stages, as presented in Table 19 below.

Table 19: Summary of overall stage in interpreting PRO in adjuncts

Subject	VP attach	Stage Mixed	Adult
FLHD:			
1. WB			+
2. SR	+		
3. MB		+	
4. NA			+
5. FC		+	
6. JL	+		
Controls:			
1. SF			+
2. KY			+
3. SS			+
4. SM		+	
5. JP			+
6. CL		+	

To summarize, on temporal adjuncts 5/6 controls had the adult grammar (subject control of PRO in adjuncts), and 1 (6 year-old) subject was in the "mixed"stage, consistent with reports in the literature. Two of the 6 FLHD subjects had the adult grammar with regard to PRO, and 1 (young) subject was in the mixed stage, appropriate to his age. Three subjects appear to be delayed in this area: SR (who has object control with VP attachment of adjuncts), and FC and JL (who are older, but still in the mixed stage.

Clearly, the FLHD subjects appear to deal with PRO in complements and adjuncts in both processing and production tasks, and are in the process of mastering control when it is not free. Some controls and some FLHD subjects do not yet know the peripheral facts concerning the unusual subject control property of particular lexical items such as *promise*, and in this there may be evidence of a delay in the two older FLHD subjects.

5.5 NP movement, linking of theta roles and the passive

For this construction, only four subtasks contained relevant items. No passive items were included in the animal description task because it was found to be nearly impossible to elicit passive (rather than an active voice construction) descriptions without changing the task significantly to focus on the patient and thus cue the passive. Thus, all of the data on the passive are pesented in Table 20 below. Note that the controls performed correctly on all act-out and judgement items; the table includes only the FLHD subjects. Note also that some subjects produced responses on the CYCLE-E which are considered to be frame violations; that is, the subject rejects the proferred sentence frame and starts a new utterance (in the active voice).

Table 20: Performance on passive items

Subjects FLHD:	Enactment (3)	Judgement (1)	CYCLE-R (5)	CYCLE-E (2)	Spont. speech/ elicit.
1. WB	100%	+	100%	NG	
2. SR	100%	+	0%	50%	+
3. MB	100%*	+	100%	NG	NM
4. NA	100%	+	40%	NG	+
5. FC	100%	+	80%	+*	+
6. JL	100%	+	60%	+*	+

Note:
* = One response was a frame violation; percentage correct was for remaining responses
NM = example from spontaneous speech was misssing appropriate morphology
+ = correct performance

Again, we have a fairly clear division between parsing/comprehension tasks and production, with all subjects able to comprehend/interpret passives on at least one task (with the exception of the CYCLE-R, which seems clearly harder, again because it pictures the competing alternatives which the subject is forced to consider at the time the sentence is being parsed). However, in production, there are many fame violations and nontarget responses. This preference for "avoiding the passive" has been noted previously in normal adult populations, and seems to indicate here the normal preference, as all subjects tested did produce at least one passive construction. An additional point here is that while the passive may be less preferred in certain situations, two subjects produced a passive earlier in their attempt to produce an OO relative (producing instead an OS relative):

48) (NA) *Pick the bear that's wash...that's getting cleaned.*

49) (SR) *Pick up the bear that's getting cleaned.*

Thus, unlike what has been reported for adult aphasics, these FLHD subjects do not demonstrate a partricular deficit with A-chains and associate them with roles with syntactic positions. However, in production, it appears that at least some of these subjects tolerate (but do not prefer, perhaps) A-chaining and empty categories.

Given the infrequency of the passive in spontaneous speech, it is not too surprising that only two of the FLHD subjects, with one (MB) produced the appropriate word order but without the appropriate verbal morphology.

50) (JL) *...they're broken by that kid.*

51) (JL) *It got stolen.*

52) (JL) *It was called a pit bike.*

53) (MB) *... and then he was transform to cars.*

Similarly, only two controls produced passives:

54) (SS) *...so he got benched.*

55) (KY) *'Cause you get fined if you, like, get fined if you get in fights.*

5.6 DISCUSSION AND SUMMARY PROFILES

Many details concerning aspects of the grammar have been discussed in the previous sections. However, this study, while allowing for some group comparisons, is essentially a collection of detailed case studies. Group comparisons are useful for addressing questions of comparisons of performance, but to address the question of the "normalcy" of the grammars of the individuals, we will now look at the data as summarized for each FLHD subject overall. The data for each subject will be summarized in Tables 21 - 26. For all profiles, errors are classified as being related to syntactic structures (violating expected grammatical knowledge) or as being related to processing/performance difficulties.

Group I: FLHD occurring prenatally or before age 1

Table 21: Summary profile of WB (7-6 to 7-9)

Aspect of grammar	Performance overall with respect to core	Task variability	Errors linked to: struct. (-gram)	proc./ perf.	Age approp.
Recursion					
in NP	+/-	+		+	+
in VP[1]	+				+
Binding:					
A	+[2]		+		+
B	+/-	+	+	+	+
C	+/-	+	+	+	+
PRO/control	+				+
NP movement/ passive	+				+

1 Only task for this aspect of syntactic knowledge.
2 Reflexives were allowed as subjects, however, possibly along the lines of emphatic reflexives..

WB is functioning within normal limits for a seven year old in most areas. He makes some errors clearly linked to structural constraints (e.g. reflexive is OK as subject; Principle C is obeyed in simple but not infinitival clauses); these are errors within the normal range. However on other tasks (e.g. some of the relative clause tasks) his errors were inconsistent and performance/processing related. He differs qualitatively from the controls in the type of error, but can demonstrate performance within normal limits on most tasks. Note that WB does have difficulty with the peripheral facts at least for control structures: see chapter 6.

Table 22: Summary profile of SR (13-2)

Aspect of grammar	Performance overall with respect to core	Task variability	Errors linked to: struct. (- gram)	proc/ perf.	Age
Recursion					
in NP	+				+
in VP[1]	+				+
Binding:					
A	+/-	+	+		-
B	+/-	+	+		+
C	+/-		+		+
PRO/control	+/-	+	+		-
NP movement/ passive	+/-	+	+		-

[1] Only task for this aspect of syntactic knowledge.

SR presents even more variability across tasks than WB, and performs clearly below age-level expectations on three of the seven areas of grammar. However, even for these three areas of grammar, there was no clear-cut, consistent deficit. Errors were inconsistent across tasks and within the same task. Even for those aspects of the grammar for which he appears to demonstrate delayed mastery (e.g. Binding A), he demonstrated no evidence of an abberrant grammar. Further, he was able to demonstrate some correct performance (e.g. on the judgement task his score was 80%).

Group II: FLHD occurring between age 2 to 4

Table 23: Summary profile of MB (5-9 to 5-10)

Aspect of grammar	Performance overall with respect to core	Task variability to:	Errors linked struct. (-gram.)	proc/perf.	Age approp.
Recursion					
in NP	+/-	+	+	+	+
in VP[1]	+				+
Binding:					
A	+/-	+	+		+
B	+/-	+	+	+	+
C	+/-	+	+	+	+
PRO/control	+/-	+	+		+
NP movement/ passive	+/-[2]	+			+/-

[1] Only task for this aspect of syntactic knowledge.
[2] Only error was in production; passives were produced with correct word order but missing morphology.

MB, with less than adult competence in many areas, is nevertheless performing at expected levels for a five-year old. In addition to errors found in normal subjects, however, he did have some processing errors on comprehension tasks, indicating that any evidence of delayed performance might be linked to non-representational deficits. It is interesting to note his production error on the passive, in that the morphology of passive constructions can be considered a peripheral part of the construction; the word order (and the tense of the aux be) were correct. This will be discussed further in the next chapter. In any case, we have no evidence at this point of delayed or deviant knowledge of core syntax; obviously, following MB over time will allow us to definitively address this question.

Table 24: Summary profile of NA (6-3 to 6-4)

Aspect of grammar	Performance overall with respect to core	Task variability	Errors linked to: struct. (-gram.)	Errors linked to: proc/ perf.	Age approp.
Recursion					
in NP	+/-	+		+	+
in VP[1]	+				+
Binding:					
A	+[2]		+		+
B	+/-	+	+	+	+
C	+/-	+	+	+	+
PRO/control	+				+
NP movement/ passive	+				+

1 Only task for this aspect of syntactic knowledge.
2 Reflexives were allowed as subjects, however, possibly along the lines of emphatic reflexives..

NA is also one of the youngest subjects, and his performance is also within normal limits in spite of errors. As with MB, a longitudinal study of his development would definitively address questions regarding his development. Interestingly, he demonstrated none of the processing errors typical of the other FLHD subjects. His performance with regard to PRO in VP complements will be addressed in Chapter 6.

Group III: FLHD occurring between ages 4 to 5 years

Table 25: Summary profile of FC (9-9 to 10-2)

Aspect of grammar	Performance overall with respect to core	Task variability	Errors linked to: struct. (-gram.)	proc/ perf.	Age approp.
Recursion					
in NP	+/-	+	+	+	-
in VP[1]	+				+
Binding:					
A	+/-	+	+		-
B	+/-	+	+	+	+
C	+/-	+	+		+
PRO/control	+/-	+	+		-
NP movement/	+				+

1 Only task for this aspect of syntactic knowledge.

FC demonstrates normal performance in some areas (e.g. knowledge of some of the binding principles and with regard to NP movement) but also appears to be somewhat delayed in other areas (e.g. knowledge of PRO/control structures). He also demonstrates both processing errors as well as difficulties in production (the latter of which may be influenced by lexical deficits).

Table 26: Summary profile of JL (12-7 to 12-8)

Aspect of grammar	Performance overall with respect to core	Task variability	Errors linked to: struct. (-gram.)	proc/ perf.	Age approp.
Recursion					
in NP	+/-	+	+		-
in VP[1]	+				+
Binding:					
A	+				+
B	+/-	+	+		+
C	+/-		+		+
PRO/control	+/-	+	+		-
NP movement/	+/-	+			-

[1] Only task for this aspect of syntactic knowledge.

JL overall appeared to be functiong within normal limits with the exception of the peripheral facts of infinitival constructions. In addition, he demonstrated some difficulties with PRO in adjuncts and with comprehension of relative clauses.

Thus, overally, we found that the FLHD subjects were largely functioning at age-expected levels for the specific aspects of core syntactic knowledge investigated here. However, two of the subjects were too young to definitively answer this question. Further, the performance of the FLHD subjects was not similar to that of the controls in all respects. Specifically, the FLHD subjects evidenced much more inconsistent performance, both across tasks and within a single task. The FLHD subjects also demonstrated some performance indicative of processing/memory problems which were not found in the patterns of performance of the controls subjects.

Now we will return to the hypotheses of Chapter 1, and sumnmarize the findings of this study.

H1: Early focal left hemisphere damage will result in grammatical deficits.

H1a: Acquisition of core properties of syntax will generally not be impaired if key areas of the left hemisphere are damaged early in development before the end of the hypothesized critical period.

The data from this chapter indicates that the FLHD subjects largely were able to demonstrate knowledge of the core principles of grammar investigated herein. However, there was some variability of performance, with individual subjects demonstrating below age-level performance for particular principles. It should be noted that all of the subjects demonstrated variability in their performance, both across tasks and within the same task. In many cases, responses to tasks were incorrect, but the error could be linked to processing difficulties rather than incorrect construction of the grammar. In some cases the FLHD cases evidenced protracted rate of development/acquisition, making their responses signficantly different on a given task from that of their CA-matched peers (e.g. FC's performance on tasks relating to the binding principle A). However, overall their performance as a group as well as the individual profiles regarding each principle of grammar was not significantly different from that of the controls. Thus, there was no evidence that early FLHD leads to abberant construction of the grammar or interferes in a consistent way with knowledge of core principles of grammar. Early FLHD may protract the acquisition process somewhat, and to definitively address the question of whether or not the delayed subjects attain the adult grammar a longitudinal study is needed. Certainly, early FLHD (and, perhaps, any brain damage) may result in processing difficulties or in formulation problems which inconsistently affect performance on tasks assessing linguistic knowledge.

H1b: Acquisition of the peripheral aspects of the grammar will be impaired following focal left hemisphere damage.

We did find that acquisition of certain aspects of peripheral aspects of grammar was affected. This includes specific aspects of constructions used to assess knowledge of grammatical principles studied for the H1a hypothesis (e.g. promise vs tell for control). This hypothesis is the subject of Chapter 6 (as follows).

H2: Age at onset will affect the nature and extent of deficits.

No significant effect of age of onset of the cortical damage was found here. Although earlier it was noted that the small sample size required caution in interpreting these results, it is also possible that none of the subjects studied here sustained brain damage late enough to test the critical period window. While Lenneberg (1967) proposed the onset of puberty as the time limit for the equipotentiality of the hemispheres of the brain, others have proposed an earlier age limit for equipotentaility for language (e.g. 5 years; Krashen, 1972), as discussed ealier. Still others propose an innate specialization of the left hemisphere (e.g. Kinsbourne, 1976). We will return to this point in Chapter 5 in the discussion of the critical period hypothesis.

H3: Performance of FLHD subjects will vary according to the demands of the tasks, implicating processing rather than representational deficits.

The FLHD subjects did show great variability across tasks (as was noted in section 4.4) as evidenced by the lack of correlation of performance across task types. The findings of this dissertation perhaps stand as a cautionary tale for those using a single methodology (e.g. a judgement task, a comprehension task or a production task) to make a determination of the linguistic knowledge of a brain-injured subject (and perhaps of non-impaired subjects as well).

CHAPTER 1

INTRODUCTION

1.1 THE BASIC ISSUES

The question of how children acquire grammar has long intrigued and puzzled psychologists and philosophers as well as linguists. This dissertation seeks to investigate a specific aspect of this general issue; namely, the issue of the nature of the relationship between the grammatical knowledge of young children, presumed by some to be biologically endowed, and the neuroanatomical foundation for the innate human language faculty.

The issue of the relationship between neural structure and function on the one hand and the process of language acquisition on the other is a complicated one. Theories of grammar acquisition typically focus on explaining the acquisition process without reference to neurolinguistic issues. One approach to child language acquisition views child grammars as being discontinuous with adult grammatical knowledge in the sense that child grammars restructure during the acquisition process. The early grammars are considered to be semantically or communicatively based, later becoming organized along grammatical principles (Bowerman, 1973; Schlesinger, 1971; Maratsos, 1982). An alternative approach assumes that children are innately equipped with abstract, formal grammatical principles which constitute Universal Grammar, or UG, the set of principles or operations which holds across all languages (Chomsky, 1980). These abstract principles guide the construction of the child's grammar, and predispose the child to entertain only certain hypotheses about the input language (all grammatically based). Support for this position is presented in recent studies which suggest that children's earliest hypotheses about the organization of their language are grammatical in nature (e.g. Hyams, 1986; Crain and McGee, 1986; Crain and Nakayama, 1985; Tavakolian, 1981; Roeper, 1988). It follows from this view that children do not learn or acquire fundamental grammatical constructs; these are already present as acquisition starts. Rather, they learn only the idiosyncratic aspects of their language; e.g. vocabulary, aspects of the phonetic system, and specific language-particular syntactic facts.

If children come to the task of language acquisition with basic syntactic knowledge (in the form of UG), why is adult grammatical competence not instantaneous? Two answers to this question have been proposed. One is that the as yet nonfunctioning grammatical principles are invoked or "triggered" by data which is only gradually made available to the child (Pinker, 1984). The specific data are either literally unavailable at early stages in development (i.e. are not used in speech to the child) or not accessible due to the constraints of immature nonlinguistic cognitive or perceptual systems, e.g. limitations on memory interacting with input processing in some way. A second proposal is that grammatical principles mature in the same way that other biologically governed behaviors mature and develop over time (Borer and Wexler, 1984). However, as Roeper (1988) notes, both maturation and triggering of latent abilities could apply to different portions of the grammar, and at different times. In any case, syntactic knowledge is viewed as biologically predetermined; even a maturational view does not imply that grammatical principles are learned (one would not say that a child "learns" to increase short-term memory, for example, or "learns" hormonal changes at puberty).

Recent work within this theoretical framework has begun to make explicit what aspects of grammatical knowledge might be innate. This acquisition theory, however, has not been concerned with the neural or anatomical basis for (presuamed to be) innate grammatical knowledge. This dissertation will attempt to consider this question from the point of view of how damage to the left "language" hemisphere early in development may affect specific aspects of syntactic and morphological knowledge which are acquired later in childhood. Should a specific effect of early left hemisphere damage be found, the argument for the biological basis of UG and language acquisition is thereby strengthened.

1.2 A LANGUAGE-BRAIN RELATIONSHIP EARLY IN DEVELOPMENT?

1.2.1 Early brain damage and theories of hemispheric specialization

A major source of data used to support theories about the relationship between grammatical knowledge and its neurological substrate in the mature system has been studies of adults with localized brain damage. For over 100 years, research on adults with aphasia document the linguistic impairments which occur in the cases of left- but not right hemisphere damage for right-handed males (beginning with Broca (1863) and Wernicke (1874)). However, the role of the left hemisphere in language acquisition has not been unambiguously attested. Early studies of focal cortical damage of varying etiology in children found that right- as well as left-hemisphere damage led to later deficits in language (e.g. Sachs and Peterson, 1890; Basser, 1962; Hood and Perlstein, 1955a; 1955b). These data led Lenneberg (1967) to hypothesize an equipotentiality of the cortical hemispheres for language acquisition during the first two years of life, with neither hemisphere yet specialized to support language at birth. This hemispheric equipotentiality was attributed to the immature character and plasticity of the brain at birth. According to Lenneberg, specialization for language continues to develop in the left hemisphere until puberty, at which time lateralization is complete.

Krashen (1972) modified Lenneberg's hypothesis by showing that lateralization is complete by age five in normal cases, although some acquisition of language could take place after this completion of lateralization (hypothesized as due to compensatory support of linguistic functioning by the right hemisphere). Further, Kinsbourne (1976; 1979) proposed that left hemisphere specialization exists at birth, with the asymmetry in function beginning before overt language skills are apparent. Kinsbourne and Hiscock

(1977) specifically criticized the notion that language is only gradually biased towards left hemisphere representation, stating "...we know of no animal model and of no human analogue to the idea that, for a given behavior, the brain base shrinks with increasing functional sophistication" (p. 134). They supported a developmental invariance hypothesis, in which there is a preprogrammed asymmetry favoring left hemisphere specialization for language from birth.

More recently, studies of brain damage in children, which have largely excluded etiologies with a likelihood of bilateral involvement and which have also been conducted since the advent of more accurate methods of lesion localization, support the position of innate hemispheric differences. Several studies have found that acquired aphasia or language disturbance in children, as in adults, is more often the result of left hemisphere focal damage (Annett, 1973; Alajouanin and Lhermitte, 1965; Hecaen, Perenin and Jeannerod, 1984; Woods, 1980a; Woods and Carey, 1979; Woods and Teuber, 1978). This is also the conclusion of Satz and Bullard-Bates (1981) who apply a strict set of criteria in interpreting the various data (including knowledge of premorbid handedness and evidence of speech development before the onset of the lesion). Woods has formulated an "initial potential equipotentiality theory" (1980b); while the left hemisphere may be prepotent for language, the continuing lateralization of the left hemisphere for language overrides the potential of the right hemisphere to subserve language, a potential which is realized only if development of the left hemisphere is hampered in some way.

1.2.2 Neurological evidence of hemispheric assymmetry

There is additional evidence for the view that hemispheric asymmetries may be relevant to language and language lateralization. Anatomical asymmetries have been demonstrated in adults, with the left planum temporale[1] larger in the majority of cases (Geschwind and Levitsky, 1968), resulting in a longer and more horizontal Sylvian fissure, with greater volume in the auditory association cortex (Rosen and Galaburda, 1985). Geschwind and Levitsky conclude that the anatomical asymmetry is "compatible with the known functional asymmetries [p.187]". There are other asymmtries in the adult brain which favor the frontal and temporal areas of the left hemisphere, including increased amounts of neurotransmitter activity in the temporal lobe (Amaducci, Sorbi, Albanese and Gianotti, 1981; Glick, Ros and Hough, 1982) and in Broca's area (Braak, 1979).

