LONG TERM LINGUISTIC CONSEQUENCES OF HEAD INJURY IN CHILDHOOD AND ADOLESCENCE.

By

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ABSTRACT

TITLE: Long-term linguistic consequences of traumatic head injury in childhood and adolescence.

Considerable interest has been expressed regarding the issue of recovery of language following head injury in childhood. The two questions most frequently addressed are:

1) Do children recover linguistic abilities faster and better than adults after suffering a head injury?

2) Is the linguistic disorder, if evident, mainly syntactic or lexical in nature?

We have examined 8 children from 6;10-17;0 who suffered traumatic head injury and who are in varying stages of recovery. Each child has been matched with a normal child of the same age. Despite reports of complete recovery from childhood aphasia, our results indicate persistent word finding problems, with otherwise normal language abilities. There was no correlation between severity of deficit and age at injury or length of coma.
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CHAPTER ONE

Introduction:
It has been proposed that acquired aphasia in children is a distinct clinical disorder, differing from adult aphasia in both: (1) symptomatology and (2) extent of recovery. By the term "acquired aphasia" we refer to the language disorder incurred through brain trauma after a period of normal development. The association between brain injury and aphasia is inconsistent; aphasia is not always present regardless of site of lesion.

In the literature it has long been held that the language deficits of the head-injured child are distinct from those of an adult in terms of symptomatology (Basser, 1962; Lenneberg 1967; Hecaen, 1976; Shapiro, 1983). Some of the proposed differences are as follows:

1.) Rarity of jargon and paraphasias in children.
2.) Initial phase of mutism in children; subacute phase of fluency, non-fluency or mixed aphasia in adults.
3.) Faster and more complete recovery of auditory comprehension in children versus much slower and incomplete recovery in adults.

Recent studies, however, point to a less discernable symptomatological difference between adult and child. For example, paraphasias which were cited as rare (Hecaen, 1983; Gloning and Hift 1970) are now being demonstrated (Visch-Brink and Van de Sandt-Koenderman 1984) as a prevalent component of spontaneous speech. Deficits in auditory comprehension also
appear to be more frequent than once thought (Hecaen, 1983; Alajouanine and Lhermitte 1965).

The question concerning differences between child and adult aphasics may not be one of symptomatology, but rather one which concerns course and extent of recovery. To date, the implication has been that if aphasia does exist in the child, recovery of language is more complete the earlier the lesion is sustained. This belief has been enhanced by the numerous case reports which purport to show more rapid recovery from acquired aphasia in children. (Guttman, 1942; Lewin, 1966; Mealey, 1968). Recovery has been considered particularly fast and complete for external head trauma versus closed head injury. (Walker, 1969; St. James Roberts, 1979 for review).

An alternate explanatory position which finds growing support claims that recovery in children is not as complete as previously thought. (Woods and Carey, 1979; Hecaen, 1983; Klonoff, 1977; Byers and Mclean, 1962). Furthermore, a number of cross sectional studies have failed to find age differences in recovery from brain trauma, and/or have shown better recovery in adult patients, and/or poorer than predicted recovery in children (Fuld & Fisher, 1977; Kershner & King, 1974; Kertesz & McCabe, 1977; Rudel, Teuber & Twitchell, 1974; Van Dongen Loonen, 1977). It is suggested that longitudinal investigation of head-injured children may show evidence for persisting linguistic deficits.

The majority of studies of head-injured children have
employed analytic methods which gave only a gross indication of language performance. That is, scores for various language sub-tests were tabulated for comparison against control subjects. Furthermore, in many cases, tests used have been designed for administration to adult aphasics. In these instances, the vocabulary used and abilities tested, were clearly inappropriate for use with children.

The purpose of this investigation was to examine language in children who had suffered external head trauma (e.g. motorvehicle accidents), after spontaneous recovery had occurred. The tests which were used, focused on different levels of linguistic functioning; i.e. comprehension, word-retrieval and expression of syntactic structures. Results were examined for possible residual language deficits which might be characteristic of this population. Primary objectives of the study were:

1) To obtain data on the language of eight brain-injured children, at least 6 mos. post-onset, and their matched normal control subjects.

2) To objectively examine receptive and expressive syntax and word retrieval as evidenced in the data.

3) To examine the data in relation to documented symptomatology and extent of recovery in adults'.