Assymmetries have been found in the brain in utero as well as at or shortly after birth. Gross structural asymmetries have been found in key portions of the left temporal lobe of the fetal brain (e.g. a larger left planum temporale) which are present by the 29th gestational week (Witelson and Pallie, 1973; Wada, Clark and Hamm, 1975; LeMay and Culebras, 1972). However, it is not the case that the left hemisphere structures always exceed right hemisphere structures in absolute volume, size or number. In spite of the larger appearance of parts of the left hemisphere at 29 weeks, Chi, Dooling and Gilles (1977) found that structures surrounding the planum temporale may appear in recognizable form in the fetal brain earlier in the right than in the left, indicating slower growth of certain language areas of the left hemisphere. Reviewing the embryonic literature, Best (1988) proposed several vectors of growth in the emergence and develo0pment of the cerebral hemispheres, the most relevant here being a vector of right to left growth. Turkewitz (1988), citing Galaburda's (1984) findings that fetal

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1 Roughly speaking, the planum temporale is the part of the temporal lobe known as the auditory association cortex, an area often affected in Wernicke's aphasia.

development of the right temporal lobe precedes that of the left, proposed that the acoustic environment later in pregnancy (when the uterine walls become tauter, thinner, and better able to transmit external sounds, including the maternal voice) coincides with the later development of the left hemisphere. Thus, his view proposed an interaction of development and growth of the neural substrate with environmental stimuli to achieve specialization of function.

An asymmetry favoring the right hemisphere is also apparent at the level of the dendrites, or the branches of the neurons. Initially in the young child there is greater dendritic complexity found in the right hemisphere, with the left and right hemispheres alternating in this regard until the age of three to four years, when the left hemisphere establishes and maintains greater dendritic complexity (Simonds and Schiebel, 1988). Thus, it may be that the left hemisphere develops more slowly, but for a longer period of time, and that it eventually surpasses the right in dendritic complexity (Rosen and Galaburda, 1985). It has been suggested that the final establishment of greater dendritic complexity in Broca's region in the left hemisphere corresponds with lateralization of hemispheric function (Schiebel, Paul, Fried, Forsythe, Tomiyasu, Wechsler, Kao and Slotnick, 1985).

It is difficult to link these anatomical, cytoarchitechtonic and metabolic differences directly to linguistic functioning, but it is clear that the cerebral hemispheres are structurally and functionally different, in some aspects early on, and in others in ways which may be linked to language acquisition and continuing support for language functioning.

1.2.3. Behavioral assymmetries: Response of the normal brain to linguistic stimuli

In addition to neurological asymmetries, there are also perceptual asymmetries for processing linguistic vs. non-linguistic sounds found in neonates and young children, indicating that at birth or shortly therafter, the hemispheres differ in their response to language stimuli. Researchers have found strongly lateralized responses using dichotic listening techniques (Entus, 1977) and EEG activity (Gardiner and Walter, 1977), with the left hemisphere implicated to a greater extent in processing linguistic vs. nonlinguistic (music) stimuli. Likewise, studies utilizing electrophysiological data from auditory event-related potentials, or AERP's (Molfese, 1972; Molfese, Freeman and Palermo, 1975; also see Molfese and Betz, 1988, for a thorough review of this area) have found hemispheric differences in AERP's, although the language/nonlanguage distinction is not so clear. For example, categorical perception of consonants via voice onset time (VOT) typically elicits a right hemisphere response (at least for English speakers), while perception of consonantal place of articulaton typicallly elicits a left hemisphere response.

These response asymmetries, while not necessarily directly linked to lateralization of (adult) cognitive functions, imply a biologically fixed program for the infant's brain to be asymmetrically sensitive to certain kinds of input, with the left hemisphere specially prepared to process linguistic information. The implications of these asymmetries for the specifics of language acquisition, however, remain unclear.

1.3 LANGUAGE ACQUISITION FOLLOWING SPECIFIC BRAIN DAMAGE IN CHILDREN

If the left hemisphere is neurobiologically preprogrammed for language, how does damage to this neural substrate affect language acquisition? Data from three classes of individuals are relevant here: 1) cases with early focal cortical lesions, 2) cases of early hemidecortication, and 3) cases with identified language disorders (e.g.

developmental dyslexics) who were then found to have unusual neurological conditions. Each of these populations will be discussed in turn.

1.3.1 Focal cortical lesions in early development

The first population reviewed here is that of children with unilateral focal cortical lesions acquired during birth or in early childhood. These children face the task of language acquisition with a damaged hemisphere. Many of the early studies of this group were impressionistic and concerned with clinical issues, i.e. classification of disorders according to adult aphasia typologies, degree of recovery to premorbid level of functioning, etc. Acquired aphasia in children[2] has traditionally been described as "nonfluent" in nature, with production halting and often grammatically incomplete (Guttman, 1942; Benson, 1967; Brown and Hecaen, 1976; Hecaen, 1976). This type of aphasia was reported for cases with early damage as well as those with damage occuring later in childhood (i.e. after some acquisition had already taken place). This stands in contrast to the fluent/nonfluent (or Wernicke's/Broca's) distinction which is noted in adults after similar types of damage. The lack of comprehension deficits as well as impairment in naming and dysarthria were also noted by various researchers (a symptom complex associated with nonfluent aphasias). However, more recent studies have reported "fluent" aphasias (output with structurally intact but with jargon/paraphasias persent) in childhood which appear to be most common immediately after the onset of

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2 The term "aphasic" has often been utilized to described children with language disorders even without a proven etiology of neurological damage. The term here is restricted to that population where there is clear evidence of brain damage as an underlying cause of language impairment.

the damage (Visch-Brink and van de Sandt-Koenderman, 1984; Van Hout, Evrard and Lyons, 1985). Childhood aphasia has also been characterized as being associated with more complete recovery than was typical for adults, especially for children who suffer their damage very early in life (e.g. Guttman, 1942; Roberts, 1958), although Alajouanine and Lhermitte (1965) noted that many of their apparently recovered subjects had difficulty in school, particularly in subjects which emphasized language skills. Woods and Carey (1979) also conclude that recovery from aphasia in childhood is less complete than previously proposed (see following discussion).

Clinical issues aside, it is unclear what, if anything, is revealed about the linguistic knowledge of children with focal lesions by the studies discussed above. Information about the specific linguistic abilities of children following focal damage is rare in these reports, with information about the extent to which language had been acquired before the neurological difficulties rarer still. When objective assessment of specific linguistic abilities was used, it consisted most often of verbal intelligence testing. Until recently, few groups of researchers have attempted to evaluate specific linguistic (including morphosyntactic) knowledge. Woods and Carey (1979) were among the first to use tests designed to evaluate knowledge of specific aspects of language as well as tests in academic-related areas with their left-hemisphere patients (aged 10 to 25 years). They found only an impairment in spelling in patients with lesions before age 1.0. For the late lesion group (mean age 5.7 years) significant impairments were found in a naming task, on performance on the Token Test, on sentence judgement and completion tasks, and on a test of knowledge of kinship terms. However, some of their tasks involve more than just linguistic abilities; e.g. their sentence completion task requires good reading comprehension ability. Further, the data are presented in terms of scores on individual tests; no interpretation of error types or patterns is given.

There are a few additional studies which support the hypothesis that very early damage to the left hemisphere results in no overt linguistic impairment (e.g. Bullard-Bates and Satz, 1983; Satz, Orsini, Saslow and Henry, 1985); Landsdell, 1969). Some of these researchers claim that the early reorganization of linguistic function to the right hemisphere was responsible for the essentially normal performance of the subjects. Interestingly, this purported shift of language representation to the right hemisphere is not without cost, as the above studies report that visuo-spatial abilities, traditionally thought to be within the province of the right hemisphere, were impaired. While these studies rely on standardized tests (typically IQ tests), they do produce evidence contrary to the viewpoint that the left hemisphere substrate is ready and necessary to support language function from a very early point in development.

Most other recent research efforts have found an association of early brain damage with linguistic deficits of one sort or another. Beginning with early, prespeech milestones, Marchman, Miller and Bates (1989) found some differences in the character of early babbling and in the onset of first words, with early vocalizations being considered to be less complex (containing fewer true consonants) than those of controls. However, at least three of their five subjects were performing comparably to the by 22 months of age. There is only one study which investigates phonological knowledge, and it looks only at very young children. Keefe, Feldman and Holland (1989) evaluated the utterances of four children aged approximately two to four years of age who had suffered brain damage within the first week of life. They found no significant differences between controls and brain-damaged individuals in terms of the phonological processes which characterized their spontaneous speech (e.g. most of children had evidence of the operation of age-appropriate phonological processes, such as cluster reduction, and did not produce utterances reflecting the presence of a phonological change not typical of their age, such as unstressed syllable deletion.)

Several studies note the relationship between brain damage in either hemisphere and an impairment in lexical knowledge (Annett, 1973; Aram, Ekelman, Rose and Whitaker, 1985; Rankin, Aram and Horowitz, 1981; Kiessling, Dencla and Carlton, 1983 (although their results were not statistically significant)), with the deficit apparent even at the point of acquisition of first words (Marchman et al. 1989). Thal, Marchman, Stiles, Trauner, Nass and Bates (1989) studied 11 cases with focal damage to one hemisphere, and found the following: 1) left hemisphere damage was associated with near normal word comprehension but decreased expressive vocabulary, as well as a significant delay in the onset of word combinations; 2) right hemisphere damage was associated with a deficit in word comprehension with an equivalent or lesser deficit in production of single words. They found little effect of lesion size or severity (see also Vargha-Khadem, O'Gorman and Watters, 1985). Keefe, Feldman and Holland (1989), using a task requiring learning novel lexical items found that brain-damaged children required more presentations of the novel words to learn them (both in comprehension and production).

One of the first reports of deficits in morphosyntax comes from the case studied by Dennis (1980c). Dennis studied a child 9 years old who was tested three months post onset of a left temporal-parietal cerebral infarct). A wide variety of neuropsychological tests were administered, with the child described as nonfluent and as having difficulty in repeating sentences. She was able to comprehend single words and short utterances, but she was impaired in "...her expression and understanding of more complex language..." Unfortunately, no detailed analysis of specific structures was reported. Further, the child was only studied shortly after onset. Spontaneous recovery even in adults is known to continue at least until six months post onset (Sheewan, 1986) and possibly longer; in this case, we do not know what might have occurred with further neurological recovery.

Thal et al. (1989) reported on early acquisition of word combinations and grammatical markers by focally-lesioned subjects. They found a variety of patterns for their subjects, but found that right hemisphere lesions were associated with abnormally high numbers of "closed class" items, which they took to be evidence of a reliance on formulaic utterances (such as "want dat" instead of "want cookie" or "want go"). Left posterior lesions were associated with a high reliance on nominals at the expense of closed class items. According to this account, posterior lesions in adults and children have different consequences. Thal et al speculate that the anterior cortex becomse responsible for the phonological and grammatical processing (the computational component) only with time, as certain key language functions become automaticized. Early on, the posterior cortex may be responsible for not only lexical but grammatical and phonological development as well. However, it should be remembered that these patterns were variable, with one left anterior subject performing normally and one performing like the right hemisphere subjects. In addition, there is no evidence to suggest that any difficulties with closed class items reflect a lasting deficit.

Aram and co-workers (Rankin et al., 1981; Aram et al., 1985; Aram, Ekelman and Whitaker, 1986; Aram and Whitaker, 1988) have contributed a substantial body of data utilizing standardized tests as well as an analysis of spontaneous speech. Rankin et al. (1981) found that right hemiplegic children (indicating left hemisphere pathology) performed less well than left hemiplegic children on various lexical and syntactic measures, including comprehension of grammar on a picture pointing task and elicited production (on the Northwestern Syntax Screening Test (NSST); Lee 1976, which utilizes a picture pointing task in comprehension and in single-word vocabulary comprehension, but which is only a screening measure and not an in-depth assessment instrument). The left-hemisphere damaged cases also demonstrated delayed early language milestones (e.g. onset of first words and word combinations). Aram et al. (1985) studied a group of children aged 1.67 to 8.1 years. They found that 1) both left and right-lesioned cases had impaired lexical comprehension and production, with the left-damaged group performing slightly better than the right-damaged group, and 2) left-hemisphere cases were significantly impaired as compared to normals on mean length of utterance (MLU; calculated as in Miller, 1981), on a measure of syntactic complexity of sentences from spontaneous speech (DSS; Lee, 1974) and on their comprehension of various morphosyntactic structures (on the NSST). Data from the spontaneous speech of these same cases (Aram et al., 1986) indicated that the left- but not the right-lesioned cases produced fewer sentences which were grammatically correct than their controls. Using the weighted scoring system of the DSS (Lee, 1974), deficits were found in the left-lesioned subjects as compared to their controls (and generally, as compared to the right-lesioned subjects as well). They made more errors overall in the use of verbal morphology. No deficit was noted for pronoun use. They made more errors in simple sentences and in wh-questions, but no significant difference was found for negative constructions. On a separate analysis of syntactically simple versus complex constructions, the left-lesioned cases produced more malformed complex constructions than their controls, with the complex constructions examined including infinitives, full sentential complements, and relative clauses.

The data from these studies suggest that brain damage in either hemisphere may have consequences for early speech and first word combinations (although possible short-lived) as well as consequences for lexical learning. Further, there appears to be a morphosyntactic deficit in many individuals following early focal left-hemisphere lesions. Specifically, there is evidence that comprehension and production of verbal morphology might be impaired. Additionally, production of simple as well as complex syntactic constructions appears to be at risk.

1.3.2 Surgical removal of a single hemisphere

A second population, that of children who have had surgical removal of part or all of one hemisphere, have also been studied in an attempt to elucidate the status of language functions following damage to the proposed neurological substrate. Kohn (1980) studied 12 patients who had demonstrated some evidence of left hemisphere pathology (hemiplegia or seizures). The patients had all had surgical excision of the presumed loci of seizures. Of the eight cases with onset of left hemisphere symptoms before age 9 months, five demonstrated impaired comprehension of syntactic structures on the Token Test and in comprehension of passive and negative passive sentences. Of the four cases with onset after 9 months, two demonstrated an impairment in syntactic comprehension.[3]

Within the surgical group, hemidecorticate individuals have received more attention in the literature because of the unusual neuroanatomical situation. Hemidecorticates, those individuals who have had surgical removal of the cortex of an entire hemisphere, differ from the nonsurgery or focal surgery groups in that any role of the damaged hemisphere in supporting a given cognitive function is ruled out. These individuals have been the focus of a number of studies examining the functioning of the isolated hemispheres in a variety of cognitive domains. However, many of the studies present conflicting results. In the area of intellectual functioning, some researchers report

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3 Age at surgery is not noted, [illegible] comprehension was

above normal IQ scores after both left (Smith and Sugar, 1975) and right (Damasio, Lima and Damasio, 1975) hemispherectomy; others report that patients with isolated hemispheres demonstrated borderline (non-normal) scores on both verbal and nonverbal (performance) measures of IQ (Strauss and Verity, 1983). It has been suggested that lowered cognitive status, may reflect damage remaining in non-excised brain tissue (Verity, Strauss, Moyes, Wada, Dunn and Lapointe, 1982), with those patients with neurological integrity demonstrating normal functioning in nonlanguage tests. Still others report impaired performance IQ but normal verbal IQ after left hemispherectomy (Bruell and Albee, 1962; Gott, 1973). Studies of visual spatial functioning, thought to be within the functional domain of the right hemisphere, and thus an interesting parallel to cases with left hemisphere specialization for language, also present similarly disorderly results. Some reports indicate visual perception and visuospatial difficulties following right but not left hemispherectomy (Day and Ulatowska, 1979; Kohn and Dennis, 1974); others found significant visuospatial deficits in both left and right hemidecorticates (Strauss and Verity, 1985; Verity et al., 1972), indicating that neither the left nor the "crowded" right hemisphere are able to sufficiently support this particular cognitive function.

In the area of language, in spite of the signficant neurological difference between focal lesion cases and hemispherectomy cases, acquisition following removal of the left hemisphere appears in several respects to parallel that of the focal lesion cases. First, initial studies reported that "no clinical disturbance of speech" was found regardless of which hemisphere was removed (cf. Wilson's (1970) survey of 50 cases studied as long as 19 years post surgery completed at an age ranging from 1.5 to 31 years of age). However, subsequent work revealed evidence of a grammatical deficit on formal tests. Day and Ulatowska (1979) reported that both their right hemispherectomy case (aged 4 to 6 years) and their left hemispherectomy case (aged 5 to 11 years) demonstrated cognitive deficits. However, linguistic performance varied for the two cases. The individual with the right hemispherectomy suffered visual perceptual and visual motor deficits, but her language ability was judged to be basically intact. The individual with the left hemispherectomy demonstrated poor performance on a sentence completion task focusing on production of morphological markers (the Grammatic Closure subtest of the Illinois Test of Psycholinguistic Abilities (ITPA; Kirk, McCarthy and Kirk, 1968), which largely features prepositions, inflectional morphology and pronouns). She also had difficulties with metalinguistic tasks (sentence correction tasks, explaining similarities between words). However, her own spontaneous speech was fluent, contained complex constructions (e.g. embedded sentences) and was generally morphologically well-formed. It is also interesting that the performance of this second case was judged to be within normal limits at early stages in development (when testing was largely restricted to comprehension of simple commands and knowledge of vocabulary); later testing indicated the deficits noted above.

The most often cited research in this area are the studies of Dennis and colleagues (Dennis, 1980a; 1980b; 1983; Dennis and Kohn, 1975; Dennis and Whitaker, 1976). Their conclusions are based on data from a group of individuals whose age at the time of hemidecortication ranged from shortly after birth to as old as 20+ years, and who were tested at least 8, and as long as 17, years post surgery. They found that the isolated (intact) right hemisphere was superior to the left in some nonlanguage measures (specifically, on measures of visual-spatial functioning). They also found that both isolated hemispheres were able to acquire language to some extent, with no significant differences in receptive or productive lexical skills (including word retrieval). However, the isolated (intact) left hemisphere was superior to the (intact) right hemisphere in many of the computational aspects of language. The finding of the superiority of the left hemisphere for syntactic processing was based on the subjects' performance on tasks which test linguistic judgements without nonlinguistic cues to the meaning of structure (e.g. semantically reversible active/passive - affirmative/negative combinations). These results are especially surprising in light of the apparent competence of all subjects in most communicative situations. This is consistent with the Day and Ulatowska findings (1979). It is important to note that in less linguistically sophisticated research, the Dennis et al. subjects might have been erroneously assessed as having no language deficit (as was assumed before the work of Dennis and colleagues). In spite of the interesting implications of this work, however, Bishop (1983) raises some critical issues with respect to Dennis's research findings, citing the lack of normal controls on some tasks, statistical inadequacies (and errors), and the variability of Dennis's subjects' performance as well as the variation in the normal population on relevant tasks.

One additional case has been followed longitudinally throughout the preschool years (Curtiss and Jackson, ~~to appear~~ accepted for publication). S.M. had the cortex of his left hemisphere removed at 13 months. On formal tests of lexical knowledge (Peabody Picture Vocabulary Test-Revised, or PPVT-R, Boston Naming Test), he demonstrated performance within normal limits. On formal tests of grammatical knowledge (the Curtiss-Yamada Comprehensive Language Evaluation; CYCLE; Curtiss and Yamade, in press), he demonstrated below age-level performance in both comprehension and elicited production, with persistent problems in comprehending negative scope, and some aspects of morphology (including non-lexical grammatical markers as well as pronouns, prepositions, etc.). However, an extensive analysis of spontaneous speech revealed a different picture. At the first data point, SM shows a lag in the length, well-formedness and morphological elaboration of his utterances as compared to those of his peers. This is not surprising given the handicap of a probable late start in the process of acquisition with only a right hemisphere substrate (certainly sometime after his surgery at 13 months). However, by the final data point (age 6) lexical, semantic, and syntactic measures all indicated abilities comparable to that of the non-impaired controls. His spontaneous speech was only ill-formed in the area of morphology (consistent with his errors on the CYCLE), and he also demonstrated continuing production problems linked to intelligibility, revision and reformulation of his utterances. The only other evidence of a syntactic deficit was in his inability to deal with negative scope on formal tests, and he had no other evidence of a grammar which was deviant in its construction. He did not demonstrate difficulties with other types of constructions which have been reported to be difficult for other hemispherectomy or surgery cases (e.g. the passive; Dennis, 1980a; Kohn, 1980).

While the typical approach to elucidating the relationship between key areas of the left hemisphere and grammatical competence is to study cases with damage to these areas, investigations taken from the opposite perspective are also enlightening. In the next section we shall consider investigations which have focused on the neurological integrity of individuals who have a documented language impairment.

1.4 BRAIN DAMAGE IN LANGUAGE-IMPAIRED INDIVIDUALS

Two populations present evidence suggesting that developmental language disorders can be linked to either anomalies of the cortex in the left hemisphere or evidence of unusual patterns of cerebral dominance. Developmental dyslexia has been attributed historically to incomplete brain lateralization since the work of Orton (1937), with more recent specific hypotheses being an underlying processing deficit of the left hemisphere such as temporal sequencing (Bakker, 1972) or a specific linguistic deficit.