NULL HYPOTHESES:

1. There is no difference between the language deficits of head-injured child when compared with the head-injured adult.

2. There is no difference between the extent of recovery in the head-injured child when compared with the head-injured adult.
CHAPTER TWO

2.1 INCIDENCE:

Many researchers have considered childhood aphasia to be rare. (Bayley, 1939; Denckla, 1979). As Satz and Bullard-Bates (1983) point out "Does one mean that the unilateral lesion is rare or the aphasia given a unilateral lesion?"

Unilateral lesions, incurred in closed head injury are rarer in children than in adults (Heilman and Valenstein, 1979). Primary cerebral damage, however, caused by external head injury is equally likely in adults and children.

Secondary damage which influences recovery outcomes has been shown to be unique in brain-damaged children versus adults. (Isaacason, 1975; Smith and Sugar, 1975). Bruce et al. (1979) point out, that secondary damage such as hyperemia and vasodilation are ubiquitous responses of the pediatric brain to head trauma, with the main cause being intracranial hypertension. Raimondi and Hirschauer (1984) found subdural hematomas to be most common in children under 1;0 year.

Consistent with this, Bacchi (1980) showed extradural hematomas to be less common in children than in adults giving elasticity of the pediatric skull as a reason for this difference.

The risk of aphasia given an etiology is not rare in childhood. Guttman (1942) pointed to the similar frequency of aphasia in children and adults. Hecaen (1983) in summarizing
his study of acquired aphasia in children states "Aphasia is more frequent, at least among the youngest children, than in adults."

A raised incidence of aphasia in children with right brain injury led to the postulation of the "Equipotentiality Hypothesis". (Freud, 1897; Krashen, 1973; Hecaen, 1976; Basser, 1962). That is, during childhood the cerebral specialization of speech is represented in both hemispheres, and hence both are equally susceptible to aphasia. A gradual development of cerebral dominance occurs with age. Support for this hypothesis is based on a higher risk of aphasia in right handed children with lesions of the right hemisphere.

Two factors contributing to this raised incidence of right hemispheric aphasias are:

a) vague definitions of aphasia
b) crossed aphasias

Hecaen (1976) studied acquired aphasia in children 3-15 years of age with a view to comparing results with those available in relation to ontogenesis of hemispheric specialization. He found a raised incidence of language disorders with right-sided lesions (33%) admitting that it may be artificially elevated. First, the number of right hemispheric lesions is very small therefore representing a statistical bias (2/6). Second the definition of aphasia in these particular children were loosely defined and hardly characteristic of a language disorder. One had a transitory articulation disorder, while
the other (left-handed) had a writing disorder.

Dunsdon (1952) employed vague definitions of aphasia in reporting his statistics. He described speech deficits of children as a "lack of necessary control of speech mechanism muscles." Aphasia, however, includes comprehension and production disorders but not motor problems related to language output.

Crossed aphasias have also contributed to this raised incidence of right hemispheric aphasia. By "crossed aphasias" is meant those cases in which a right-handed subject has right hemisphere disease. Bilateral disease (i.e. trauma and neoplasms) can inflate the overall incidence of aphasia, particularly crossed aphasias.

Basser's study (1962) included subjects who had sustained lesions prior to 1940, before the introduction of antibiotics and mass immunization; hence bilateral pathological damage was possible. Hecaen (1976) and others include trauma as a common etiology for aphasia; since this type of injury causes diffuse effects, it is impossible to exclude lesions in the other hemisphere.

2.2 CEREBRAL_LATERALIZATION_FOR_LANGUAGE:

Recent literature points to hemispheric dominance for language in the infantile brain rather than functional equivalency during a critical period. Researchers have indicated a greater percentage of aphasia following left brain injury than
following right brain injury.

Satz and Bullard-Bates (1983) concluded from their statistical examination of the literature that overall mean incidence of aphasia is the same for left brain injury regardless of age; the risk with right brain injury is higher in children than in adults but significantly lower than in left brain injury.

Woods and Teuber (1978) found 74% of their subjects with a left hemisphere lesion to have initial aphasia while only 13% with a right hemisphere lesion to have initial aphasia. Krashen (1973) in his study of childhood aphasia found that the percentage of right sided lesions producing an aphasia was similar to that observed in adults.