This latter hypothesis is supported both by behavioral studies as well as studies of functional or anatomical asymmetries in areas of the left hemisphere known to be key to linguistic abilities in adults. Cortical abnormalities found in the post-mortem studies of individuals with developmental dyslexia have been primarily neuronal and architectonic anomalies in the perisylvian region of the left hemisphere (Galaburda and Kemper, 1979; Galaburda, Sherman, Rosen, Aboitiz, and Geschwind, 1985; Drake, 1968). Liederman (1988) notes that these findings are a good example of how "bigger is not always better", as the Galaburda et al cases had symmetric planum temporale, possible due to a lack of selective cell death in the right hemisphere. Additionally, regional cerebral blood flow (rCBF) studies (Lassen, Ingvar and Skinhoj, 1980) and topographic mapping of brain electrical activity have both indicated that dyslexics have reduced activity in key portions of the left hemisphere (but also in some regions of the right hemisphere).

There have been several studies linking linguistic deficits (again, primarily deficits in comprehension of morphosyntax) with developmental dyslexia (Vogel, 1975; Whitehouse, 1983). Kean (1984) has reported results which specifically address the integrity of grammatical principles within the Government-Binding framework. In her study of the syntactic knowledge of adult dyslexics, she found that they made errors on sentence judgement items involving coreferential NP's (nouns coreferent with other noun phrases). Thus, there is evidence that a specific aspect of UG is impaired in this population. Evidently judgement of the grammaticality of other types of constructions hinging crucially on principles of UG (e.g. subjacency) and those testing a variety of other types of morphosyntactic constructions (passives, items testing subcategorization and selectional restrictions, definiteness, prepositions and subject verb-agreement) did not reveal any abnormal response patterns. Measuring reaction time on a word monitoring task, Kean found that the adult dyslexics were delayed in their ability to process determiners ("the") in comparison to their reaction times for items from other syntactic categories (nouns, verbs, adjectives, prepositions and quantifiers), indicating (according to Kean) a possible deficit in processing grammatical markers in general. These reports are important because they point to specific deficits in judging and processing aspects of grammar in a population with demonstrated cortical abnormalities.

A second group which has a language impairment as its primary deficit is the group of children with developmental language disorders. These children, like the group of dyslexic individuals, are not homogenous, but display different linguistic profiles and nonlinguistic deficits. Further, while there are studies describing the patterns of their delayed/disordered language acquisition (Morehead and Ingram, 1973; Johnston and Kamhi, 1984; Lee, 1966), little is known about the linguistic basis for their deficits; as Curtiss (1989)notes, their syntactic deficit "...has been taxonomized, not characterized". Language impaired children and adults with isolated (hemidecordicates) or disconnected (commissurectomy cases) right hemispheres often perform similarly on the Token Test, evidencing more difficulty with items taxing short term verbal memory than those thought to embody greater grammatical complexity (Tallal, 1975; Zaidel, 1977).

Language impaired children have also long been suspected as having a neurological deficit, i.e. atypical hemispheric specialization (hence the term "childhood aphasia", another common term used to describe children with primary language disorder). Dichotic listening studies are somewhat equivocal concerning patterns of asymmetry in this group (Springer and Eisenson, 1977; Bryden, 1970, Witelson and Rabinovitch, 1972). Historically, "soft" neurological signs rather than demonstrable neurological damage have been the primary diagnostic signs (e.g. Eisenson, 19XX). However, Rapin (1977) suggests that most children in her clinical practice with language disorders also evidence brain dysfunction. In three studies, specific regions of the brain are implicated. Dalby (1975) found that 46% of his developmentally dysphasic subjects had damage to the left temporal horn of the lateral ventricles, and 16% had bilateral damage in this area. He concludes that their disorder is linked to damage of the medial temporal area, with more severe deficits associated with bilateral involvement. Landau, Goldstein and Kleffner (1960) present the only case with severe receptive and expressive language deficits that has been brought to autopsy; they note the presence of old bilateral cystic infarcts involving the superior temporal gyrus. Plante and colleagues (Plante, 1988; Plante, Swisher and Vance, 1989), studying three language impaired children with MRI, reported no evidence of focal damage per se. However, the three cases demonstrated abnormal patterns in the perisylvian area, with two subjects having equivalent area in both hemispheres in this region, and one having a clear asymmetry (the right greater in area than the left). Typically greater volume in this area is associated with localization of function: this finding thus suggests an abnormal pattern of localization.

The research on all of these populations may be summarized as follows. First, in children and adults, language impairment typically follows left but not right hemisphere damage. However, recall that there were some reports of cases indicating that cases with *very* early damage, e.g. the first year of life, that appeared to be exempt from serious deficits. Thus, language functions appear to be lateralized to the left cerebral hemisphere very early in development (if not at birth.

Second, children appear to recover language abilities to a greater extent than adults with similar brain damage.

Third, there is evidence that the linguistic deficit in children with left hemisphere is primarily morphosyntactic, with a lexical deficit possibly underlying damage to either hemisphere.

However, many questions remain unanswered about the syntactic knowledge of children with focal hemispheric damage. Much work remains to be done to delimit the specific linguistic consequences of early cortical damage. The previous investigations of syntactic abilities is less than conclusive for several reasons. As mentioned above, the criticisms of Dennis' work justify a replication. The work of Aram et al.(1985) employed only relatively gross measures, such as screening tests or standardized tests; their 1986 study does provide some evidence that in production "complex" constructions may be difficult for these children. However, we do not have an explanation of the nature of the errors, nor an analysis of the deficits.

1.5 RESEARCH QUESTIONS

This dissertation addresses the following questions regarding morphosyntactic knowledge in children with focal damage to the left hemisphere (hereafter, FLHD).

1. Is there a demonstrable linguistic deficit in children with FLHD?

This initial research question is an attempt to confirm the findings of Aram et al. (1985; 1986), and will attempt to establish the presence or absence of a linguistic deficit on the basis of various and often standardized assessment procedures. This initial and general question will focus on both lexical and grammatical knowledge to investigate the extent to which a grammatical deficit, if found, exists in isolation or in tandem with a lexical deficit.

2. If there is a grammatical deficit, what specific areas of grammar are involved?

Government-Binding theory (Chomsky, 1981) proposes that syntax, as one component of grammar, is composed of subcomponents or systems of grammatical principles which constrain grammatical representations and operations. The theory differentiates "core" principles of syntax and more "peripheral" aspects of grammar. Core principles are those provided by Universal Grammar (UG), which underly the grammatical organization of all languages; the fixing of the parameters of UG (e.g. determining whether or not the language has optional lexical subjects of the clause; Hyams, 1983; 1986) determines the core grammar for a particular language. UG is assumed to make available to the child a finite group of possibilities for core grammar, thus constraining the acquisition process and making the relatively rapid rate of acquisition possible.

The periphery of the grammar is composed of exceptions to the settings of UG or language-unique instantiations of given parameters or rules. Hyams (1987) proposes that this syntactic distinction between the core and the periphery of grammar has specific implications for how grammar is acquired by children. She notes that peripheral aspects of grammatical constructions will be acquired later than core aspects of a construction, due to their greater difficulty in being acquired, due to the peripheral aspects being less accessible aspects of the input or to the possibility that learning the periphery involves a different kind of computation than core grammar.

Given the proposed distinction between the core and peripheral grammar, a question of interest is whether a grammatical deficit in this population is restricted to one or the other. No specific claims along this line are known to us at present, but there are relevant hypotheses about adult aphasia concerning linguistic impairment after neurological damage. Jakobson (1968) proposed that linguistic knowledge which is more "marked" and acquired latest is the first to be "lost". Note that peripheral aspects of a given grammatical construction are learned last. Along similar lines, Blumstein (1973) found that aphasic phonological errors could be rank ordered in frequency, with this order corresponding to acquisition (i.e. distinctive features which are acquired later are most problematic for adult aphasics).

Therefore, peripheral aspects of the grammar, being "learned" and not innately specified as is core grammar, are also a relevant area for investigation. One candidate for peripheral status in the grammar of English, according to Hyams (1987) is verbal inflection (see 2.8). What is the evidence concerning whether peripheral aspects will be impaired following focal left hemisphere damage in childhood? First, "learning" in a general sense is impaired following brain damage (Witelson, 1966), and, as noted earlier, lexical learning is specifically affected following focal damage to either hemisphere (Aram et al, 1985). If acquisition of non-major lexical items (e.g. verbal inflection) occurs in similar fashion to that of acquisition of major category lexical items, then we might expect a deficit (or delay) in verbal inflection.[4]

Second, it is reasonable to suspect that a morphological deficit is partly responsible for the grammatical deficit described by Aram et al. (1985). The assessment procedures (the NSST and DSS) used in their study include a number of items which assess morphology (specifically, Aux and verbal morphology) rather than syntactic knowledge. These findings make a morphological deficit probable in the cases we propose to study here. Note that verbal morphology does not have the same grammatical status and impact in all languages; thus, here we are predicting that it is in English cases that verbal morphology might be selectively vulnerable. Levy, Amir and Shalev (1989) found no impairment in inflectional morphology in their left-hemisphere lesioned case who was acquiring Hebrew. In Hebrew, a word cannot be well-formed unless an inflectional morpheme is present. This is not the case for English. We will return to this

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4 This assumes a model of grammar in which morphology is a separable "module" from syntax, and which, while interacting with syntactic principles and derivations, may have its own structure, rules and organization (e.g. see Anderson, 1986).

point in the discussion, but it should be apparent that a prediction regarding the selective vulnerability of peripheral grammar will have language specific consequences.

3. Does the age at which neurological damage occurs effect grammatical knowledge?

There is one study which found early damage was associated with more more profound impairment on verbal perfomance (on IQ tests; Vargha-Khadem et al., 1985)[5]. However, most others (Woods and Carey, 1979; Satz et al, 1985; Riva and Cazzaniga, 1986) present evidence consistent with the hypothesis that age at onset of damage has important consequences for language acquisition. Woods and Carey found that lesions occuring before one year of age resulted in no significant impairment on a variety of language tasks, while lesions which ocurred after one year of age were associated with more severe deficits. Differential effects were noted for naming, comprehension of subject and object relative clauses, knowledge of kinship terms, comprehension of *ask* vs. *tell*, and the Token Test. Similarly, Vargha-Khadem et al. found that impairments in naming and on the Token Test were more profound with onset after age five.

There is also related evidence from two studies of hemispherectomy cases. S.M., (studied by Curtiss and Jackson, to appear) whose surgery was at 13 months, outperformed SD (studied by Day and Ulatowska, 1979) on standardized tests and in spontaneous speech, in spite of the fact that SD was only two years older when surgery was performed.

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5 Vargha-Khadem and colleagues note that, at least for their sample, late lesions were more focal, thus perhaps causing less tissue damage and thus associated with lesser cognitive deficits.

There is little empirical evidence as to which aspects of the grammar (core or periphery) will be effected by age at onset. However, on theoretical grounds we might predict that the core is resistant to damage at *any* stage in development. This work assumes a theoretical view in which acquisition of syntax requires unique and special acquisition mechanisms that are not shared by other linguistic or cognitive domains. Thus, for phylogenetic reasons this knowledge should be housed in the brain in such a way as to be resistant to damage. The neurological basis for this encoding is presently unkown. In any case, the prediction is that core grammatical knowledge is not disrupted by focal left hemisphere damage.

The periphery, on the other hand, is necessarily more learnable, and thus dependent on different. On the grounds that earlier damage in general leads to better recovery (cf. the Woods and Carey study, as well as the prevailing view in neurology concerning age at onset for prognosis of recovery of function), we might predict that, while any left hemisphere damage in childhood might affect learning ability (and thus acquisition of the periphery), damage later in childhood might have a greater affect on acquisition of this aspect of grammar.

4. Are the linguistic deficits of left-hemisphere damaged children due to impairment in the underlying representations of knowledge or in language processing mechanisms?

This question is related to the extent to which performance of these individuals is consistent or varies across different tasks assessing knowledge of similar grammatical structures. There are several studies indicating apparent dissociations of performance abilities; adult ("agrammatic") aphasics who can make judgements about what they cannot themselves produce or comprehend (Linebarger, Schwartz and Saffran, 1983; see also Goodglass and Menn, 1985 for a discussion of this issue), adult Wernicke aphasics who are insensitive to grammatical cues to word order in any but the most simple sentences, and yet who are fluent and appear to be able to control word order in their own spontaneous speech (von Stockert, 1972), and, in development, a hemispherectomy case (Curtiss and Jackson, to appear), who can produce spontaneously what he cannot necessarily comprehend or produce in structured tasks. Thus, it seems likely that in the population of interest here, children with focal lesions, there may be patterns of performance which are indicative of a processing deficit. That is, access to or implementation of structural knowledge may be impaired on one or more tasks, while their correct performance on other tasks may indicate that the structural knowledge itself is intact and accesible on tasks which do not overly tax the damaged brain. Thus, there may be only one or two tasks on which these individuals can demonstrate their "best" linguistic performance. It is also possible that these tasks might be different across individuals, depending on the extent and type of damage, as well as other factors, such as age of onset.

1.6 HYPOTHESES

The following hypotheses about early focal following early focal left hemisphere lesions and the acquisition of morphosyntactic knowledge can be stated.

H1: Early focal left hemishere damage will result in deficits on standardized tests assessing lexical as well as morphosyntactic knowledge. However, in depth assessment of grammatical performance will reveal:

H1a: Acquisition of core properties of syntax will generally *not* be impaired if key areas of the left hemishere are damaged early in development (before the end of the hypothesized critical period, or before age 5).

H1b: Acquisition of the peripheral aspects of the grammar *will* be impaired following focal left hemisphere damage at any point in childhood.

H2: Age at onset will affect the nature and extent of deficits in the acquisition of peripheral aspects of grammar, with an increasing age at onset related to greater deficits in knowledge of the periphery.

H3: Performance of focally lesioned subjects will vary according to demands of the tasks used to assess syntactic knowledge, implicating processing deficits rather than deficits in underlying linguistic representations.

The remainder of the dissertation is organized as follows. Chapter 2 will outline the specific grammatical principles to be investigated, along with specific hypotheses concerning the acquisition of each of these principles by the children involved in this study. Chapter 3 will present the methods used herein. Chapters 4 through 6 will detail the results. Chapter 7 will summarize these findings and discuss their relevance for linguistic and neurolinguistic theory.

1.1 THE BASIC ISSUES

The question of how children acquire grammar has long intrigued and puzzled psychologists and philosophers as well as linguists. This dissertation seeks to investigate a specific aspect of this general issue; namely, the issue of the nature of the relationship between the grammatical knowledge of young children, presumed by some to be biologically endowed, and the neuroanatomical foundation for the innate human language faculty.

The issue of the relationship between neural structure and function on the one hand and the process of language acquisition on the other is a complicated one. Theories of grammar acquisition typically focus on explaining the acquisition process without reference to neurolinguistic issues. One approach to child language acquisition views child grammars as being discontinuous with adult grammatical knowledge in the sense that child grammars restructure during the acquisition process. The early grammars are considered to be semantically or communicatively based, later becoming organized along grammatical principles (Bowerman, 1973; Schlesinger, 1971; Maratsos, 1982). An alternative approach assumes that children are innately equipped with abstract, formal grammatical principles which constitute Universal Grammar, or UG, the set of principles or operations which hold across all languages (Chomsky, 1980). These abstract principles guide the construction of the child's grammar, and predispose the child to entertain only certain hypotheses about the input language (all grammatically based). Support for this position is presented in recent studies which suggest that children's earliest hypotheses about the organization of their language are grammatical in nature (e.g. Hyams, 1986; Crain and McGee, 1986; Crain and Nakayama, 1985; Tavakolian, 1981; Roeper, 1988, Bloom, 1990). It follows from this view that children do not learn or acquire fundamental grammatical constructs; these are already present as acquisition starts. Rather, they learn only the idiosyncratic aspects of their language; e.g. vocabulary, aspects of the phonetic system, and specific language-particular syntactic facts.

If children come to the task of language acquisition with basic syntactic knowledge (in the form of UG), why is adult grammatical competence not instantaneous? Two answers to this question have been proposed. One is that the as yet nonfunctioning grammatical principles are invoked or "triggered" by data which is only gradually made available to the child (Pinker, 1984). The specific data are either literally unavailable at early stages in development (i.e. are not used in speech to the child) or not accessible due to the constraints of immature nonlinguistic cognitive or perceptual systems, e.g. limitations on memory interacting with input processing in some way. A second proposal is that grammatical principles mature in the same way that other biologically governed behaviors mature and develop over time (Borer and Wexler, 1984). However, as Roeper (1988) notes, both maturation and triggering of latent abilities could apply to different portions of the grammar, and at different times. In any case, syntactic knowledge is viewed as biologically predetermined; even a maturational view does not imply that grammatical principles are learned (one would not say that a child "learns" to increase short-term memory, for example, or "learns" hormonal changes at puberty).

Recent work within this theoretical framework has begun to make explicit what aspects of grammatical knowledge might be innate. This acquisition theory, however, has not been concerned with the neural or anatomical basis for (presuamed to be) innate grammatical knowledge. This dissertation will attempt to consider this question from the point of view of how damage to the left "language" hemisphere early in development may affect specific aspects of syntactic and morphological knowledge which are acquired later in childhood. Should a specific effect of early left hemisphere damage be found, the argument for the biological basis of UG and language acquisition is thereby strengthened.

1.2 A LANGUAGE-BRAIN RELATIONSHIP EARLY IN DEVELOPMENT?

1.2.1 Early brain damage and theories of hemispheric specialization

A major source of data used to support theories about the relationship between grammatical knowledge and its neurological substrate in the mature system has been studies of adults with localized brain damage. For over 100 years, research on adults with aphasia document the linguistic impairments which occur in the cases of left- but not right hemisphere damage for right-handed males (beginning with Broca (1863) and Wernicke (1874)). However, the role of the left hemisphere in language acquisition has not been unambiguously attested. Early studies of focal cortical damage of varying etiology in children found that right- as well as left-hemisphere damage led to later deficits in language (e.g. Sachs and Peterson, 1890; Basser, 1962; Hood and Perlstein, 1955a; 1955b). These data led Lenneberg (1967) to hypothesize an equipotentiality of the cortical hemispheres for language acquisition during the first two years of life, with neither hemisphere yet specialized to support language at birth. This hemispheric equipotentiality was attributed to the immature character and plasticity of the brain at birth. According to Lenneberg, specialization for language continues to develop in the left hemisphere until puberty, at which time lateralization is complete.

Krashen (1972) modified Lenneberg's hypothesis by showing that lateralization is complete by age five in normal cases, although some acquisition of language could take place after this completion of lateralization (hypothesized as due to compensatory support of linguistic functioning by the right hemisphere). Further, Kinsbourne (1976;

1979) proposed that left hemisphere specialization exists at birth, with the asymmetry in function beginning before overt language skills are apparent. Kinsbourne and Hiscock (1977) specifically criticized the notion that language is only gradually biased towards left hemisphere representation, stating "...we know of no animal model and of no human analogue to the idea that, for a given behavior, the brain base shrinks with increasing functional sophistication" (p. 134). They supported a developmental invariance hypothesis, in which there is a preprogrammed asymmetry favoring left hemisphere specialization for language from birth.

More recently, studies of brain damage in children, which have largely excluded etiologies with a likelihood of bilateral involvement and which have also been conducted since the advent of more accurate methods of lesion localization, support the position of innate hemispheric differences. Several studies have found that acquired aphasia or language disturbance in children, as in adults, is more often the result of left hemisphere focal damage (Annett, 1973; Alajouanin and Lhermitte, 1965; Hecaen, Perenin and Jeannerod, 1984; Woods, 1980a; Woods and Carey, 1979; Woods and Teuber, 1978). This is also the conclusion of Satz and Bullard-Bates (1981) who apply a strict set of criteria in interpreting the various data (including knowledge of premorbid handedness and evidence of speech development before the onset of the lesion). Woods has formulated an "initial potential equipotentiality theory" (1980b); while the left hemisphere may be prepotent for language, the continuing lateralization of the left hemisphere for language overrides the potential of the right hemisphere to subserve language, a potential which is realized only if development of the left hemisphere is hampered in some way.

1.2.2 Neurological evidence of hemispheric assymmetry

There is additional evidence for the view that hemispheric asymmetries may be relevant to language and language lateralization. Anatomical asymmetries have been demonstrated in adults, with the left planum temporale[1] larger in the majority of cases (Geschwind and Levitsky, 1968), resulting in a longer and more horizontal Sylvian fissure, with greater volume in the auditory association cortex (Rosen and Galaburda, 1985). Geschwind and Levitsky conclude that the anatomical asymmetry is "compatible with the known functional asymmetries [p.187]". There are other asymmtries in the adult brain which favor the frontal and temporal areas of the left hemisphere, including increased amounts of neurotransmitter activity in the temporal lobe (Amaducci, Sorbi, Albanese and Gianotti, 1981; Glick, Ros and Hough, 1982) and in Broca's area (Braak, 1979).

Assymmetries have been found in the brain in utero as well as at or shortly after birth. Gross structural asymmetries have been found in key portions of the left temporal lobe of the fetal brain (e.g. a larger left planum temporale) which are present by the 29th gestational week (Witelson and Pallie, 1973; Wada, Clark and Hamm, 1975; LeMay and Culebras, 1972). However, it is not the case that the left hemisphere structures always exceed right hemisphere structures in absolute volume, size or number. In spite of the larger appearance of parts of the left hemisphere at 29 weeks, Chi, Dooling and Gilles (1977) found that structures surrounding the planum temporale may appear in recognizable form in the fetal brain earlier in the right than in the left, indicating slower growth of certain language areas of the left hemisphere. Reviewing the embryonic literature, Best (1988) proposed several vectors of growth in the emergence and

1 Roughly speaking, the planum temporale is the part of the temporal lobe known as the auditory association cortex, an area often affected in Wernicke's aphasia.

develoOpment of the cerebral hemispheres, the most relevant here being a vector of right to left growth. Turkewitz (1988), citing Galaburda's (1984) findings that fetal development of the right temporal lobe precedes that of the left, proposed that the acoustic environment later in pregnancy (when the uterine walls become tauter, thinner, and better able to transmit external sounds, including the maternal voice) coincides with the later development of the left hemisphere. Thus, his view proposed an interaction of development and growth of the neural substrate with environmental stimuli to achieve specialization of function.

An asymmetry favoring the right hemisphere is also apparent at the level of the dendrites, or the branches of the neurons. Initially in the young child there is greater dendritic complexity found in the right hemisphere, with the left and right hemispheres alternating in this regard until the age of three to four years, when the left hemisphere establishes and maintains greater dendritic complexity (Simonds and Schiebel, 1988). Thus, it may be that the left hemisphere develops more slowly, but for a longer period of time, and that it eventually surpasses the right in dendritic complexity (Rosen and Galaburda, 1985). It has been suggested that the final establishment of greater dendritic complexity in Broca's region in the left hemisphere corresponds with lateralization of hemispheric function (Schiebel, Paul, Fried, Forsythe, Tomiyasu, Wechsler, Kao and Slotnick, 1985).

It is difficult to link these anatomical, cytoarchitechtonic and metabolic differences directly to linguistic functioning, but it is clear that the cerebral hemispheres are structurally and functionally different, in some aspects early on, and in others in ways which may be linked to language acquisition and continuing support for language functioning.

1.2.3. Behavioral assymmetries: Response of the normal brain to linguistic stimuli

In addition to neurological asymmetries, there are also perceptual asymmetries for processing linguistic vs. non-linguistic sounds found in neonates and young children, indicating that at birth or shortly therafter, the hemispheres differ in their response to language stimuli. Researchers have found strongly lateralized responses using dichotic listening techniques (Entus, 1977) and EEG activity (Gardiner and Walter, 1977), with the left hemisphere implicated to a greater extent in processing linguistic vs. nonlinguistic (music) stimuli. Likewise, studies utilizing electrophysiological data from auditory event-related potentials, or AERP's (Molfese, 1972; Molfese, Freeman and Palermo, 1975; also see Molfese and Betz, 1988, for a thorough review of this area) have found hemispheric differences in AERP's, although the language/nonlanguage distinction is not so clear. For example, categorical perception of consonants via voice onset time (VOT) typically elicits a right hemisphere response (at least for English speakers), while perception of consonantal place of articulaton typicallly elicits a left hemisphere response.

These response asymmetries, while not necessarily directly linked to lateralization of (adult) cognitive functions, imply a biologically fixed program for the infant's brain to be asymmetrically sensitive to certain kinds of input, with the left hemisphere specially prepared to process linguistic information. The implications of these asymmetries for the specifics of language acquisition, however, remain unclear.

1.3 LANGUAGE ACQUISITION FOLLOWING SPECIFIC BRAIN DAMAGE IN CHILDREN

If the left hemisphere is neurobiologically preprogrammed for language, how does damage to this neural substrate affect language acquisition? Data from three classes of individuals are relevant here: 1) cases with early focal cortical lesions, 2) cases of early hemidecortication, and 3) cases with identified language disorders (e.g. developmental dyslexics) who were then found to have unusual neurological conditions. Each of these populations will be discussed in turn.

1.3.1 Focal cortical lesions in early development

The first population reviewed here is that of children with unilateral focal cortical lesions acquired during birth or in early childhood. These children face the task of language acquisition with a damaged hemisphere. Many of the early studies of this group were impressionistic and concerned with clinical issues, i.e. classification of disorders according to adult aphasia typologies, degree of recovery to premorbid level of functioning, etc. Acquired aphasia in children[2] has traditionally been described as "nonfluent" in nature, with production halting and often grammatically incomplete (Guttman, 1942; Benson, 1967; Brown and Hecaen, 1976; Hecaen, 1976). This type of aphasia was reported for cases with early damage as well as those with damage occuring later in childhood (i.e. after some acquisition had already taken place). This stands in contrast to the fluent/nonfluent (or Wernicke's/Broca's) distinction which is noted in adults after similar types of damage. The lack of comprehension deficits as well as impairment in naming and dysarthria were also noted by various researchers (a symptom complex associated with nonfluent aphasias). However, more recent studies have reported "fluent" aphasias (output with structurally intact but with jargon/paraphasias

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2 The term "aphasic" has often been utilized to described children with language disorders even without a proven etiology of neurological damage. The term here is restricted to that population where there is clear evidence of brain damage as an underlying cause of language impairment.

persent) in childhood which appear to be most common immediately after the onset of the damage (Visch-Brink and van de Sandt-Koenderman, 1984; Van Hout, Evrard and Lyons, 1985). Childhood aphasia has also been characterized as being associated with more complete recovery than was typical for adults, especially for children who suffer their damage very early in life (e.g. Guttman, 1942; Roberts, 1958), although Alajouanine and Lhermitte (1965) noted that many of their apparently recovered subjects had difficulty in school, particularly in subjects which emphasized language skills. Woods and Carey (1979) also conclude that recovery from aphasia in childhood is less complete than previously proposed (see following discussion).

Clinical issues aside, it is unclear what, if anything, is revealed about the linguistic knowledge of children with focal lesions by the studies discussed above. Information about the specific linguistic abilities of children following focal damage is rare in these reports, with information about the extent to which language had been acquired before the neurological difficulties rarer still. When objective assessment of specific linguistic abilities was used, it consisted most often of verbal intelligence testing. Until recently, few groups of researchers have attempted to evaluate specific linguistic (including morphosyntactic) knowledge. Woods and Carey (1979) were among the first to use tests designed to evaluate knowledge of specific aspects of language as well as tests in academic-related areas with their left-hemisphere patients (aged 10 to 25 years). They found only an impairment in spelling in patients with lesions before age 1.0. For the late lesion group (mean age 5.7 years) significant impairments were found in a naming task, on performance on the Token Test, on sentence judgement and completion tasks, and on a test of knowledge of kinship terms. However, some of their tasks involve more than just linguistic abilities; e.g. their sentence completion task requires good reading comprehension ability. Further, the data are presented in terms of scores on individual tests; no interpretation of error types or patterns is given.

There are a few additional studies which support the hypothesis that very early damage to the left hemisphere results in no overt linguistic impairment (e.g. Bullard-Bates and Satz, 1983; Satz, Orsini, Saslow and Henry, 1985); Landsdell, 1969). Some of these researchers claim that the early reorganization of linguistic function to the right hemisphere was responsible for the essentially normal performance of the subjects. Interestingly, this purported shift of language representation to the right hemisphere is not without cost, as the above studies report that visuo-spatial abilities, traditionally thought to be within the province of the right hemisphere, were impaired. While these studies rely on standardized tests (typically IQ tests), they do produce evidence contrary to the viewpoint that the left hemisphere substrate is ready and necessary to support language function from a very early point in development.

Most other recent research efforts have found an association of early brain damage with linguistic deficits of one sort or another. Beginning with early, prespeech milestones, Marchman, Miller and Bates (1989) found some differences in the character of early babbling and in the onset of first words, with early vocalizations being considered to be less complex (containing fewer true consonants) than those of controls. However, at least three of their five subjects were performing comparably to the by 22 months of age. There is only one study which investigates phonological knowledge, and it looks only at very young children. Keefe, Feldman and Holland (1989) evaluated the utterances of four children aged approximately two to four years of age who had suffered brain damage within the first week of life. They found no significant differences between controls and brain-damaged individuals in terms of the phonological processes which characterized their spontaneous speech (e.g. most of children had evidence of the operation of age-appropriate phonological processes, such as cluster reduction, and did not produce utterances reflecting the presence of a phonological change not typical of their age, such as unstressed syllable deletion.)

Several studies note the relationship between brain damage in either hemisphere and an impairment in lexical knowledge (Annett, 1973; Aram, Ekelman, Rose and Whitaker, 1985; Rankin, Aram and Horowitz, 1981; Kiessling, Dencla and Carlton, 1983 (although their results were not statistically significant)), with the deficit apparent even at the point of acquisition of first words (Marchman et al. 1989). Thal, Marchman, Stiles, Trauner, Nass and Bates (1989) studied 11 cases with focal damage to one hemisphere, and found the following: 1) left hemisphere damage was associated with near normal word comprehension but decreased expressive vocabulary, as well as a significant delay in the onset of word combinations; 2) right hemisphere damage was associated with a deficit in word comprehension with an equivalent or lesser deficit in production of single words. They found little effect of lesion size or severity (see also Vargha-Khadem, O'Gorman and Watters, 1985). Keefe, Feldman and Holland (1989), using a task requiring learning novel lexical items found that brain-damaged children required more presentations of the novel words to learn them (both in comprehension and production).

One of the first reports of deficits in morphosyntax comes from the case studied by Dennis (1980c). Dennis studied a child 9 years old who was tested three months post onset of a left temporal-parietal cerebral infarct). A wide variety of neuropsychological tests were administered, with the child described as nonfluent and as having difficulty in repeating sentences. She was able to comprehend single words and short utterances, but she was impaired in "...her expression and understanding of more complex language..." Unfortunately, no detailed analysis of specific structures was reported. Further, the child was only studied shortly after onset. Spontaneous recovery even in adults is known to continue at least until six months post onset (Sheewan, 1986) and possibly longer; in this case, we do not know what might have occurred with further neurological recovery.

Thal et al. (1989) reported on early acquisition of word combinations and grammatical markers by focally-lesioned subjects. They found a variety of patterns for their subjects, but found that right hemisphere lesions were associated with abnormally high numbers of "closed class" items, which they took to be evidence of a reliance on formulaic utterances (such as "want dat" instead of "want cookie" or "want go"). Left posterior lesions were associated with a high reliance on nominals at the expense of closed class items. According to this account, posterior lesions in adults and children have different consequences. Thal et al speculate that the anterior cortex becomes responsible for the phonological and grammatical processing (the computational component) only with time, as certain key language functions become automaticized. Early on, the posterior cortex may be responsible for not only lexical but grammatical and phonological development as well. However, it should be remembered that these patterns were variable, with one left anterior subject performing normally and one performing like the right hemisphere subjects. In addition, there is no evidence to suggest that any difficulties with closed class items reflect a lasting deficit.

Aram and co-workers (Rankin et al., 1981; Aram et al., 1985; Aram, Ekelman and Whitaker, 1986; Aram and Whitaker, 1988) have contributed a substantial body of data utilizing standardized tests as well as an analysis of spontaneous speech. Rankin et al. (1981) found that right hemiplegic children (indicating left hemisphere pathology) performed less well than left hemiplegic children on various lexical and syntactic measures, including comprehension of grammar on a picture pointing task and elicited production (on the Northwestern Syntax Screening Test (NSST); Lee 1976, which utilizes a picture pointing task in comprehension and in single-word vocabulary comprehension, but which is only a screening measure and not an in-depth assessment instrument). The left-hemisphere damaged cases also demonstrated delayed early language milestones (e.g. onset of first words and word combinations). Aram et al. (1985) studied a group of children aged 1.67 to 8.1 years. They found that 1) both left and right-lesioned cases had impaired lexical comprehension and production, with the left-damaged group performing slightly better than the right-damaged group, and 2) left-hemisphere cases were significantly impaired as compared to normals on mean length of utterance (MLU; calculated as in Miller, 1981), on a measure of syntactic complexity of sentences from spontaneous speech (DSS; Lee, 1974) and on their comprehension of various morphosyntactic structures (on the NSST). Data from the spontaneous speech of these same cases (Aram et al., 1986) indicated that the left- but not the right-lesioned cases produced fewer sentences which were grammatically correct than their controls. Using the weighted scoring system of the DSS (Lee, 1974), deficits were found in the left-lesioned subjects as compared to their controls (and generally, as compared to the right-lesioned subjects as well). They made more errors overall in the use of verbal morphology. No deficit was noted for pronoun use. They made more errors in simple sentences and in wh-questions, but no significant difference was found for negative constructions. On a separate analysis of syntactically simple versus complex constructions, the left-lesioned cases produced more malformed complex constructions than their controls, with the complex constructions examined including infinitives, full sentential complements, and relative clauses.

The data from these studies suggest that brain damage in either hemisphere may have consequences for early speech and first word combinations (although possible short-lived) as well as consequences for lexical learning. Further, there appears to be a morphosyntactic deficit in many individuals following early focal left-hemisphere lesions. Specifically, there is evidence that comprehension and production of verbal morphology might be impaired. Additionally, production of simple as well as complex syntactic constructions appears to be at risk.

1.3.2 Surgical removal of a single hemisphere

A second population, that of children who have had surgical removal of part or all of one hemisphere, have also been studied in an attempt to elucidate the status of language functions following damage to the proposed neurological substrate. Kohn (1980) studied 12 patients who had demonstrated some evidence of left hemisphere pathology (hemiplegia or seizures). The patients had all had surgical excision of the presumed loci of seizures. Of the eight cases with onset of left hemisphere symptoms before age 9 months, five demonstrated impaired comprehension of syntactic structures on the Token Test and in comprehension of passive and negative passive sentences. Of the four cases with onset after 9 months, two demonstrated an impairment in syntactic comprehension.[3]

Within the surgical group, hemidecorticate individuals have received more attention in the literature because of the unusual neuroanatomical situation. Hemidecorticates, those individuals who have had surgical removal of the cortex of an entire hemisphere, differ from the nonsurgery or focal surgery groups in that any role of the damaged hemisphere in supporting a given cognitive function is ruled out. These individuals have been the focus of a number of studies examining the functioning of the isolated hemispheres in a variety of cognitive domains. However, many of the studies present conflicting results. In the area of intellectual functioning, some researchers report above normal IQ scores after both left (Smith and Sugar, 1975) and right (Damasio, Lima

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3 Age at surgery is not noted.

and Damasio, 1975) hemispherectomy; others report that patients with isolated hemispheres demonstrated borderline (non-normal) scores on both verbal and nonverbal (performance) measures of IQ (Strauss and Verity, 1983). It has been suggested that lowered cognitive status, may reflect damage remaining in non-excised brain tissue (Verity, Strauss, Moyes, Wada, Dunn and Lapointe, 1982), with those patients with neurological integrity demonstrating normal functioning in nonlanguage tests. Still others report impaired performance IQ but normal verbal IQ after left hemispherectomy (Bruell and Albee, 1962; Gott, 1973). Studies of visual spatial functioning, thought to be within the functional domain of the right hemisphere, and thus an interesting parallel to cases with left hemisphere specialization for language, also present similarly disorderly results. Some reports indicate visual perception and visuospatial difficulties following right but not left hemispherectomy (Day and Ulatowska, 1979; Kohn and Dennis, 1974); others found significant visuospatial deficits in both left and right hemidecorticates (Strauss and Verity, 1985; Verity et al., 1972), indicating that neither the left nor the "crowded" right hemisphere are able to sufficiently support this particular cognitive function.

In the area of language, in spite of the signficant neurological difference between focal lesion cases and hemispherectomy cases, acquisition following removal of the left hemisphere appears in several respects to parallel that of the focal lesion cases. First, initial studies reported that "no clinical disturbance of speech" was found regardless of which hemisphere was removed (cf. Wilson's (1970) survey of 50 cases studied as long as 19 years post surgery completed at an age ranging from 1.5 to 31 years of age). However, subsequent work revealed evidence of a grammatical deficit on formal tests. Day and Ulatowska (1979) reported that both their right hemispherectomy case (aged 4 to 6 years) and their left hemispherectomy case (aged 5 to 11 years) demonstrated cognitive deficits. However, linguistic performance varied for the two cases. The individual with the right hemispherectomy suffered visual perceptual and visual motor deficits, but her language ability was judged to be basically intact. The individual with the left hemispherectomy demonstrated poor performance on a sentence completion task focusing on production of morphological markers (the Grammatic Closure subtest of the Illinois Test of Psycholinguistic Abilities (ITPA; Kirk, McCarthy and Kirk, 1968), which largely features prepositions, inflectional morphology and pronouns). She also had difficulties with metalinguistic tasks (sentence correction tasks, explaining similarities between words). However, her own spontaneous speech was fluent, contained complex constructions (e.g. embedded sentences) and was generally morphologically well-formed. It is also interesting that the performance of this second case was judged to be within normal limits at early stages in development (when testing was largely restricted to comprehension of simple commands and knowledge of vocabulary); later testing indicated the deficits noted above.

The most often cited research in this area are the studies of Dennis and colleagues (Dennis, 1980a; 1980b; 1983; Dennis and Kohn, 1975; Dennis and Whitaker, 1976). Their conclusions are based on data from a group of individuals whose age at the time of hemidecortication ranged from shortly after birth to as old as 20+ years, and who were tested at least 8, and as long as 17, years post surgery. They found that the isolated (intact) right hemisphere was superior to the left in some nonlanguage measures (specifically, on measures of visual-spatial functioning). They also found that both isolated hemispheres were able to acquire language to some extent, with no significant differences in receptive or productive lexical skills (including word retrieval). However, the isolated (intact) left hemisphere was superior to the (intact) right hemisphere in many of the computational aspects of language. The finding of the superiority of the left hemisphere for syntactic processing was based on the subjects' performance on tasks which test linguistic judgements without nonlinguistic cues to the meaning of structure (e.g. semantically reversible active/passive - affirmative/negative combinations). These results are especially surprising in light of the apparent competence of all subjects in most communicative situations. This is consistent with the Day and Ulatowska findings (1979). It is important to note that in less linguistically sophisticated research, the Dennis et al. subjects might have been erroneously assessed as having no language deficit (as was assumed before the work of Dennis and colleagues). In spite of the interesting implications of this work, however, Bishop (1983) raises some critical issues with respect to Dennis's research findings, citing the lack of normal controls on some tasks, statistical inadequacies (and errors), and the variability of Dennis's subjects' performance as well as the variation in the normal population on relevant tasks.

One additional case has been followed longitudinally throughout the preschool years (Curtiss and Jackson, to appear). S.M. had the cortex of his left hemisphere removed at 13 months. On formal tests of lexical knowledge (Peabody Picture Vocabulary Test-Revised, or PPVT-R, Boston Naming Test), he demonstrated performance within normal limits. On formal tests of grammatical knowledge (the Curtiss-Yamada Comprehensive Language Evaluation; CYCLE; Curtiss and Yamade, in press), he demonstrated below age-level performance in both comprehension and elicited production, with persistent problems in comprehending negative scope, and some aspects of morphology (including non-lexical grammatical markers as well as pronouns, prepositions, etc.). However, an extensive analysis of spontaneous speech revealed a different picture. At the first data point, SM shows a lag in the length, well-formedness and morphological elaboration of his utterances as compared to those of his peers. This is not surprising given the handicap of a probable late start in the process of acquisition with only a right hemisphere substrate (certainly sometime after his surgery at 13 months). However, by the final data point (age 6) lexical, semantic, and syntactic measures all indicated abilities comparable to that of the non-impaired controls. His spontaneous speech was only ill-formed in the area of morphology (consistent with his errors on the CYCLE), and he also demonstrated continuing production problems linked to intelligibility, revision and reformulation of his utterances. The only other evidence of a syntactic deficit was in his inability to deal with negative scope on formal tests, and he had no other evidence of a grammar which was deviant in its construction. He did not demonstrate difficulties with other types of constructions which have been reported to be difficult for other hemispherectomy or surgery cases (e.g. the passive; Dennis, 1980a; Kohn, 1980).

While the typical approach to elucidating the relationship between key areas of the left hemisphere and grammatical competence is to study cases with damage to these areas, investigations taken from the opposite perspective are also enlightening. In the next section we shall consider investigations which have focused on the neurological integrity of individuals who have a documented language impairment.