Similar assymetries have been disclosed in animal experimentation. Neuroscientists have discovered behavioural and anatomical assymetries in the brains of apes and monkeys as well as of birds and rats. Nottebohm (1979) found left-brain centers in canaries which he showed to be responsible for the development of song. Sectioning of the left hemisphere led to the loss of most song components. When damage occurs before song is developed, centers on the right side can take over. This plasticity is apparently hormone-depended.

Kinsbourne and Hiscock (1977) found no increase in laterality with age on dichotic listening tasks. Molfese (1971) observed lateralized responses in newborns in their perception of speech
sounds. Furthermore Dennis (1980) found right-left differences in hemidecorticated children, before acquisition of language. More specifically the right hemisphere was more competent in perceptual skills and the two hemispheres used different verbal strategies to encode and decode language.

Besides behavioural data, evidence for early lateralization comes from structural asymmetries between the hemispheres. (Galaburda et al., 1978; Geschwind & Levitsky, 1968; LeMay & Culebras, 1972). Galaburda et al. found structural differences in the auditory regions and the Sylvian Fissure even in the foetus. From their data they also suggested that "asymmetries seem to be distributed along a continuum, that is, the region which is larger on one side may vary from being only slightly larger to, at times, being many times larger."

As a consequence such differences in asymmetry may account for individual differences in recovery; when two sides are less lateralized, recovery is better. However, Corballis & Beale (1983) point out that measured differences in asymmetry do not correspond to proportions of individuals with language represented on the left, bilaterally, or on the right. They suspect "the discrepancy probably has to do with the nature of the measurements" (P.141). Nonetheless, brains without a particular asymmetry are more common in left handers (Rasmussen and Milner, 1977), while asymmetry for verbal functions may be more consistently established in males (McGlone, 1978).

Variations on the "equipotentiality position" have been
postulated in an attempt to explain differences in lateralization. Rasmussen and Milner (1977) discussed the possibility of partial use of either hemisphere depending on the site of lesion. They used Sodium Amytal to test for cerebral asymmetry in both brain-damaged and control subjects. Results indicated that the locus of the lesion was critical in determining lateralization of speech functions after early left-brain injury. For example one subject, a 16;0 year old girl had incurred an injury at 2;5 years, but language was adequate and represented in the right hemisphere at testing. They speculated that damage to the parieto-temporal region led to the development of speech representation in the corresponding region of the right hemisphere. The site of lesion, according to this study, is the critical factor in displacement of functional representation.

Other variations which have been discussed include intrahemispheric reorganization of the hemisphere subserving lanaguage, (Hecaen, 1976), and recovery of language functions in the left hemisphere at the expense of nonlanguage functions in the right hemisphere. (Woods and Teuber, 1978).

In summary, aphasia is not rare in children, but it is more prominent in damage to the dominant left hemisphere. This evidence contradicts the equipotentiality hypothesis, on the basis of which other variations concerning cerebral asymmetry have been suggested. Besides behavioural data, there is
structural evidence for early lateralization. This lateralization differs in individuals and may not be comparable in function to the adult.

2.3 PREINJURY STATUS:

The head-injured population does not, in many cases, typify the normal child population. Various social or academic problems may make the child more susceptible to a head injury. Klonoff et al. (1977) in their developmental follow-up of head-injured children, found that preinjury learning disabilities and other "developmental anomalies" were common in boys. Jennet (1974) examined the psychological sequelae of head-injured children and concluded that few head-injured children have behavioural disorders; those who do prove to have been maladjusted before the injury.

Fuld & Fisher (1977) conducted one of the few studies which includes detailed preinjury data on all subjects. In their sample of seven children only one was described as bright and one as normal before the accident. The other 5 had learning disabilities, mild mental retardation, and mild reading problems. Fuld and Fisher state that in their clinical experience they "only saw three who could be described as academically and socially normal before their accident."

2.4 SYMPTOMATOLOGY:
Similarities Across Studies:

It is difficult to make comparisons across studies concerning
symptomatology; this lack of comparison is due to: failure to control language measures, inadequate description of the status of the brain damage, recovery periods involved, and experiential variables. All these factors contribute to brain damage recovery measures. However, one can derive from the literature two almost distinct hypotheses concerning language of the head-injured child. One posits that the child recovers faster the earlier the damage is sustained and that given time he will recover completely (Basser, 1962). The other suggests that recovery of language is not so complete and linguistic deficits may be a potential cause of academic and social problems (Rankin et. al., 1981; Woods and Carey, 1979).