1.4 BRAIN DAMAGE IN LANGUAGE-IMPAIRED INDIVIDUALS

Two populations present evidence suggesting that developmental language disorders can be linked to either anomalies of the cortex in the left hemisphere or evidence of unusual patterns of cerebral dominance. Developmental dyslexia has been attributed historically to incomplete brain lateralization since the work of Orton (1937), with more recent specific hypotheses being an underlying processing deficit of the left hemisphere such as temporal sequencing (Bakker, 1972) or a specific linguistic deficit. This latter hypothesis is supported both by behavioral studies as well as studies of functional or anatomical asymmetries in areas of the left hemisphere known to be key to linguistic abilities in adults. Cortical abnormalities found in the post-mortem studies of individuals with developmental dyslexia have been primarily neuronal and architectonic anomalies in the perisylvian region of the left hemisphere (Galaburda and Kemper, 1979; Galaburda, Sherman, Rosen, Aboitiz, and Geschwind, 1985; Drake, 1968). Liederman (1988) notes that these findings are a good example of how "bigger is not always better", as the Galaburda et al cases had symmetric planum temporale, possible due to a lack of selective cell death in the right hemisphere. Additionally, regional cerebral blood flow (rCBF) studies (Lassen, Ingvar and Skinhoj, 1980) and topographic mapping of brain electrical activity have both indicated that dyslexics have reduced activity in key portions of the left hemisphere (but also in some regions of the right hemisphere).

There have been several studies linking linguistic deficits (again, primarily deficits in comprehension of morphosyntax) with developmental dyslexia (Vogel, 1975; Whitehouse, 1983). Kean (1984) has reported results which specifically address the integrity of grammatical principles within the Government-Binding framework. In her study of the syntactic knowledge of adult dyslexics, she found that they made errors on sentence judgement items involving coreferential NP's (nouns coreferent with other noun phrases). Thus, there is evidence that a specific aspect of UG is impaired in this population. Evidently judgement of the grammaticality of other types of constructions hinging crucially on principles of UG (e.g. subjacency) and those testing a variety of other types of morphosyntactic constructions (passives, items testing subcategorization and selectional restrictions, definiteness, prepositions and subject verb-agreement) did not reveal any abnormal response patterns. Measuring reaction time on a word monitoring task, Kean found that the adult dyslexics were delayed in their ability to process determiners ("the") in comparison to their reaction times for items from other syntactic categories (nouns, verbs, adjectives, prepositions and quantifiers), indicating (according to Kean) a possible deficit in processing grammatical markers in general. These reports are important because they point to specific deficits in judging and processing aspects of grammar in a population with demonstrated cortical abnormalities.

A second group which has a language impairment as its primary deficit is the group of children with developmental language disorders. These children, like the group of dyslexic individuals, are not homogenous, but display different linguistic profiles and nonlinguistic deficits. Further, while there are studies describing the patterns of their delayed/disordered language acquisition (Morehead and Ingram, 1973; Johnston and Kamhi, 1984; Lee, 1966), until recently little was known about the linguistic basis for their deficits. Curtiss, Katz and Tallal (to appear) found their data to suggests that language-impaired children were constructing grammars along the same lines as their normal controls, and that their linguistic impairments were due to processing rather than representational deficits. As with developmental dyslexia, primary language impairment has long been suspected as having a neurological basis, i.e. atypical hemispheric specialization (hence the term "childhood aphasia", another common term used to describe children with primary language disorder). Dichotic listening studies are somewhat equivocal concerning patterns of asymmetry in this group (Springer and Eisenson, 1977; Bryden, 1970, Witelson and Rabinovitch, 1972). Historically, "soft" neurological signs rather than demonstrable neurological damage have been the primary diagnostic signs. However, in three studies specific regions of the brain are implicated. Dalby (1975) found that 46% of his developmentally dysphasic subjects had damage to the left temporal horn of the lateral ventricles, and 16% had bilateral damage in this area. He concludes that their disorder is linked to damage of the medial temporal area, with more severe deficits associated with bilateral involvement. Landau, Goldstein and

Kleffner (1960) present the only case with severe receptive and expressive language deficits that has been brought to autopsy; they note the presence of old bilateral cystic infarcts involving the superior temporal gyrus. Plante and colleagues (Plante, 1988; Plante, Swisher and Vance, 1989), studying three language impaired children with MRI, reported no evidence of focal damage per se. However, the three cases demonstrated abnormal patterns in the perisylvian area, with two subjects having equivalent area in both hemispheres in this region, and one having a clear asymmetry (the right greater in area than the left). Typically greater volume in this area is associated with localization of function: this finding thus suggests an abnormal pattern of localization.

The research on all of these populations may be summarized as follows. First, in children and adults, language impairment typically follows left but not right hemisphere damage. However, recall that there were some reports of cases indicating that cases with *very* early damage, e.g. the first year of life, that appeared to be exempt from serious deficits. Thus, language functions appear to be lateralized to the left cerebral hemisphere very early in development (if not at birth.

Second, children appear to recover language abilities to a greater extent than adults with similar brain damage.

Third, there is evidence that the linguistic deficit in children with left hemisphere is primarily morphosyntactic, with a lexical deficit possibly underlying damage to either hemisphere.

However, many questions remain unanswered about the syntactic knowledge of children with focal hemispheric damage. Much work remains to be done to delimit the specific linguistic consequences of early cortical damage. The previous investigations of syntactic abilities is less than conclusive for several reasons. As mentioned above, the criticisms of Dennis' work justify a replication. The work of Aram et al.(1985)

employed only relatively gross measures, such as screening tests or standardized tests; their 1986 study does provide some evidence that in production "complex" constructions may be difficult for these children. However, we do not have an explanation of the nature of the errors, nor an analysis of the deficits.

1.5 RESEARCH QUESTIONS

This dissertation addresses the following questions regarding morphosyntactic knowledge in children with focal damage to the left hemisphere (hereafter, FLHD).

1. Is there a demonstrable linguistic deficit in children with FLHD?

This initial research question is an attempt to confirm the findings of Aram et al. (1985; 1986), and will attempt to establish the presence or absence of a linguistic deficit on the basis of various and often standardized assessment procedures. This initial and general question will focus on both lexical and grammatical knowledge to investigate the extent to which a grammatical deficit, if found, exists in isolation or in tandem with a lexical deficit.

2. If there is a grammatical deficit, what specific areas of grammar are involved?

Government-Binding theory (Chomsky, 1981) proposes that syntax, as one component of grammar, is composed of subcomponents or systems of grammatical principles which constrain grammatical representations and operations. The theory differentiates "core" principles of syntax and more "peripheral" aspects of grammar. Core principles are those provided by Universal Grammar (UG), which underly the grammatical organization of all languages; the fixing of the parameters of UG (e.g. determining whether or not the language has optional lexical subjects of the clause; Hyams, 1983; 1986) determines the core grammar for a particular language. UG is assumed to make available to the child a finite group of possibilities for core grammar, thus constraining the acquisition process and making the relatively rapid rate of acquisition possible.

The periphery of the grammar is composed of exceptions to the settings of UG or language-unique instantiations of given parameters or rules. Hyams (1987) proposes that this syntactic distinction between the core and the periphery of grammar has specific implications for how grammar is acquired by children. She notes that peripheral aspects of grammatical constructions will be acquired later than core aspects of a construction, due to their greater difficulty in being acquired, due to the peripheral aspects being less accessible aspects of the input or to the possibility that learning the periphery involves a different kind of computation than core grammar.

Given the proposed distinction between the core and peripheral grammar, a question of interest is whether a grammatical deficit in this population is restricted to one or the other. No specific claims along this line are known to us at present, but there are relevant hypotheses about adult aphasia concerning linguistic impairment after neurological damage. Jakobson (1968) proposed that linguistic knowledge which is more "marked" and acquired latest is the first to be "lost". Along similar lines, Blumstein (1973) found that aphasic phonological errors could be rank ordered in frequency, with this order corresponding to acquisition (i.e. distinctive features which are acquired later are most problematic for adult aphasics). The general suggestion is that lastest learned material is more vulnerable in the face of adult language loss: n1jp26

ote that peripheral aspects of a given grammatical construction are learned last.

Therefore, peripheral aspects of the grammar, being "learned" and not innately specified as is core grammar, are also a relevant area for investigation. One candidate for peripheral status in the grammar of English, according to Hyams (1987) is verbal inflection (see 2.8). What is the evidence concerning whether peripheral aspects will be impaired following focal left hemisphere damage in childhood? First, "learning" in a general sense is impaired following brain damage (Witelson, 1966), and, as noted earlier, lexical learning is specifically affected following focal damage to either hemisphere (Aram et al, 1985). If acquisition of non-major lexical items (e.g. verbal inflection) occurs in similar fashion to that of acquisition of major category lexical items, then we might expect a deficit (or delay) in verbal inflection.[4]

Second, it is reasonable to suspect that a morphological deficit is partly responsible for the grammatical deficit described by Aram et al. (1985). The assessment procedures (the NSST and DSS) used in their study include a number of items which assess morphology (specifically, Aux and verbal morphology) rather than syntactic knowledge. These findings make a morphological deficit probable in the cases we propose to study here. Note that verbal morphology does not have the same grammatical status and impact in all languages; thus, here we are predicting that it is in English cases that verbal morphology might be selectively vulnerable. Levy, Amir and Shalev (1989) found no impairment in inflectional morphology in their left-hemisphere lesioned case who was acquiring Hebrew. In Hebrew, a word cannot be well-formed unless an inflectional morpheme is present. This is not the case for English. We will return to this point in the discussion, but it should be apparent that a prediction regarding the selective vulnerability of peripheral grammar will have language specific consequences.

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4 This assumes a model of grammar in which morphology is a separable "module" from syntax, and which, while interacting with syntactic principles and derivations, may have its own structure, rules and organization (e.g. see Anderson, 1986).

3. Does the age at which neurological damage occurs effect grammatical knowledge?

There is one study which found early damage was associated with more more profound impairment on verbal perfomance (on IQ tests; Vargha-Khadem et al., 1985)[5]. However, most others (Woods and Carey, 1979; Satz et al, 1985; Riva and Cazzaniga, 1986) present evidence consistent with the hypothesis that age at onset of damage has important consequences for language acquisition. Woods and Carey found that lesions occuring before one year of age resulted in no significant impairment on a variety of language tasks, while lesions which ocurred after one year of age were associated with more severe deficits. Differential effects were noted for naming, comprehension of subject and object relative clauses, knowledge of kinship terms, comprehension of *ask* vs. *tell*, and the Token Test. Similarly, Vargha-Khadem et al. found that impairments in naming and on the Token Test were more profound with onset after age five.

There is also related evidence from two studies of hemispherectomy cases. S.M., (studied by Curtiss and Jackson, to appear) whose surgery was at 13 months, outperformed SD (studied by Day and Ulatowska, 1979) on standardized tests and in spontaneous speech, in spite of the fact that SD was only two years older when surgery was performed.

There is little empirical evidence as to which aspects of the grammar (core or periphery) will be effected by age at onset. However, on theoretical grounds we might predict that the core is resistant to damage at *any* stage in development. This work

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5 Vargha-Khadem and colleagues note that, at least for their sample, late lesions were more focal, thus perhaps causing less tissue damage and thus associated with lesser cognitive deficits.

assumes a theoretical view in which acquisition of syntax requires unique and special acquisition mechanisms that are not shared by other linguistic or cognitive domains. Thus, for phylogenetic reasons this knowledge should be housed in the brain in such a way as to be resistant to damage. The neurological basis for this encoding is presently unkown. In any case, the prediction is that core grammatical knowledge is not disrupted by focal left hemisphere damage.

The periphery, on the other hand, is necessarily more learnable, and thus dependent on different. On the grounds that earlier damage in general leads to better recovery (cf. the Woods and Carey study, as well as the prevailing view in neurology concerning age at onset for prognosis of recovery of function), we might predict that, while any left hemisphere damage in childhood might affect learning ability (and thus acquisition of the periphery), damage later in childhood might have a greater affect on acquisition of this aspect of grammar.

4. Are the linguistic deficits of left-hemisphere damaged children due to impairment in the underlying representations of knowledge or in language processing mechanisms?

This question is related to the extent to which performance of these individuals is consistent or varies across different tasks assessing knowledge of similar grammatical structures. There are several studies indicating apparent dissociations of performance abilities; adult ("agrammatic") aphasics who can make judgements about what they cannot themselves produce or comprehend (Linebarger, Schwartz and Saffran, 1983; see also Goodglass and Menn, 1985 for a discussion of this issue), adult Wernicke aphasics who are insensitive to grammatical cues to word order in any but the most simple sentences, and yet who are fluent and appear to be able to control word order in their own spontaneous speech (von Stockert, 1972), and, in development, a hemispherectomy case

(Curtiss and Jackson, to appear), who can produce spontaneously what he cannot necessarily comprehend or produce in structured tasks. Cornell, Fromkin and Mauner (to appear) prpose a spcific account for the disparity in performance on comprehension/judgement task seen for agrammatics. They propose a "partial structures model", in which agrammatism is due to a the language processor receiving an incomplete grammatical representation of specific linguistic structures. This is not a problem on a judgement task, where grammatically possible interpretations could be made for ungrammatical stimuli (possible because the agrammatics are missing some of the information which makes it ungramamtical). Thus, the agrammatical would accept ungrammatical sentences as grammatical (this is, in fact, the error they make; rejecting grammatical sentences is not a typical response). However, on comprehension tasks, the subject must derive the correct parse for the sentence in order to differentiate between different and competing responses.

Given analyses of other brain-damaged populations which propose processing rather than representational deficits, it seems likely that in the population of interest here, children with focal lesions, there may be patterns of performance which are indicative of a processing deficit. That is, access to or implementation of structural knowledge may be impaired on one or more tasks, while their correct performance on other tasks may indicate that the structural knowledge itself is intact and accesible on tasks which do not overly tax the damaged brain. Thus, there may be only one or two tasks on which these individuals can demonstrate their "best" linguistic performance. It is also possible that these tasks might be different across individuals, depending on the extent and type of damage, as well as other factors, such as age of onset.

1.6 HYPOTHESES

The following hypotheses about early focal following early focal left hemisphere lesions and the acquisition of morphosyntactic knowledge can be stated.

H1: Early focal left hemishere damage will result in deficits on standardized tests assessing lexical as well as morphosyntactic knowledge. However, in depth assessment of grammatical performance will reveal:

H1a: Acquisition of core properties of syntax will generally *not* be impaired if key areas of the left hemishere are damaged early in development (before the end of the hypothesized critical period, or before age 5).

H1b: Acquisition of the peripheral aspects of the grammar *will* be impaired following focal left hemisphere damage at any point in childhood.

H2: Age at onset will affect the nature and extent of deficits in the acquisition of peripheral aspects of grammar, with an increasing age at onset related to greater deficits in knowledge of the periphery.

H3: Performance of focally lesioned subjects will vary according to demands of the tasks used to assess syntactic knowledge, implicating processing deficits rather than deficits in underlying linguistic representations.

The remainder of the dissertation is organized as follows. Chapter 2 will outline the specific grammatical principles to be investigated, along with specific hypotheses concerning the acquisition of each of these principles by the children involved in this study. Chapter 3 will present the methods used herein. Chapters 4 through 6 will detail the results. Chapter 7 will summarize these findings and discuss their relevance for linguistic and neurolinguistic theory.

CHAPTER 2

PRINCIPLES OF GRAMMAR:

THEORETICAL ANALYSIS AND NORMAL ACQUISITION

2.1 INTRODUCTION

This chapter will present the current theoretical analysis within a GB framework of several types of syntactic principles and constructions. This set of principles and subcomponents of grammar will be those which form the basis of investigation of the syntactic knowledge of focally lesioned children. We begin with an overview of how the theory represents the basic organization of grammar, with this section serving as a base for the discussions of more specific aspects of the grammar which follow (Chomsky 1981; 1982; 1986). UG is viewed as containing subsystems, each of which has specific properties which affect various domains of grammatical constructions. The result of the "modular character of grammar" (Chomsky, 1981) is that a given grammatical phenomenon arises from the interaction of these subsystems.

In the base, or phrase structure component, the phrase structure rules generate an infinite class of structures at the level of D-structure. The rules determine word order within constituents (e.g. NP --> Det NP; S ---> NP INFL VP. X-bar theory (cf. Stowell, 1981) allows further generalizations about the structure of constituents. By viewing the phrase structure components as relationships between specifiers and complements, specifying unique phrase structure rules for the maximal projections of the lexical categories becomes unnecessary. Thus, only two rules are needed: XP = SPEC X' and X' = X YP. An example of these rules can be seen in the phrasal spell-out for IP (what used to be called S); IP = NP I'; I' = INFL VP .

The application of movement (NP, wh- or head movement) results in the level of S-structure. Application of phonological rules, including various deletion operations, and the rules which characterize the scope of variables result in the levels of PF and LF respectively.

The general organization of the rule system is as exemplfied below in Figure 1:

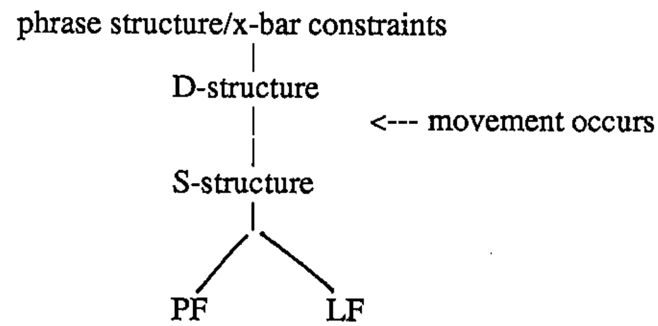


Figure 1: general organization of grammar

Within these various levels of grammatical representation, there operate various subsystems of principles which constrain grammatical representations (e.g. the Binding theory, principles of control and other principles to be discussed in the following sections). The (at least partially) independent principles interact, resulting in various grammatical constructions. For example, "move alpha", the rule which allows movement of a constituent to a new locale, is restructed from unwanted activity by other principles of grammar, such as theta-theory, the binding principles and the principles of subjacency. Thus, the fact that only certain constituents can be moved to specific locations is not the result of complicated movement rules, but of the restrictions of other aspects of the grammar on a single, simple rule of constituent movement.

Two additional principles are referred to here:

> The Projection Principle: Representations at each syntactic level (i.e. LF, D- and S-structure are projected from the lexicon, in that they observe the subcategorization properties of lexical items (Chomsky 1981:29)

> The Theta Criterion: Each argument bears one and only one theta role and each theta role is assigned to one and only one argument (Chomsky 1981:35).

The first principle ensures that arguments (NP's) cannot be added or deleted during a derivation. They also cannot move unless the leave behind a trace which in effect holds the original place (and thus the original relationship of nouns to verbs) of the moved element. The Theta Criterion ensures that all NP's are assigned theta-roles at D-structure (e.g. are assigned the role of subject/agent or object/theme), and that are only allowed one role. The results of these two principles is to preserve any original lexical requirements of the verbs (e.g. that *put* must have both an object and a preposition phrase/location following it) and any original role of a word in a sentence that was assigned before movement of constitutents (e.g. that in a sentence like *John is hit by Mary* it is *Mary* who is the agent, not *John*). Both of these principles will be discussed further in the sections to come.

An important consequence of this constrained and modular theory of grammatical organization introduced above is that, because constructions are the result of the interaction of grammatical subsystems, mastery of a particular aspect of the grammar may be acquired in a piecemeal fashion. Hopefully, this point will be clear after the discussion of the specific principles in the upcoming sections; however, it is clear that passive verb morphology, passive word order and the by-phrase do not emerge all at the same point in time. Likewise, anaphors may be appropriately have local binding but may still appear as subjects within the grammar of a given child.

In summary, UG contains the important grammatical endowment central to all languages. These fundamental principles have certain possibilities of variation which restrict possible human grammars and yet permit the diversity seen across languages in grammatical organization. Once UG is fixed in a certain way, the core grammar of the language at hand is the result. As discussed in chapter 1, there are other aspects of grammatical knowledge which are considered more peripheral. The grammatical periphery, exceptions to the settings allowed for the parameters of UG, or language-unique features, are the aspects of a specific grammatical construction hypothesized as being later acquired and "learned" in a sense that is not attibuted to core grammatical principles, unlearnable on the basis of input. What constitutes the periphery of the grammar varies from language to language. Thus, in English, bare lexical stems appear at S-level as acceptable words, thus, verbal inflection has been proposed to be peripheral for the grammar of English. In contrast, in Italian a bare stem is not an acceptable word, with the appearance of overt verbal morphology required to make an acceptable word in the language. Thus, in Italian verbal morphology is part of core grammatical structure (Hyams, 1987).