Similarities across studies concerning language of the head-injured child do exist in the literature. Alajouanine and Lhermitte (1965) conducted a study of 32 children ranging from 6-15 years at time of trauma. The study is comprehensive in that the children were followed over a period of one to twelve years. At three months testing the symptomatologies included a reduction in oral and written expression, syntactic simplification, absence of logorrhea and perseveration.

The authors suggest that absence of automatized sequences such as logorrhea and perseveration is due to the nervous circuits which are "less deeply established" in the child. Receptive disorders were noted to be rare, and reading problems were described as different from those in adults. Instead of having a problem with letters like adults, most problems were
encountered on words as wholes. After one year many of the symptoms were reported to have disappeared; some difficulties were still noted in construction of sentences and word definitions in 14 children. Writing disturbances also tended to persist.

Hecaen (1976) confirmed these findings in his study of 26 children with acquired aphasia (ages 3.5-15;0). The etiologies in these children were mixed and included trauma, hematomas, tumors and absesses. From an examination of the language of these children he reported 15/17 left-lesioned and 2/6 right-lesioned to have language disorders. It should be noted that this definition of language disorder varied greatly depending on the individual. It included deficits as mild as a transitory articulation problem or as severe as a 6 year writing disorder. Like Alajouanine and Lhermitte, he reports a frequency of initial mutism, and rarity of paraphasias and logorrhoea. Disorders of reading were also noted in the acute stage but they tended to disappear rapidly. Disorders of writing and naming were most frequent and tend to persist longest. Hecaen reported few auditory comprehension problems, which was consistent with the findings of Alajouanine and Lhermitte. With respect to recovery, he found size and bilaterality of lesion to be two of the most important factors, but found no correlation between coma and severity of deficit.

Fuld & Fisher (1977) conducted a study of seven children with
closed head injury. Age at injury varied from 1 to 15 years. Of these children only 2 could be considered to be normal prior to the injury; problems included mild mental retardation, learning disabilities and mild reading problems. They presented an overview of all children in addition to detailed case studies of two of the children. Testing was performed a few months after the injury as well as 6 months and 1 year later. Behaviour problems were marked in two children, and attention problems were noted in four. Taking into consideration premorbid status, they identified intellectual impairment long after EEG's and neurological exams had returned to normal. Comprehension deficits were revealed in two cases a couple of months after injury but they disappeared 6 months later. In one case, reading problems were described, which persisted for at least 6 months.

Byers & Mclean (1962) report 11 cases of hemiplegia accompanied by aphasia. This study was very comprehensive in that it presented the clinical recovery course for each of the children as well as a follow-up 3 to 7 years later. Disturbances of all forms of expressive language including initial mutism were described as a common symptom in the acute stage. These language difficulties were in all instances combined with visual difficulties which contributed to reading problems. Reversals were noted both in order of letters and in their formation. Recovery proceeded at different speeds in all cases, but all children gained spontaneous speech. Four
appeared to be functioning adequately after a few years, while all the others showed persisting psychological problems.

A consensus can be arrived at from these studies (and others) regarding the symptomatology of the head-injured child. It appears that initial mutism and absence of paraphasias is a common symptom. Auditory comprehension problems are found in some cases but disappear quickly. Writing and reading disturbances are common and often persist.

2.5 SYMPTOMATOLOGY:
Differences Across Studies-

Despite these similarities, differences in the language deficits of head-injured children still exist. Researchers who have analyzed language at an acute stage have recognized the frequency of paraphasias. Fuld & Fisher (1977) reported a girl with occasional paraphasias one year after her injury. Vish-Brink and Van de Sandt-Koenderman (1984) analyzed the spontaneous speech of 14 children with acquired aphasia, varying in age from 5;0 to 12;0 years. They showed that the term "rare" has been inappropriately applied to paraphasias. More than half of the children they studied produced paraphasias, and the number of paraphasias uttered by a single child could be quite large. Furthermore they found that all the children, at an early stage, produced more than one paraphasia a minute, a frequency similar to that found in adult aphasics (Goodglass & Kaplan, 1972).