We now proceed to a discussion of several specific aspects of core grammar and the available information on how these principles are acquired under normal conditions. Each syntactic structure or principle discussed here was chosen for its presumed theoretical importance; it embodies a particular principle thought to be characteristic of human grammars and thus part of UG. However, there were also two practical concerns in the selection of these specific aspects of grammar. First was the necessity that there be adequate research concerning how the principle or subcomponent of the grammar was acquired by normal, non-brain injured children. Second, as it was somewhat unclear how impaired or delayed grammar acquisition might be in the brain-injured cases, it was important to select principles which were evidenced at very early points in development.

In addition to the discussion of aspects of the core grammar of English, there is also a discussion of one aspect of the periphery of English in section 2.8; verbal morphology. As mentioned earlier, the model of morphology assumed here is the extended word paradigm theory (Anderson, 1977; 1982; 1988), where morphology (in particular, the inflectional component) is considered an independent module of grammar which operates on lexical stems to arrive at phonemic level structures.

2.2 RECURSION IN NP: RELATIVE CLAUSES

2.2.1 Theoretical analysis

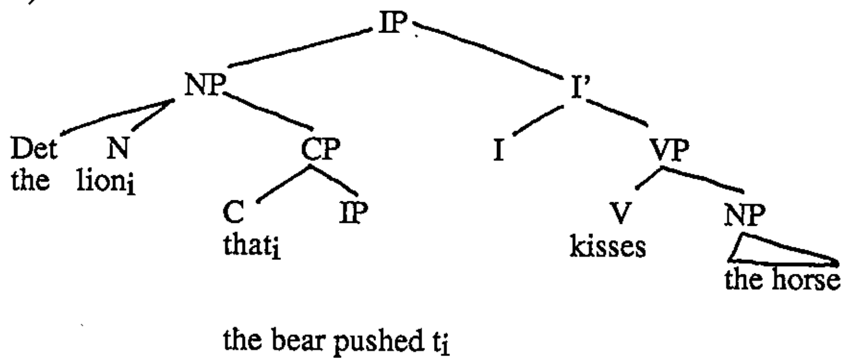
In GB theory, the base subcomponent of the grammar utilizes simple rules specifying the relationship of complements to heads of phrasal categories. These rules allow the generatation of a variety of types of phrasal structures for each language. One important property of the the phrase structure rules is that they allow for recursion, or the ability to embed one clause in another. Recursion in noun phrases (NP's[1]), creates relative clauses, as represented by NP --> Det N CP; CP --> C' IP (the CP being the embedded Comp phrase, or sentence). Relative clauses are analyzed as involving wh-movement and thus a resulting wh-trace, as in 1) and 2)

1) The lion that the bear pushed kisses the horse.

---

[1] I recognize the current question as to whether or not the category traditionally known as NP is, in fact projected from the determiner (D) and not from the noun (N) (e.g. see Abney 1983). I will use the NP analysis here, recognizing that this is an area of current investigation. Likewise, the question of whether or not the subject NP originates within the VP at the level of D-structure and is then moved at the surface (e.g. Koopman and Sportiche, 1988) is a matter of current interest; this analysis will not be included here.

2)



Here, the relative pronoun <u>that</u> has been moved to the clause initial position Comp. It leaves behind a trace of this movement (t), to which it is coindexed or coreferenced. The theory has stipulations on movement, as well as on linking of traces to the moved constituents. While wh-movement figures in other constructions, we shall restrict our discussion here to the treatment of the recursive clause (or IP) within NP, and to how this aspect of relatives is apparently acquired by the child.

Relative clauses can be subject relatives, with the matrix subject being either the subject of the embedded clause (SS relatives) or the object of the embedded clause, as in 3) and 4) respectively:

3) The dog$_i$ that t_i bit the cat kicked the mouse. (SS rel)

4) The dog$_i$ that the cat bit t_i kicked the mouse (SO rel)

Likewise, object relatives can feature relativized subjects or objects:

5) The dog bit the cat$_i$ that t_i kicked the mouse. (OS rel)

6) The dog bit the cat$_i$ that the mouse kicked t_i. (OO rel)

2.2.2 Studies of normal acquisition

As with VP recursion, there are several domains which the child must master. First, the child must have a grammar which allows for recursion within specific categories (e.g. for relatives, it must allow recursion inside of NP). The child must also have a procedure for interpreting empty elements; here, there must be a method for determining reference for the wh-trace.

In production data there is evidence for early mastery of a recursive NP rule. Hamburger and Crain (1982) propose that as early as 24 months child grammars may contain such a recursive NP rule, as evidenced by the appearance of what they call "protorelatives". They describe protorelatives as consisting of a restrictive IP (or at least a VP) within an NP, as in:

7) This my did it.

and in two examples from my daughter Ellen at about this same point in development:

8) This is Mommy's write

9) This is my read it

As can be seen above, early protorelatives are "headless". The first true relatives are also headless, as in these examples from Ellen at 2-22

10) I want what you have, Mommy.

These headless constructions seem to indicate that early on children are capable of embedding an S, but that some of the mechanics for more complex embedding are not yet mastered. Relative pronouns and mastery of rules of construal for empty elements appear still later, as in:

11) I know a girl at achool that Miss Jacklin likes.

12) Dumbo needs the feather that is magic.

---

2 Following convention, ages of children will be represented in years-months (2 years, 2 months, in this case).

As mentioned earlier, a modular theory of grammar would allow (and perhaps predict) this somewhat piecemeal mastery of grammatical constructions. In this case, recursion appears to be an early, core property of grammar, with other aspects of grammar maturing or triggered later on.

Most of the initial comprehension studies involving relative clauses indicated that: a) very young children can interpret SS relatives (subject relatives where the matrix subject is also the subject of the embedded clause) (Lahey, 1974; Brown, 1971; Sheldon, 1974); b) comprehension of Object relatives with relativized objects (OO relatives) and object relatives with the matrix object the same as the embedded subject (OS relatives) is initially incorrect, with the subject of the matrix coreferential with the relative pronoun, followed by correct interpretation by around age 4 - 5 (e.g. Goodluck and Tavakolian, 1981; Solan and Roeper, 1978). Later comprehension than production of some types of relative clauses was somewhat problematic for theories of competence; however, with important methodological changes, even three- to four-year olds are able to comprehend OS relatives (most relevantly, it was found that the number of lexically full NP's in the sentences can affect comprehension; Hamburger and Crain, 1982). Thus recursion in NP is apparent early; the structural analysis needed to correctly interpret or parse empty elements may appear slightly later.

2.3. RECURSION IN VP: VERBAL COMPLEMENTS

2.3.1 Theoretical analysis

Embedded clauses can occur in yet another grammatical context; they can appear in the VP as a complement to the verb. To comprehend and produce structures with recursion in VP, there a number of principles and domains of grammatical knowledge the child must have access to. First, the PS rules must include a rule which allows the recursive structure to be generated in the base. Thus, sentential complements are generated within VP: VP --> V CP; CP --> C IP (similar to the account of NP recursion. Sentential complements are not the only way that clauses may be "added" within the matrix clause; adjunct clauses, which are not subcategorized for, are hung directly from S, and thus must be analyzed differently).

Second, the child must deal with both tensed and infinitival complements, as in 13) and 14) respectively:

13) I hope you will wait for me.

14) I told you to wait for me.

Infinitival complements such as 14) are also analyzed as containing an empty element known as PRO (this will be discussed further with the analysis presented in section 2.5); thus, the child must have a procedure for interpreting phonologically null categories to successfully interpret this type of complement.

2.3.2 Studies of normal acquisition

The earliest studies of complementation focused on production of complements by young children. Propositional complements (tensed and infinitival) appear early in children's spontaneous speech, at roughly 2 to 2 1/2 years of age (Limber, 1973; Bloom, Takeff and Lahey, 1984) (as in 15) and 16) :

15) I gonna get it

16) Want the man stand up.

Data from my daughter Ellen indicate the production of "small clause" complements (non-maximal projections but still clause-like structures) as early as 22 months, with true infinitives like 18) appearing slightly later (at 2-6):

17) I think doggie little bit wet.

18) I expected you to be gone.

Hyams (1987) suggests that both tensed complements and early infinitivals appear as the result of a recursive rule for the VP (VP --> V CP) being introduced into the grammar (although others have claimed that early infinitives are initially nonsentential; see Bloom et al, 1984). According to Hyams, the sentential structure of complements is a core property of the grammar (the phrase structure rule which in child as well as adult grammars allows for recursion within VP). It is acquired early, and provides the basic structure onto which other properties of complementation are mapped.

There are, according to Hyams, some other aspects of verbal complementation which are peripheral and which appear later, such as the appearance of overt complementizers, selction of specific type of complementizer, and S'deletion and exceptional case marking associated with raising verbs.

Research on verbal complementation in the grammars of older children has largely utilized comprehension tasks, and has largely focused on the status of structures with PRO and control; see section 2.5. Acquisition of indirect discourse and wh-complements continues somewhat later, with such things as choice of wh-complementizer and structure of indirect questions taking somewhat longer.

2.4 BINDING OF OVERT NP'S

The principles of binding are included here because of their importance for a wide range of construction types (from overt pronouns to null elements, and from single-clause sentences to (crucially) recursive structures. As Lust (1986) notes, anaphora (the relationship between a proform such as a pronoun and an antecedent) may be key to complex sentence formulation, in that embedded structures " inherently involves redundancy reduction, and therefore provides a domain for possible anaphora (p. 10)".

Within GB theory, the Binding Theory is proposed as a module delineating the formal constraints on these relationships between NP's. We shall further restrict this discussion to lexically realized NP's. In section 2.3 coreference of one of the null elements also affected by the Binding Theory, PRO, will be reviewed).

2.4.1 Theoretical analysis

The original formulation of the binding theory (i.e. Chomsky 1981) proposed the following:

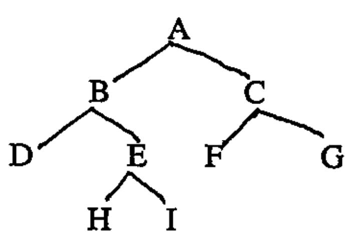
A. An anaphor must be locally bound (bound in its governing category).

B. A pronoun must be locally free (*not* bound in its governing category).

C. An R-expression (or name) must be free everywhere.

Some definitions of these terms are called for. "Bound" means that an NP is c-commanded by and co-indexed (or coreferential) with another NP, with "free" meaning the opposite (thus, not c-commanded by a co-indexed antecedent). C-command (based on Reinhart, 1976) is defined as follows: one element c-commands another if the branching node dominating the first element also dominates the second, and if the first item does not itself dominate the second. This structural relationship is illustrated in 19)

19)

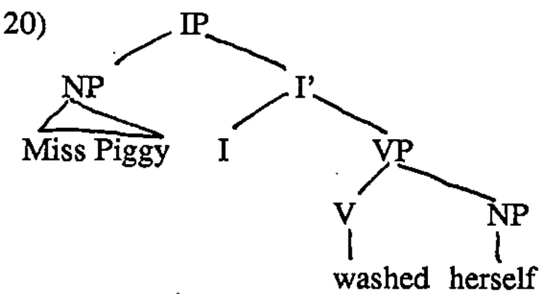


In the above example, D and E c-command C, F, G, H and I. However, H and I do c-command only E (and each other) in that the branching node B dominates only H, I, and E.[3]

[3] At least so far, c-command appears to be an excellent example of a structural relationship which is difficult to explain in terms of other, more general cognitive

"Governing category" and "local" are terms refering to the syntactic domain in which NP's may or may not be bound. X can be said to govern Y if it is the minimal lexical category (V, A, N, P or AGR) which c-commands Y without an intervening S or NP barrier. The governing category for X is the minimal NP or S which contains the constituent which governs X[4]. An example of these syntactic relationships is exemplified in 20):

20)



In 20) above, *herself* is governed (minimally c-commanded) by the verb *washed.* S is the governing category for *herself* (it contains the verb *washed*). For our purposes here, the governing category or local domain will largely amount to the clause, or IP (as in 20) above).

Recent reformulations of the binding principles focus on the notion Complete Functional Complex (CFC) (Chomsky 1986). CFC is defined as follows (Johnson, 198X):

---

principles. Roeper (1988) notes "...one is forced to the conclusion that...this constraint is essentially pre-programmed into the child."

4 Note that this is a simplified version of this definition; while it will suffice for our purposes here, the reader is referred to the formal definition in Aoun and Sportiche (1980), among others.

b is a CFC if all grammatical functions theta-marked by a head dominated by b are contained in b.

CFC's, then, are the category in which all constituents theta-marked by a head are contained (i.e. NP or S). Binding theory can be now formulated in terms of CFC. Informally stated, the binding domain for pronouns and anaphors is the least CFC (NP or S) in which the binding theory can be satisfied (or, the smallest CFC in which pronouns can be free and reflexives can be bound). This reformulation has implications for the acquisition literature, as we will see in section 2.2.2.

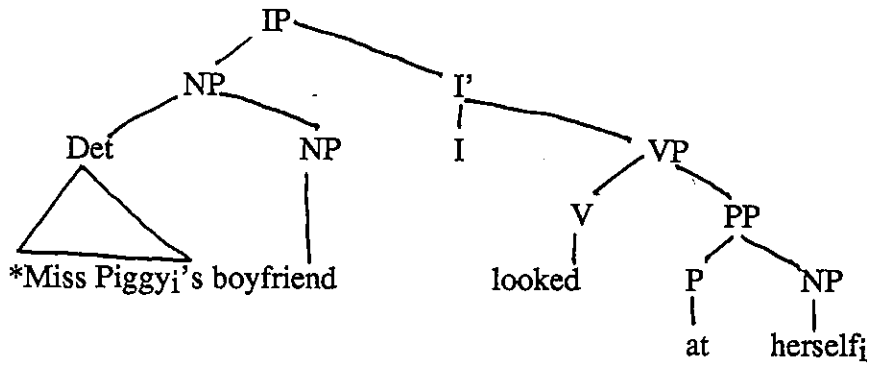
There are some generalizations about each of the binding principles which are discussed further below.

The following can be said about lexical anaphors (such as reflexive pronouns): a) They must have an antecedent (a corefential NP) in the (tensed) clause; b) this antecedent must have a specific structural relationship to the reflexive; it must c-command it (and thus it may not be lower in the sentential tree than the reflexive), and c) the antecedent must be within the governing category (the same clause) as the reflexive. All of these requirements are responsible for the judgements of 21) - 24) below:

21) Miss Piggy looked at herself.

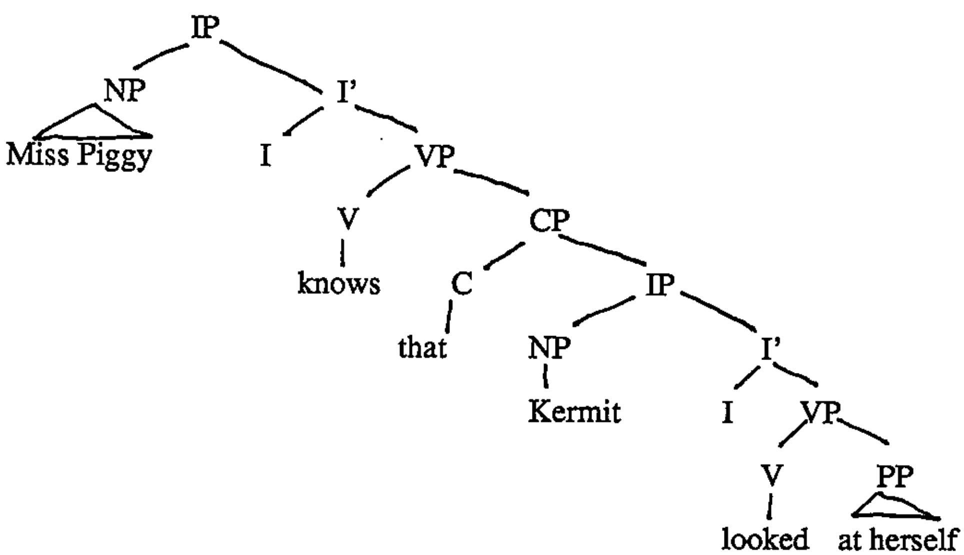
22) *Miss Piggy looked at himself. (*himself* must have a local antecedent but can not be coreferential with *Miss Piggy*).

23)



In 23) the antecedent for *herself* is *Miss Piggy*, which is contained within a larger NP and is thus too low on the tree structure to c-command *herself*).

24) (*)

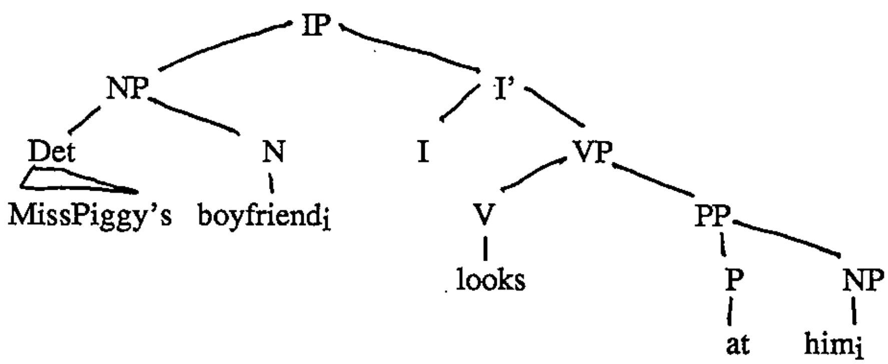


In 24) here is no possible local antecedent for *herself* within the lower clause; thus, it is not grammatical.

In contrast to anaphors, pronouns must be free within their governing category. Thus, the requirements for their grammatical use are: a) pronouns may (or may not) have an antecedent in the same (tensed) clauses, but b) the antecedent may not c-command it, and c) the antecedent may not be local (may not be in within the clause). The corresponding examples are:

25) *Miss Piggy$_i$ looked at her$_i$. (there is a non-allowed local antecedent for *her*).

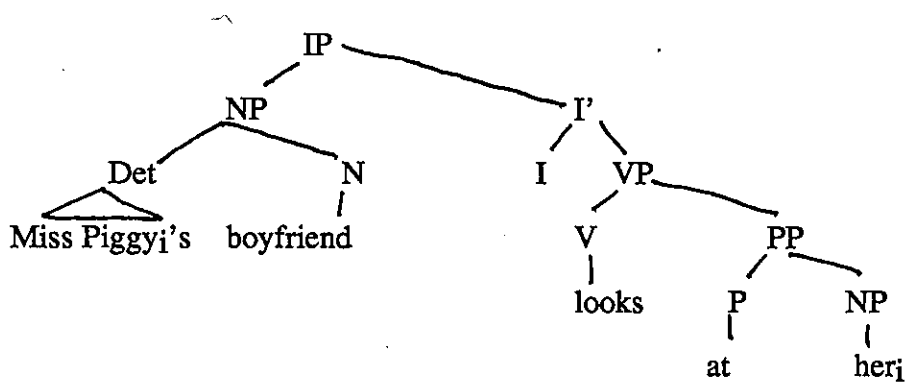
26)



Example 26) is unacceptable in that *boyfriend* is a possible antecedent for and c-commands *him* and thus must be coreferent, violating principle B).

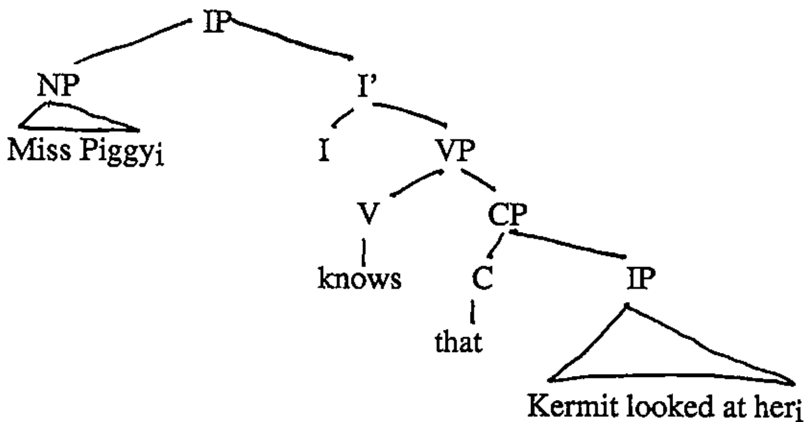
Contrast 26) with 27) below:

27)



Here, the possible antecedent for *her* is *Miss Piggy*, which does not c-command the pronoun (it is contained within the larger NP *Miss Piggy's boyfriend*), and thus is allowed to be coreferent). An additional grammatical example is 28):

28)



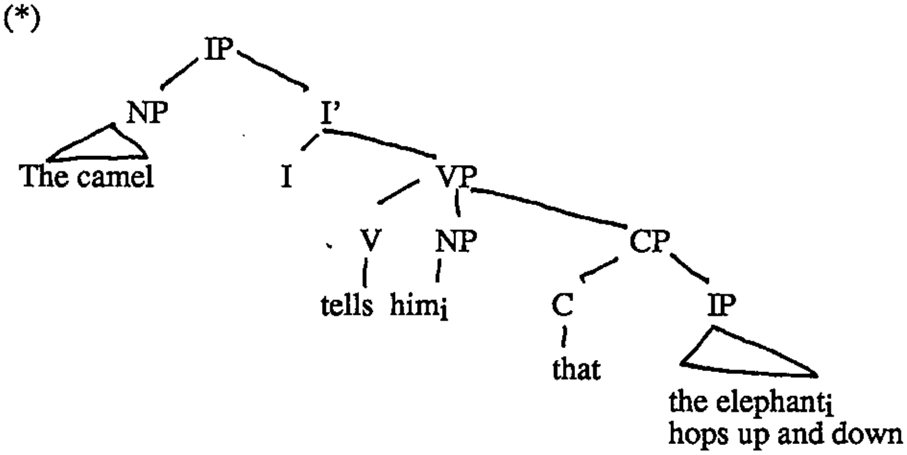
The example above is grammatical because there is no local NP coreferential with *her* in the same clause, which is the governing category of the pronoun.

The final binding condition (C) is as follows: R-expressions, or full lexical NP's, must be free in the entire sentence context. Thus, they may not have a c-commanding referent. Thus, 29) is ungrammatical:

29) *Miss Piggy$_i$ looked at Miss Piggy$_i$

Likewise, backwards anaphora, or the coreference of a pronoun with a following (full) NP, is restricted by this principle, as in 30):

30) (*)



In 30) the structural configuration of the sentence is such that the pronoun c-commands *the elephant*, violating principle C.

2.2.2. Studies of normal acquisition

Much of the research on mastery of binding concerns Principles A and B. Most studies of acquisition conclude that young children show gradually increasing mastery of tasks assessing knowledge of Principle A from age 2 to approximately age 4 years, with near perfect performance by age 5 to 6 years (Wexler and Chien, 1985; Jacubowicz, 1985; McDaniel, Cairns and Hsu, 1989). There are several interpretations of this early but apparently less than instanteous acquisition of Principle A. McDaniel et al propose a series of specific stages:

1) children do not recognize reflexives as anaphors; thus, Principle A does not apply (similar to Wexler and Manzini, below).

2) reflexives are recognized as anphoric NP's; Principle A applies. Some children in this stage get the domain for binding anaphors wrong and allow reflexives to refer to higher subjects in infinitives.

3) Principle A is obeyed (reflexives are locally bound), but children may have a subsequent confusion as to whether reflexives can be subjects (related to their acquisition of the emphatic reflexive).

4) reflexives are fully acquired (the adult grammar is attained).

To account for the slight delay in acquisition of Principle A, Wexler andManzini (1987) following Borer (1984) proposed the Lexical Learning Hypothesis; namely, that children must learn which words are anaphors, with the grammatical facts ready in place once lexical facts have been sorted out. Most of the data concerning Principle A seem to support this hypothesis, with gradually improving importance over time. However, the data concerning Principle B, is not explained by this hypothesis. The first studies in this area uniformly found that children continue to make errors on pronominal reference even after age 6. Specifically, they allow pronouns to have local antecedents (Koster, 19XX; Wexler and Chien, 1985; Jacubowicz, 1984). It cannot be the case that children simply "learn" pronouns later, as they are producing pronouns with free reference in their spontaneous speech very early in development, as in these examples from my daughter at age 1-9:

31) He drinking the juice.

32) No take the book out me.

Thus, the Lexical Learning Hypothesis is not sufficient to explain these results.

Further data from other languages has complicated the picture. First, children learning Chinese do well on tasks with both anaphors and pronouns by around age 5 to 6 years (Chien and Wexler, 1987). Further, some languages (such as Korean, Icelandic and Chinese) have non-locally bound anaphors, with these children showing different patterns across languages (e.g. in Icelandic, children apparently follow B early on and prefer nonlocal binding of anaphors; in Korean the pattern is that children do not follow B and prefer local binding of anaphors). Hyams (1989) and Hyams and Sigurjonsdottir (to appear) explain some of these confusing results by proposing that: a) children do "know" the binding theory early on, and b) they "know" the lexical properties of various NP's (and hence are producing pronouns from very early points in childhood). Further, they note that children assume anaphors must be locally bound according to the subset theory (Wexler and Manzini, 1987) unless faced with evidence to the contrary (as in Chinese). What children do not know is the *domain* for the binding theory, erroneously assuming that the VP can be the CFC. Thus, in the case of 26) the pronoun is free within the VP, satisfying the binding conditions. Thus, for the child, it would be possible for the subject NP to be coreferent with the pronoun, while this is not possible within the adult grammar.[5]

With regard to principle C, the literature reports that at least some children allow violations of principle C with the age of acquisition variable from study to study (e.g. as 5 years of age (C. Chomsky,1969; most children by age 3 to 4, Crain and McKee, 1986). Hsu, Cairns, Eisenberg and Schlissberg (1989) using an act-out task, found that many children under age five (and also two adults) allow violations on sentences such as 33)

33) The lion tells him that the zebra will jump over the fence.

Given the performance of the adults, it is possible that some aspect of the experimental task interferes with performance. This was also found in the study by McDaniel et al.1989, where only two three-year-olds did not know Principle C, with some other children having difficulty on the long sentences (such as 33) but not on short sentences such as 34):

34) He is washing Grover.

Thus, at least within the domain of the single clause, the evidence suggests that Principle C is acquired quite early.

2.5 CONTROL

This section is concerned with one particular type of NP found as the subject of infinitives. This nominal expression is PRO, with the facts concerning interpretation and

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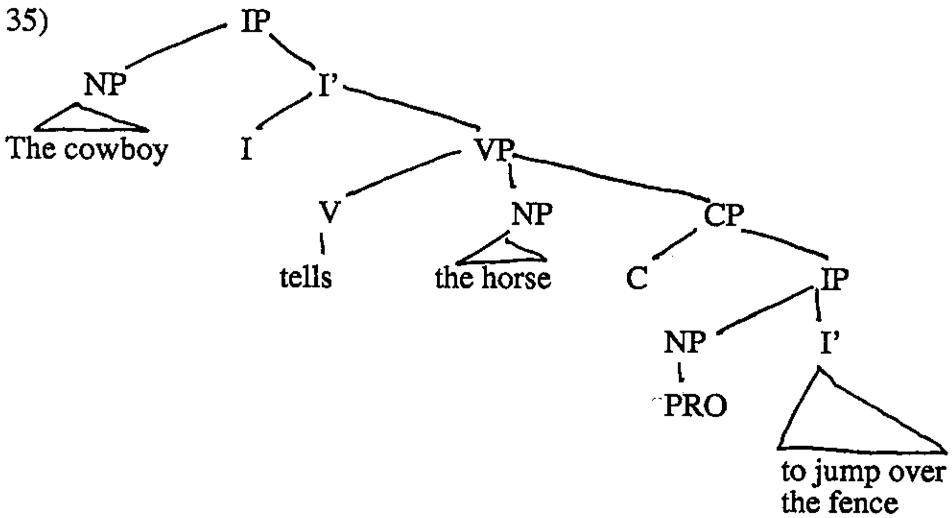
5 Their analysis goes much farther, and explains the relationship between obedience to Principle B and the binding of these long distance pronominal anaphors (essentially, children either locally bind pronouns and anaphors or non-locally bind them; see the cited works for the complete account of these data).

coreference of PRO accounted for within the submodule of grammatical facts concerning control.

2.5.1 Theoretical analysis

The structure in 35) provides an example of the type of VP complement analyzed within the GB framework as containing the empty or phonologically null element PRO:

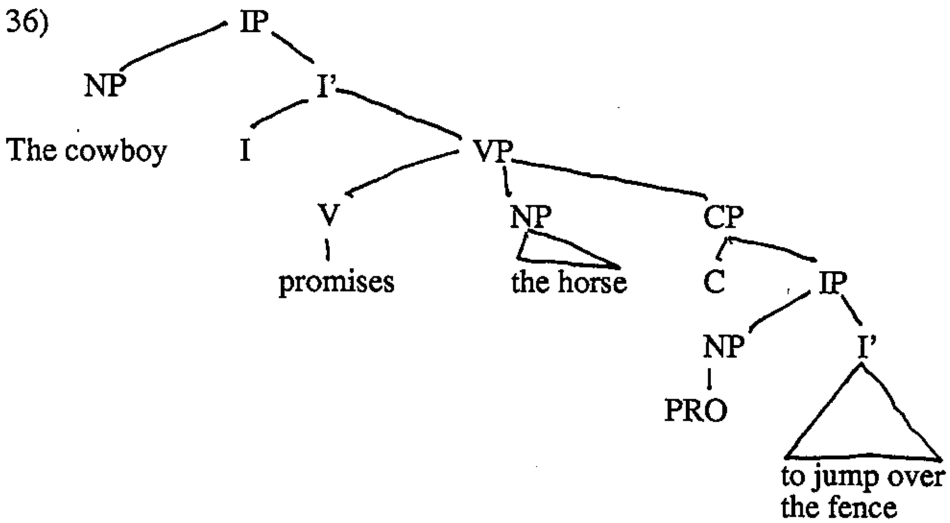
35)



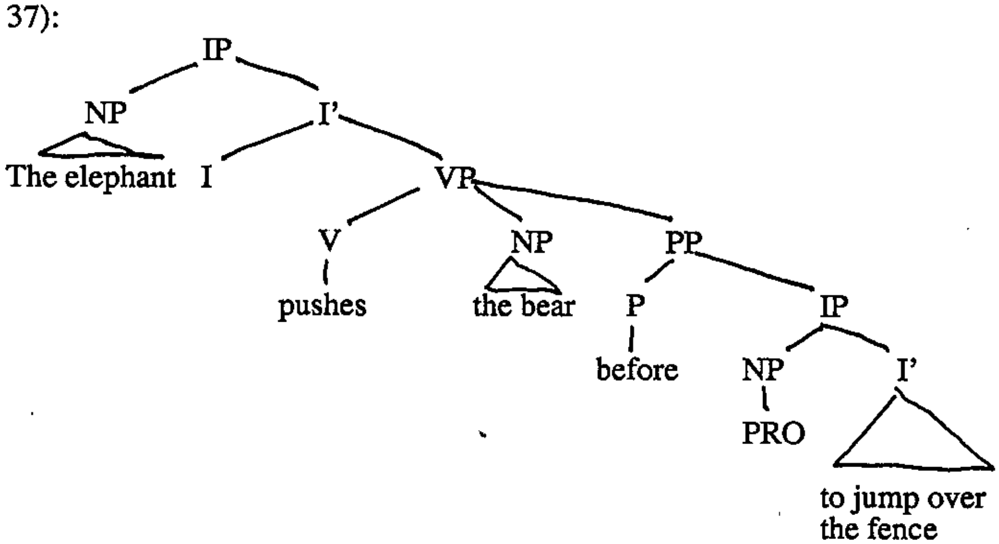
The embedded clause lacks an overt subject, but the adult native English speaker interprets the sentence as if there was a subject of the embedded clause, and as if that subject was *the horse*. This empty subject is postulated to be PRO, and is proposed for a number of theoretically motivated reasons not discussed here.

In 35) above, the controlling NP is the object of the matrix clause. However, in 36), the subject of the matrix clause is the controller:

36)



A large measure of the correct interpretation of infinitival complements is knowledge of the lexical information regarding the control properties of the verb (tell is an object control verb, while promise is a subject control verb). However, PRO also appears in other types of constructions. For example, in adverbial complements such as 37):

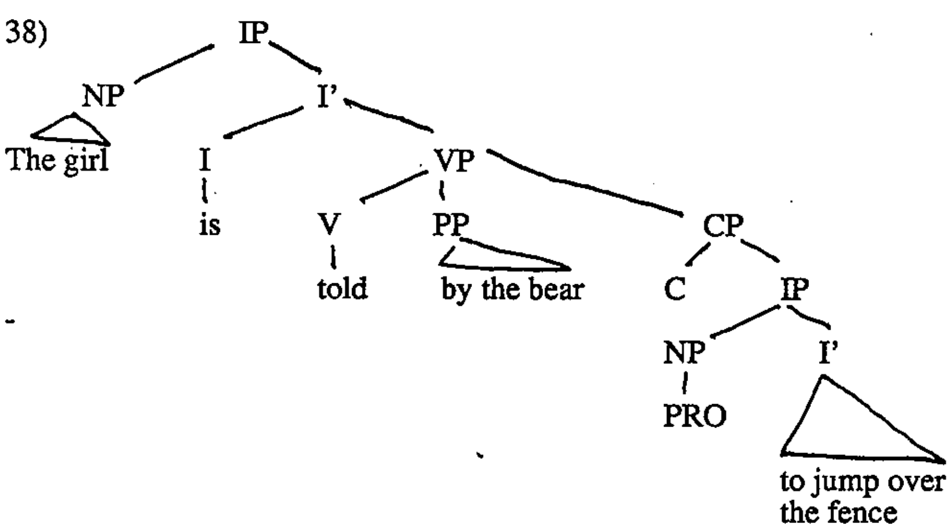


Here, syntactic facts concerning the relationship of the controlling NP and PRO become crucial to the interpretation of the empty element. The controlling NP must c-command PRO. In sentences such as 37) above, *the elephant* must control PRO, as *the bear* does not c-command PRO.

2.4.2 Studies of normal acquisition

There have been a number of studies looking at children's knowledge of contrastive object and subject control verbs (the "ask" and "tell" sentences); e.g. C. Chomsky, 1969; Maratsos, 1974; Cohen, Sherman and Lust, 1986). The initial major finding was that young children (until as late as 10 years of age) tended to interpret all verbs as being object controllers (or as having the object of the matrix clause coreferential with the subject of the embedded clause), including "promise", which is a subject control verb. C. Chomsky (1969) proposed this was the result of the children obeying a Minimum Distance Principle (MDP), selecting the closest NP to the missing subject of the infinitive. However, Maratsos (1974) found that clauses with an intervening PP (such as 38)

38)



led young children to interpret PRO as coreferential with the matrix subject. This has been interpreted as reflecting a sensitivity to c-command (a structural vs. a linear analysis): the children apparently know that the NP inside the PP (*the boy*) cannot c-command PRO, and they correctly interpret structure as involving subject control (Hsu, 1981 cited in Hsu, Cairns and Fiengo, 1985).

With regard to control in complements, it appears that normal children demonstrate a progressively mature notion of control as follows (McDaniel, Cairns and Hsu, 1989; Goodluck and Behne, 1988):

1) children lack knowledge of control (PRO = arb)

2) children have "subject control" as is the canonical case in the adult grammar but via a "highest S" strategy (subject of higher clause is interpreted as subject of lower clause for all constructions, including relatives and adjuncts).

3) children have control but attach adjuncts to the VP instead of S. Their knowledge of c-command leads them to object control for adjuncts.

4) children have mixed control, due to variable attachment of adjuncts to S or VP.

5) at 7, children attain consistent S-attachment of adjuncts and thus adult grammars.

McDaniel et al. (1987) propose that children always appear to have knowledge of c-command, but must learn control facts and structural attachment facts.

Production data reveal that children produce utterances with catenatives such as *wanna* and *hafta* very early on (Bloom, Lightbrown and Hood, 1975; Brown, 1973). My own production data indicates the following examples (ages in parentheses):

40) There's something I have to do. (1-9)

41) You hafta cook them. (1-11)

42) I expected you to be gone. (2-6)

43) I expected it to be milk. (2-6)

Thus, it appears to be the case that children are sensitive to c-command and know that PRO must be controlled early on, with the control facts concerning adjuncts mastered by age 7. Some infinitival complements are also produced very early on.

2.6 NP MOVEMENT, LINKING OF THETA ROLES AND THE PASSIVE

The passive provides yet another example of how constructions arise through the interaction of several different modules of grammar. The movement of Noun Phrases (NP's) is possible via move alpha, resulting in noncanonical word order, but there are constraints on thematic roles which serve to constrain NP movement (the projection principle and the theta criterion). There is also evidence suggesting that the passive is difficult for the isolated right hemisphere (the work of Dennis and colleagues as discussed earlier). Difficulty in detecting the thematic roles of arguments (and not difficulty in decoding syntactic information) has been argued to be a central deficit in adult aphasia (Linebarger, Schwartz and Saffran, 1983). Thus, this component of the grammar may be particularly at risk in the case of brain damage.

2.6.1. Theoretical analysis

One of the grammatical options for generating sentences with noncanonical word order is a general rule of "move alpha". As mentioned earlier, "Move alpha" is a maximally general rule which is constrained by other principles of grammar. Here we discuss one type of movement, NP movement, where an NP is moved to another NP node which is base generated by the PS rules as containing a null element. The passive is the type of construction which we will examine here that depends on NP movement. In 44), there is the D-structure representation of a sentence, with 45) showing the S-structure resulting from NP movement ("e" shows the base generated empty node, and "_" indicates the site from which the constituent was moved):

44) e was hit John by Mary.

45) John was hit _ by Mary.

Two principles are discussed here which account for a relatively constrained application of NP movement: the projection principle and the theta criterion (see pp. 31-31). The projection principle arose from observations such as the following: in passives (such as 44)) *John* cannot be both the subject and the object (or the agent and the theme) of the verb *hit*. In this account, the types of arguments a verb must take are specified in the lexicon in the form of selectional restrictions. Theta roles roughly represent the semantic role that an argument plays in a clause. Thus, in the lexical entry for bake is the information that its subject is assigned an agent thematic role, and theme is assigned to its object. The projection principle is a requirement that these selectional restrictions of verbs are observed at all levels of linguistic representation (importantly, before and after movement applies). Stated formally, the projection principle is as follows: the theta criterion holds at D-structure, S-structure and LF. The theta criterion stipulates that a) a lexical NP must occupy one and only one theta position, and b) every theta role of a given verb must be assigned exactly once. Consider 46):

46) Joe_i was pushed t_i by Sally.

In 46), *Joe* was moved from its original position as the logical object to the position of grammatical subject. The subject position does not have a theta role assigned to it, which makes this an eligible site to which another NP can be moved. Notice that "t" is the trace of the moved MP which is left behind in the original position. The trace and the moved NP are said to be coindexed to each other, or linked. The trace (and thus the linked NP) receive the theta role of *theme*, satisfying the theta criterion.

2.6.2. Studies of normal acquisition

The literature on the acquisition of the passive indicates some differential performance depending on the task demands. Information about passives in production tasks is sparse; passive constructions are rare in the spontaneous speech of children, as in that of adults.

However, most of the data places comprehension of a full passive with agent between 3- to 4- years, with comprehension of truncated, agentless passives somewhat before that (Sinclair and Bronckart, 1972; deVilliers and deVilliers, 1973; Maratsos, 1974; Baldie, 1976). There is some evidence that very young children do not rely on a grammatical analysis of this structure. Strohner and Nelson (1974) found that 2- to 3-year olds relyed on a "probable event" strategy, with slightly older children (4- and 5-year olds) demonstrating correct performance on passives, and thus showing evidence of being able to analyze the sentence syntactically.

2.7 SUMMARY OF ACQUISITION OF CORE PRINCIPLES OF GRAMMAR

To sum up our discussion of the acquisition of the grammatical principles above, several points can be made regarding their acquisition. First, the adult versions of various grammatical principles do not emerge full-blown in all cases. Some aspects of grammar appear to either mature or develop earlier than others (e.g. while knowledge of c-command appears early, binding and other principles which depend on c-command may be mastered later). Second, while constraints on coreference in particular may be mastered somewhat later in childhood, knowledge of certain aspects of structure (the c-command relationship, recursion of some sort in NP and VP) appear very early (e.g. 2- to 3- years of age). Third, following Hyams (1987) the analysis here is that the peripheral aspects *of a given construction* will be acquired later than the core properties. Thus, recursion in DP occurs early on, with knowledge of appropriate complementizers for particular verbs evident later in development. Finally, all of the properties examine above (with the possible exception of the 10-year old ceiling on subject control) appear to be mastered in comprehension tasks by the early school years. Thus, knowledge of these core principles can be investigated in a population of school-aged children.

We now turn from principles of grammar which are presumed to part of the core, to an examination of one aspect of grammar which has been proposed as having more peripheral status within the grammar of English: verbal inflection.