"Non-fluent" a term borrowed from adult aphasiology , has been
used, by consensus, to describe the initial profile of a head injured child (Hecaen, 1983; Bass, 1962; Guttmann, 1942). Cases of fluent aphasia have now been reported by a number of researchers (Visch-Brink and Van De Sandt-Koenderman, 1984; Woods and Teuber, 1978; Fuld & Fisher, 1977). Visch-Brink and Van De Sandt-Koenderman were able to classify their subjects, as either fluent or nonfluent on the basis of tempo and mean length of utterance.

Woods and Teuber (1978) point out that there can be exceptions to nonfluency, such as a 5 year old jargon aphasic, whom they studied. They indicate that previously "Our observations of primarily nonfluent aphasia after early lesions may have been influenced by our reliance on hemiparesis as the neurological criterion for inclusion in the sample."

The rarity of reports of auditory comprehension deficits in the literature may also be explained by the reliance on hemiparesis for inclusion in a sample. That is, auditory comprehension deficits have been associated with temporal lobe lesions in adults, whereas hemiparesis is generally associated with frontal lobe lesions. Hecaen (1976) found a relation between disorders of auditory comprehension and lesion localization in his study; they were found only with temporal lesions. These localization features were found in both the younger and older groups.

Hecaen (1983) has suggested that all aspects of language
including auditory comprehension, are affected more by anterior than temporal lobe damage. He further suggested that the fronto-rolandic area of the brain is engaged in more diverse language functions than in adults. However, the majority of comprehension problems in his study were mild or transitory and no objective measures were used for testing such deficits.

Auditory comprehension deficits are not as apparent as production problems, but appear to be more frequent than once thought, when objective measures are employed in testing. Alajouanine and Lhermitte (1965) found deficits of this nature in many of their subjects. The study by Aram et. al (1981) is one of the few which includes information about lesion site. They studied children (6-8 years) who had incurred brain damage during the prenatal or perinatal period. The area of damage in the left-hemisphere of these subjects included the temporal and parietal lobe in two, and the frontal and parietal lobes in another. Intelligence measures indicated comparable scores across subjects. Through an extensive battery of expressive and receptive language tests they identified comprehension deficits as well as syntactic and vocabulary deficits in these children. Children with left hemisphere damage performed significantly below the normal mean on both the Token Test (receptive language) and the Northwestern Syntax Screening Test (receptive syntax).

Rankin et al. (1985) tested 16 children with unilateral lesions 1 to 4 years after onset of damage. Extensive
data was available on lesion site, and extensive language testing was conducted. The lesion site was for the most part in the pre and retrorolandic area with or without basal ganglia involvement. In all children, there was documented evidence of normal neurological status and development, prior to lesioning. Test results indicated receptive deficits in 3/8 of the left lesioned subjects, while all but one performed at or above the 50th percentile. No significant receptive deficits were found in the right-lesioned subjects. The weakness in this study lies in its generalizability to other children with unilateral lesions since the majority of lesions reported were incurred before language acquisition. The issue presented in this study is how well these children can acquire language rather than how well they relearn "old" skills.

This discrepancy concerning symptomatology in language may be more apparent than real, reflecting the heterogeneous etiologies, lesions and linguistic maturity of the childhood samples studied. With respect to linguistic maturity, some researchers suggest that head-injured children may be able to reattain premorbid levels of functioning but have difficulty acquiring new skills (Alajouanine and Lhermitte, 1965).

Those studies which include head-injured children with lesions dating back to prenatal or perinatal periods should be separated out from those incurred after language acquisition. Annett (1972) included mainly perinatal lesions in her study,
and noted that developmental delay, rather than distinctive or specific problems. Aram et al. (1981) also indicated a delay in language development after perinatal lesions, particularly in the left lesioned group. Thus interpretation of results as either a delay or an aphasic disorder, may depend on time of lesion.

Etiology is another variable which has not been adequately controlled and may lead to misleading results. Hecaen (1976), and Alajouanine and Lhermitte (1965) included trauma, tumor, meningitis, and hematomas in calculating their percentages of language-disordered children. The etiology of lesion and its secondary effects have been shown to be significant in predicting long-term recovery of language in childhood aphasia. (Van Dongen & Loonen, 1977).

Woods and Teuber (1978) conducted a study of 65 children with unilateral lesions incurred between 2-14 years. The etiology of these lesions were diverse and may have led to his interpretation of results. They only included cases in which there was clinical evidence of a single fixed lesion. Note however, that evidence was based on brain scans, "whenever possible". More than half of the subjects' data were from chart reviews only, therefore objective measurements of aphasia could not be performed. From identification of aphasia in their subjects they posit that recovery was better and more likely before 8;0. Etiology may also be a factor in their findings; all but 2 trauma cases were in the under 8;0 group.
Since children have been shown to recover faster following trauma than they do following cerebrovascular accidents, these particular subjects could have influenced results in favour of the younger group.

Differences in the linguistic features of aphasic speech have, for many years been associated with various localization sites. In terms of fluency, Benson (1967) found a correlation between fluent and nonfluent types of aphasia with anterior and posterior lesions respectively. Visch and Van De Sandt Koenderman (1984) report an infant case in which a similar relation is found; a posterior lesion with a fluent aphasia. Hecaen (1976) reported the incidence of mutism and articulatory disorders to be associated with anterior lesions, and auditory comprehension to be associated with temporal lesions.

Other reasons for differences in symptomatology could include: language measures employed in the study, and the time post-onset at which they were administered. Many studies have employed vague measures of language, and use such phrases as "normal" or "speaking poorly." In other cases IQ measures are used which rely on semantically based information or metalinguistic skills rather than actual language abilities. It has been shown that it is syntax which is most affected in brain trauma (Dennis 1980). When more objective measures of language are used then the deficits not readily apparent, are recognized in these children.
2.6 COURSE OF RECOVERY:

Like symptomatology, recovery patterns are varied and documented in various formats, making comparisons across studies somewhat difficult. The time course of recovery is by no means invariant. Some studies report full restoration of language within one year (Lenneberg, 1967; Guttman, 1942) and others report deficits persisting up to five years (Klonoff & Clark, 1977).

Recovery effects have been reported to continue for longer periods of time in younger children. Klonoff & Clark (1977) studied recovery in a young group (mean age 5 years) and in an old group (mean age 11 years). Results indicated that "the older group stabilised three years after trauma while improvement was still evident in the younger group 5 years after trauma". Similar differences have been noted between children and adults (St. James-Roberts, 1980).

St. James-Roberts (1981) performed a critical examination of hemispherectomy data, and noted heterogeneity of recovery within infancy to be far greater than had been traditionally supposed. Comparisons were made of speech production and intelligence measures within and between age groups. Statistical analyses were applied to intelligence measures for subjects with recovery periods greater than one year. Findings indicated that neither age, hemisphere damaged, nor sex, influenced recovery scores consistently. The problem with
these analyses is that a statistical bias existed for left-damaged adult cases; many had died due to tumor recurrence. Also left-damaged children achieved higher verbal IQ scores but since they were a statistically small part of the population, results did not reach significance. The important observations regarding recovery made by St. James-Roberts are:

1) Recovery heterogeneity exists within the child and adult head-injured population.

2.) Recovery periods appear to differ between adults and children particularly in hemispherectomy cases. Adults more so than children, tend to stabilize faster or die from tumor recurrence.

3.) Secondary damage differs in adults and children and may account for, along with experiential factors, differences in recovery patterns.

Basser (1962) reported two trends observed during recovery; either recovery occurs very quickly once speech reappears, or it occurs slowly encompassing all the linguistic stages of development. These patterns of recovery were not related to severity of hemiparesis.

Byers & Mclean (1962) conducted a study of 11 aphasic children, in which outcomes were varied. Consistent with Basser's findings, some individuals recovered very quickly while others progressed slowly through the developmental stages of language acquisition. The recovery of expressive language proceeded through the following stages: 1) a few single words 2) automatic sequences such as days of the week, the alphabet and nursery rhymes 3) spontaneous language 4) spontaneous description of things or events. Those patients
that recovered quickly skipped some stages and, according to Byers and Mclean were noted to be suddenly reading.

Teuber & Rudel (1962) studied the behavioural effects of cerebral lesions in children and in adults. They employed tasks which included various visual and perceptual tests, for which heterogeneous effects were evident according to age and task. On the first, a localization experiment, the effects of early injury were not apparent until the age of 11 years, and become increasingly evident thereafter. On the second, a deficit was found across age groups, and on the third no deficits were found after 11 years. They concluded that the resiliency of the infant brain and the effects of such resiliencies on recovery, may depend on the task employed and the age at which the child is tested.