2.8 ACQUISITION OF THE PERIPHERY: VERBAL INFLECTION

As discussed in chapter 1, the periphery of the grammar varies from language to language, but is presumed to be those properties which involve relaxation of or exceptions to the settings of UG, as well as the particular grammatical features which make each language unique. Hyams (1987) suggests that one of the hallmarks of peripheral aspects of grammar is that they do not appear until somewhat later in the acquisition process. In fact, children acquiring English do not produce verbal inflectional morphology until much later than is noted for their counterparts learning other, more richly inflected languages. For example, the children in Brown's (1973) study acquired "third person regular" at 9.66 out of the fourteen morphemes examined in his study of spontaneous speech (at a mean age of 2;9); regular past /-ed/ was ranked at 9.00. On a formal task (the CYCLE-R; Curtiss and Yamada, to appear), we have the following ages for comprehension of tense/aspect inflectional morphology: /-ing/ at age 5, /-ed/ at age 6, and "will" at age seven. Agreement morphology is similarly late on the CYCLE, with verb singular and plural not passed until age 6 and 8 respectively. Hyams contrasts the late mastery of English morphology with with her own data concerning the acquisition of agreement by Italian children (at about age 2).

To account for this disparity in timing, Hyams proposes a parameter which is set according to whether a bare verbal stem is a well-formed lexical item in the language at hand. In English, a bare verb root is a well-formed word, and thus English speaking children do not need to learn verbal morphology to satisfy well-formedness conditions (unlike children learning Italian or Spanish). Thus, children learning English acquire verbal inflectional morphology relatively late in the acquisition process not because they are grammatically delayed compared to children learning other languages, but because they are not forced into learning morphology that is not required to satisfy this particular parameter. For English, inflectional morpholgy is a relatively peripheral aspect of the grammar which is learned later in the acquisition process. There is an exception to the late acquisition of verbal morphology in English, and that is the acquisition of /-ing/. Hyams and others (Bloom, 19XX) attribute the relatively early appearance of this piece of morphology as being due to the child learning each progressive form as a separate lexical item (so that verb X is separate in the lexicon from the verb X+ing).[6]

Thus, in normal English speaking children, we expect that verbal morphology may appear slightly later in development, and may be acquired in a different fashion than we observed for core principles of grammar. However, even some inflectional morphology appears in spontaneous speech in the second and third years, and performance on formal tests (like the CYCLE-R) is expected by the middle school years.

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6 Borer notes that V + *ing* constructions differ in many was from "normal" verbs (e.g. normal verbs don't occur as a subject, don't have a "property" reading but do take complements). Thus, there are various distributional differences between V + *ing* and other verb forms, and these differences may represent an important linguistic distinction that exists even in the adult grammar. Further, Radford (1986) proposes that *ing* verbs are actually unmarked for tense; thus, they are acquired outside of mastery of systematic tense morphology.

Thus, acquisition of inflection is an appropriate candidate for investigation in this study of school aged children.

This is by no means an exhaustive discussion of the important core and peripheral properties of components of the grammar, but it does provide us with a list from which to begin an inquiry concerning the grammatical knowledge of young children who have suffered neurological damage at an early age, and who have gone on to acquire their language.

CHAPTER 3

METHODOLOGY

3.1 SUBJECTS

Subjects for this study came from a variety of medical facilities in the Southern California area. They were recruited either by direct referrals from physicians or were selected after reading medical histories from a list of possible candidates compiled by physicians. The subjects had to meet the following criteria: 1) early focal left hemisphere seizure activity or focal damage evident at birth or which occurred during the first 5 years of life; 2) no evidence of right hemisphere pathology (note that JL is somewhat of an exception to this; this will be discussed further in Chapter 4); 2) no family history of learning problems or language disorders; 3) no familial left-handedness; 4) no reports of generalized cognitive deficits. With regard to the last criterion, it should be noted that, while none of the subjects was diagnosed as "mentally retarded", four of the six subjects had received some special educational help (in the form of a resource teacher or learning specialist). As such, this group will constitute a strong test of the hypotheses, in that the investigation of nonlinguistic deficits has not been within the domain of this work, and thus such deficits have not been ruled out. It is entirely possible that "normal" linguistic abilities might exist alongside deficits in other cognitive domains (e.g. memory). None of the subjects was receiving speech/language therapy, although two had been evaluated by speech/language pathologists but were subsequently determined not to be appropriate candidates for therapy.

All subjects who met the above criteria were contacted; two families declined to participate, and the rest were included in the study. Information about the neurological status of each of the experimental subjects is summarized in Table 1 (next page). Note that site of damage refers to evidence regarding structural damage on CT scan unless

Table 1: Neurological status of FLHD subjects

Subject	Age at onset	Site of damage	Hemiparesis/seizures
1. WB	0-2	Left parietal-occipital hemmorhage with some frontal extension	Mild paresis of right arm. Long history of of seizure medication
2. SR	0-7	Left temporal lobe	Long history of seizure medication
3. MB	2-2	Left temporal lobe seizures; no evidence of structural damage	None
4. NA	3-10	CVA involving internal middle cerebral artery on left after repair of tetralogy of Fallot	Mild paresis of right arm
5. FC	5-0	Malformation of vein of Galen noted at 0-2; CT at 5-0 indicated aneurysm with hemmorhage in left temporal lobe involving internal capsule and thalamus	Long history of seizures and medication
6. JL	4-5	Left temporal lobe seizures; at 8-0 had hemmorhage of anterior tip of left temporal lobe and "minimal" contusion of right temporal lobe	Long history of seizures and medication

otherwise noted. Further details concerning the case history of each subject can be found in Appendix A.

To address Hypothesis 2, which deals with the effect of age at onset of symptoms of brain damage, the subjects were divided into four groups. The groups were based on the time of onset, and would allow some between-group comparisons (although the limitation of the small number of subjects is a cautionary factor. Group I is composed of subjects with damage during the first year of life. Group II has subjects with damage from age 2 to 4. Group III has subjects with damage from age 4 to age 5. Each group has two subjects each, one with focal damage and one with focal seizure activity but no discernable damage.

Each FLHD subject was matched to a non-impaired control subject whose age was within three months of their CA at first testing. Information regarding both brain-damaged and control subjects is presented in Table 2.

Table 2: Subject information

Group	Subject	Sex	Age at testing	Control	Sex	Age at testing
I	1. WB	M	7-6 to 7-9	SF	M	7-9
I	2. SR	M	13-2	KY	M	13-2
II	3. MB	M	5-9 to 5-10	SS	M	5-9
II.	4. NA	M	6-3	SM	F	6-3
III.	5. FC	M	9-9 to 10-2	JP	F	10-0
III.	6. JL	M	12-7 to 12-8	CL	M	12-5

3.2 ASSESSMENT PROCEDURES

The assessment procedures used with each subject were of two kinds; those which were used to establish general levels of linguistic functioning, and those which were designed to evaluate linguistic knowledge in depth in key areas.

The assessment battery is detailed below.

3.2.1 Normative data

The normative tests were used in an initial session to establish: a) the presence or absence of obvious language disorders or delays, and b) to determine that the subjects were able to perform appropriately on formal tasks, and c) to allow comparison of lexical vs. grammatical performance. The tests used for that purpose are presented in Table 3.

Table 3: Normative battery

1. Curtiss-Yamada Comprehensive Language Evaluation (Curtiss and Yamada, to appear)
2. Peabody Picture Vocabulary Test-Revised (Form L) (Dunn and Dunn, 1981)
3. Producing Word Associations Subtest, Clinical Evaluation of Language Functions (Semel and Wiig, 1980)

Each of the tests is described below. The CYCLE (Curtiss-Yamada Comprehensive Language Evaluation, to appear) was used to evaluate general linguistic performance of the experimental subjects relative to their chronological peers. (It was also used as part of the grammatical battery; see 3.2.2). Two batteries of the CYCLE were used here: the CYCLE-R (Receptive Battery) and the CYCLE-E (Elicitation Battery). The CYCLE-R is a primarily a picture pointing comprehension test (with object manipulation tasks used for the locative preposition and some pronoun tests), with items testing knowledge of a variety of syntactic and morphological items. In each subtest of the CYCLE-R a particular construction type is tested five times. The picture stimuli are simple line drawings (see Appendix for examples of pictures and stimuli sentences). Each test sentence has, in addition to the picture which represents the correct response, three decoys containing the same objects or people in different relationships, ensuring that the subject must comprehend and respond to the key construction and to the entire sentence. Four out of five correct responses is considered "passing" for any given item. To pass an entire age level, the subject must pass 80% of the items at that level.

The CYCLE-E is an elicited production task, with pictures used to focus attention and cue the desired response. Thus, the examiner starts a desired utterance and the subject must "finish" it (again, see Appendix for example item). It tests a variety of grammatical constructions. Each construction is tested twice. Two out of two correct responses is considered passing a given construction. A subject must pass 80% of the items at a given level to have "passed" the level.

Two other tests were used as formal measures of fluency and lexical knowledge. The PPVT-R (Dunn and Dunn, 1981) is a picture pointing vocabulary test normed to age 18. The Producing Word Associations subtest of the CELF is a measure of word fluency, a common component of neuropsychological batteries, and a measure of word retrieval by category.

3.2.2 Evaluation of morphosyntactic knowledge

To evaluate morphosyntactic knowledge of the subjects, a variety of tasks were used in this dissertation research. First, it is often more difficult to test knowledge of a particular type of construction using any one method or another. For example, passives are rare in spontaneous speech, not comprehended in a picture-pointing task until middle childhood, but easily tested early on in an object manipulation task. In addition, children with brain damage are often plagued by various nonlinguistic performance deficits (e.g.

visual field cuts, memory deficits, etc.) which can influence performance on one task but not another.

The tasks included in the morphosyntactic battery are presented in Table 3.

Table 3: Morphosyntactic battery

1. Comprehension:
   a. Animal enactment
   b. CYCLE-R (specific subtests)

2. Elicited production:
   a. Animal description
   b. CYCLE

3. Language sample

4. Judgement task

In Appendix C all specific tests from the CYCLE-E and CYCLE-R used in the assessment of knowledge of the particular grammatical constructions which will be discussed in chapter 4 through 6. All of the other tests are described below (and appear in Appendix C).

3.2.2.1 Animal enactment task: This task is similar to those used by numerous researchers (Sheldon, 1974; Tavakolian, 1978; Solan, 1981; Goodluck, 1981) in which a child is presented with a sentence and told to use the figures provided by the examiner to act it out (see Appendix C for list of test items). In constructing the items for this task, every attempt was made to allow the subjects to produce possible incorrect as well as correct responses. Thus, for sentences such as 1):

1) The deer looked at himself.

a deer, a bear, and a mirror were placed in close proximity to the subject, allowing for correct (deer looks in mirror) as well as incorrect (deer looks at bear) responses.

In addition, use of a particular construction was made as felicitous as possible (e.g. providing two horses that could be talked about to appropriately motivate the use of the relative clause). Three tokens of each construction type were included in the randomized battery. The battery was typically presented in three parts of 21 items each.

3.2.3 Animal description task: In this task, the child is told that it is his or her turn to talk, and say what the examiner is doing with the animals. In part I, the task is simple description, with any relevant comment or description accepted as a valid response. Part II is adapted from the procedures used by Hamburger and Crain (1984) to elicit object relative clauses; a third party (a parent or sibling) was asked to hide their eyes, with the examiner hiding a penny under one of two identical animals. The examiner involved one of the animals (the one with the penny) in an enactment scheme. The child then described the ongoing action to the third person ("Pick up the (animal) that ..."). In Parts I and II three tokens of each type of item were presented. Appendix C lists examples of each type of item used in this test.

3.2.4 Judgement task: In this task, the children were asked to say whether a sentence sounded "like a good sentence-- like how a grown-up would sound speaking English". In addition, to circumvent the typical difficulty with judgement tasks (e.g. that ungrammatical stimuli are judged to be grammatical without an explanation of the basis of the judgement) the children were asked to respond to probes which determined the possibilities for reference for a given NP according to the grammatical intuitions of the child. Examples of probes were as follows:

2) The bear hits the elephant that knocks over the tree.

Judgement: (Good or Bad)

Probe: Who knocked over the tree? (The child is allowed to respond, with additional probes until all NP's mentioned in the sentence as well as one outside referent are queried: "Could it have been the bear? How about the elephant? How about the dog?"). These queries are important to determining the extent to which the child's grammar allows for possibilities outside the adult grammar by forcing them to consider all alternatives.

In an initial training session, the children were given short sentences, some of which contained very obvious grammatical errors (e.g. incorrect word order, sentences with incomplete or missing constituents; see Appendix C), and asked to make judgements about whether they sounded "good" or "bad". All subjects were able to comprehend the task and respond correctly.

One token of each type of construction was presented.

3.2.5 Language samples: The language sample data came from taped conversations between the the investigator and the subject. The topics were school, family, games and hobbies, favorite TV programs and movies, and the subject's most recent birthday. In addition to conversation, a narrative was elicited. The subjects were read the story of *Curious George* (Rey, 1941) at the beginning of the first session. They were then asked to retell that story to another person (parent, sibling or friend) at the end of that session. This data was used as supplementary to the conversational data. One hundred utterances transcribed from the sample compose the corpus. These utterances were as contiguous as possible, but exclude sentences with unintelligible portions, responses of "yes" and "no", and automatic or formulaic utterances (e.g. "you got me", "I don't know"). The samples were then scanned for constructions relevant to the principles discussed in chapter 4.

3.3 DATA COLLECTION

The testing situation varied somewhat for each subject, depending on geography and the age of the subject. The experimental subjects were tested at least two years post onset, with three children (SR, WB and NS) tested seven or more years post onset. At least two, but no more than five, visits were made to the home of the child. The visits ranged from one to three hours, and were completed within a one to three month period (with the exception of FC, whose data collection stretched over a five month period due to difficulties relating to his foster home placement). Formal tasks were alternated with conversation. Sessions with the control subjects were similarly arranged, although three of the subjects were assessed in their school rather than in their home, with the data collected from all control subjects within three visits scheduled within a month.

CHAPTER 4

DATA FROM THE NORMATIVE BATTERY AND GROUP COMPARISONS

4.1 OVERVIEW

This chapter presents the data relevant to three of the five hypotheses presented in Chapter 1. First, data from the normative battery will be presented. These data are relevant to Hypothesis 1; namely, investigating the performance of the FLHD subjects on formal or standardized tests of lexical and grammatical knowledge. In section 4.3 there will be a number of group comparisons between the FLHD subjects and the control subjects which are relevant to Hypothesis 2, which deals with the effect of age at onset of brain damage. In section 4.4 and 4.5 the data relevant to Hypothesis 3 are presented, which concerns the variability of performance across tasks.

A final word here concerns subject JL, who was the only subject with some addition focal damage to the right hemisphere. His patterns of performance are very similar to those of the remaining subjects who did not evidence damage to the right hemisphere. Thus, there is no reason to separate his data from that of the group in this section, although each subject will be discussed separately in Chapter 5 and 6.

4.2 PERFORMANCE ON STANDARDIZED TESTS

4.2.1. Tests of lexical knowledge

The data on the performance of the focally left hemisphere damaged (hereafter FLHD) subjects on standardized measures of lexical knowledge are presented in Table 1. Recall that group numbers refer to age of onset (see chapter 3). As can be seen, with the exception of WB, all subjects evidence some degree of lexical impairment on at least one

Table 1: Age and grade-level scores on standardized tests of lexical knowledge

Group	Subjects and CA	PPVT-R (form L)	Word Fluency[1]	Boston Naming Test[2]
I	1. WB (7-6 to 7-7)	7-7	Grade 8 (30)	7-5 (30)
I	2. SR (13-2)	7-6	Above Grade 12 (36)	6-5[3] (24)
II	3. MB (5-9 to 5-10)	4-6	Grade 4 (23)	below 5-0 (18)
II	4. NA (6-3 to 6-40	6-2	Grade 1 (15)	Below 5-0 (24)
III	5. FC (9-9 to 10-2)	5-10[4]	Grade 1 (13)	6-5 (27)
III	6. JL (12-7 to 12-8)	9-10	Grade 8 (30)	7-5 (30)

1 Norms are for expected grade level achievement;grade levels represent the maximum "criteria for grade level" as given in the manual. Raw scores are given inparentheses.

2 Norms are taken from Guilford and Nawojczyk, 1988. Age scores were originally given as ranges; here, ranges were calculated for each age group of one standard deviation above and below the mean. The age score attributed to these subjects is the oldest age level for which the subject's score falls within the +/- one standard deviation range. The lowest age norms were 5-0; thus, some subjects report with "below 5-0". Raw scores are given in parentheses.

3 Testing done by neuropsychologist at age 12-7.

4 Testing done by speech pathologist at age 9-6.

measure. All subjects but WB appear to have difficulty with confrontation naming (Boston Naming) even if performance is relatively unimpaired on other lexical measures.

In addition to deficits in formal test performance at least two subjects (FC and MB) give evidence of word-finding deficits in their spontaneous speech samples. FC typically just "trails off" in utterances, but resumes the utterance if the obviously missing word is supplied.

1) (FC) He's going to get ready for the ... the...
(CJ) The what?
(FC) (NR)
(CJ) The fruit, the pizza, what?
(FC) (NR)
(CJ) I think he's getting ready for the pizza, don't you?
(FC) (nods; long pause) He wants pizza.

MB uses generic, vague terms, as in the following:

2) (MB) And then he open the, the bird thingy...

3) (MB) And then the big giant, the big giant, one can... uh, uh, uh, the thingy Gargamel?

Thus, at least some of these results support Hypothesis 1 and are consistent with the findings of Aram et al. (1985) and Rankin et al. (1981): early brain damage (and as these researchers point out, not just damage to the left hemisphere) is associated with deficits on formal tests of lexical knowledge. However, the results of the word fluency test reveal some surpising integrity in lexical knowledge. All subjects but one (FC) score appropriately for their age; two subjects score surprisingly well (MB, who is in kindergarten scores at the level of grade 4; WB scores at the level of Grade 8, approximately the level of a 13 to 14-year old). Thus, while the subjects show variable performance on picture-pointing comprehension tests and on tests involving confrontation naming, they are able to access words by semantic category, indicating that their lexicons may be organized in some sense similarly to non-impaired individuals.

We will return to the implications of these findings in Chapter 7, and now consider the performance of the FLHD subjects on the grammatical tests in the normative battery.

4.2.2. Tests of morphosyntactic knowledge

Performance on formal tests of morphosyntactic knowledge is presented in Table 2.

Table 2: Performance on standardized tests of grammatical knowledge (years and months performance delayed in parentheses).

Group	Subjects and CA	CYCLE-R[1]	CYCLE-E[1]
I	1. WB (7-6 to 77)	6 1/2 (1)	61/2 (1)
I	2. SR (13-2)	8 (1)[2]	7 (2)
II	3. MB (5-9 to 5-10)	4 1/2 (1)	2 1/2 (3)
II	4. NA (6-3 to 6-4)	5 1/2 (0-6)	5 1/2 (0-6)
III	FC (9-9 to 10-2)	6 (3)	5 (4)
III	JL (12-7 to 12-8)	5 1/2 (3-6)	5 1/2 (3-6)

1Norms are available in half-year increments

2 Note that the ceiling of the test is only at age "9+"; delay scores indicate difference between this ceiling and the age level attained.

All subjects demonstrate a deficit in performance on formal tests in this area, with a slightly greater deficit in elicited production as compared to comprehension. The degree of the deficit varies from subject to subject (for NA the deficit is only 6 months on both the CYCLE-R and CYCLE-E; for JL there is a 3 1/2 year deficit on both measures). It is interesting to note that the two subjects in group III (onset of symptoms between ages 2 to 4, the latest onset group) demonstrate the most significant delays (3 years or more on both measures. (We shall return to this point in section 4.3.2 in the discussion of the effect of age at onset).

To summarize, most subjects appear to have deficits on formal/standardized measures of morphosyntactic ability as assessed by comprehension and elicited production tasks. This is, like the lexical findings, consistent with the findings of others (e.g. Aram et al. 1985;1986;1988), although the degree of the deficit varies from subject and may be related to age at onset. This is also consistent with Hypothesis 1.

The implications of these will be discussed in Chapter 6. In the next section we will examine some group comparisons relevant to the hypotheses of Chapter 1.

4.3 OVERVIEW OF THE GRAMMATICAL DATA: GROUP COMPARISONS

Up to this point we have only considered the formal test data, and have found that the FLHD subjects demonstrated deficits in lexical and grammatical performance on standardized tests. In the following chapter the subjects' performance will be evaluated individually with regard to their performance on the tasks in the grammatical battery, which will allow investigating the extent to which each subject is able to demonstrate knowledge of core principles of grammar. However, it is also interesting to compare the FLHD subjects to the control subjects as groups (and, in fact, group comparisons have been the goal of many if not most studies of the cognitive abilities of brain-injured subjects). While the primary goal of this study is to determine the status of the grammatical knowledge of each individual subject, it is relevant here to include some group comparisons with respect to performance on the tests of knowledge of syntactic knowledge.