In summary, the time course of recovery appears to be heterogeneous in head-injured children. Rapid recovery is still reported but such reports are in conflict with a number of case reports attesting to persisting deficits. It is possible that a longer period of continuing recovery in a child may partially account for the better recovery noted when children are compared with adults.

2.7_FACTORS_PREDICTING_RECOVERY:

Length of Coma:

Many investigators have observed that length of coma is inversely related to quality of recovery in children.
Heiskanen & Kaste (1974) examined children with head-injuries during a ten year period, post-trauma. They concluded that any period of unconsciousness longer than two weeks is likely to result in little chance of normal school progress, once recovery is taking place. In contrast, Hecaen (1976) found no relationship between duration of coma and persistence and severity of deficit.

Age:
Age has been studied in relation to the time course of recovery. Sugar stated, (Perlstein & Sugar, 1954) "if the speech center is damaged before the age of ten, the child will recover his speech." According to Woods and Carey (1979) any child over 1;0 who received an aphasia producing lesion in the left hemisphere is less likely to have normal language recovery. Children who have been reported to have incurred lesions before 1;0 however, did so either perinatally or prenatally. This type of damage would be different from damage incurred with head injuries in older children.

Studies which attest that recovery is better in younger children base this assessment on the acute stage of recovery. If one examines follow-up studies of long-term recovery, they provide exceptions to the theory that early lesions result in better. For example, Van Doongen & Loonen (1977) followed 15 aphasic children for periods ranging from one to three years. They concluded that age is not an important consideration in
prognosis. Mantovani & Landau (1980) reported a 4:0 year old girl who was unable to speak after minor head trauma. Left-sided seizures were noted. It took three to four years of intensive special education for her to recover her ability to communicate.

In Woods and Teuber's study (1978) the child who took the longest to recover (2.5 years) was only 5 years 1 month at the time of the CVA. Annett (1972) found younger children who had incurred an intrinsic lesion to be more severely affected than older children who had incurred similar lesions.

EEG

Shoumaker, Bennett, Bray, and Curless (1974) concluded that degree of aphasia and EEG abnormality parallel each other. In contradiction, Bacchi (1980) reported that EEG's are not reliable predictors of recovery in head-injured children, particularly those EEG's obtained in the acute stage of recovery. Rose (1969) reported that recovery of speech and language skills may lag behind EEG improvement by as much as six months. Similarly, Worster Drought (1971) and Fuld & Fisher (1977) have reported persistent speech and language problems long after normal EEG's have been obtained.

Etiology

Trauma, when compared with cerebrovascular accident as source of lesioning, has been reported to be a favourable prognostic
indicator, (Hecaen, 1983; Van Doongen & Loonen, 1977) although this relationship does not always hold. Fuld & Fisher (1977) studied only trauma cases and found persisting linguistic deficits in all children. Byers & Mclean (1962) studied children with varied etiologies; no correlation was found between trauma victims and quality of recovery.

Our purpose in this study is to examine the data for:

1) Differences between the language deficits of head-injured children and head-injured adults.

2) Correlation between severity of linguistic deficit and EEG, age, and/or length of coma.

3) Differences between the extent of recovery in the child when compared with the head-injured adult.
3.1 **Subjects:**

Head-injured patients were drawn from Sunnyhill Hospital for Children and the Surrey School Board. Ages ranged from 6;0-17;0 years. All had suffered external head injury. None of the patients had significant dysarthric symptoms and expressive language was required to be "fluent" at the spontaneous level.

Psychological testing prior to the accident indicated that intellectual functioning was within normal limits. Two subjects had to be excluded from the data analysis due to evidence of premorbid developmental delays.

3.2 **Controls:**

Each head-injured subject was matched with one control subject according to age and gender. Parental and teacher reports (if available) were used as gross estimates of premorbid developmental levels (delayed vs. normal development).

3.3 **Data Measures:**

All children were administered a battery of expressive and receptive language tests. Standardized language measures included the Peabody Picture Vocabulary Test (Dunn, 1965) which estimates receptive vocabulary, the Token test (DiSimoni, 1978) which estimates retention of detail in sequence, The Auditory comprehension test for Sentences (Shewan, 1984) and The Clinical Evaluation of Language Functions (Wigg and Semel, 1980) - Production subtests.
Other measures are outlined as follows;

1. **Conversation** was casual and intended to relieve any anxieties. The topics included friends, family and T.V. shows.

2. **Picture Description**—The child was presented with 3 pictures depicting different scenes. He was asked questions about them and in general asked to describe "What is happening?"

Both of the 2 tasks above were analyzed for:
- a. paraphasias- % and type
- b. M.L U.
- c. 14 Grammatical morphemes
- d. Syntactic Complexity
  - one word utterance- 1 point
  - simple NP VP (X) - 3 points
  - subordinate clause- 5 points
  - > 1 subord. clause- 6 or 7 points.

3. **Token Test**—
Only subtests 3, 4, 5, were administered due to time constraints. For warm-up, sample commands from subtest 1 and 2 were administered.

4. **Word Retrieval**—
   a) Auditory Sentence Completion
   A sentence was read to the subject with one word missing at the end. The grammatical categories of noun, and verb were examined for recall in this task, and in the following two tasks.
   
   e.g. To find out what to eat in a restaurant you look at the --

   b. Auditory Description
   An object, or verb is described in a question requesting its name. Subject was required to answer the question with the word being described.
   
   e.g. What is the name for a moving staircase?

   c. Picture Naming
   The subject was required to name a picture. The pictures became progressively difficult. (less frequent in the English Language, Thorndike and Lorge 1944).

   All of the 3 subtests listed above were timed in order to measure latency of response.

5. **Comprehension of Syntax**
Subject was required to point to picture which matches the sentence read by the experimenter.

Auditory Comprehension Test for Sentences (Cindy Shewan)

6. Clinical Evaluation of Language—Production
   a) Sentence Imitation
      Taperecorded sentences of varied syntactic complexity were presented to subject. Subject was required to repeat verbatim the sentence heard.
   b) Confrontation Naming
   c) Formulated Sentences

7. Sentence Order Task
   The subject was provided with the constituents of a sentence in the form of words printed on separate cards. The task is to arrange the scrambled cards in linear order to produce a well-formed sentence. The experimenter prior to testing has the subject read out each individual word.

3.4 PROCEDURES:

All subjects were tested individually by the investigator in the home. One to two sessions were required totalling 2 hours of testing time. All spontaneous language and expressive language tests were tape recorded to permit later transcription and analysis.

3.5 DATA ANALYSIS:

The data collected for each child was analyzed and compared to that of a matched control subject. The scores from the standardized tests were objectively laid out in table form. Types of errors were subjectively examined in the following tests: Token Test, Sentence Imitation, and Picture Naming.
Case Histories

CASE#1_PATIENT-JB

Preinjury:

Birth history was unremarkable and developmental milestones were reported to be within normal limits. School progress was considered to be fair but only because he frequently skipped out of classes. Psychological testing before the accident indicated overall intellectual functioning to be above average.

Injury:

JB sustained a severe head injury while riding a motorcycle. He was thrown off while taking a sharp turn and hit his head against the curb. He was found unconscious and during his transfer by ambulance he had some respiratory distress. On admission a CT Scan revealed no fractures, but soft tissue swelling in the right occipital region, and brain stem injury were observed. He was responsive to pain but was assuming decerebrate positioning. He had some twitching along the left side of his face which was presumed to be seizure activity.

Recovery:

His level of unconsciousness lightened by the 4th day and he began to open his eyes by 8 days post-injury. EEG was reported to be normal. By the 19th day post-injury he was looking around, and had spontaneous eye movement. All limbs were
notably spastic.

One month post-onset: He was more orientated. He responded to his name and followed simple commands. At this time he began receiving speech therapy.

Two months post-onset: JB began speaking words in a soft voice which became louder every day. His use of language was socially inappropriate, and he experienced severe word-finding difficulties. His comprehension increased rapidly and was almost at age level at three months post-injury.

Three months post-onset: Sentences were becoming longer and more appropriate in content. Speech was mildly dysarthric, and slow. Writing had improved but legibility was poor due to hemiparesis in his right hand. Reading was very good. He could only take a few steps at this time; gait was ataxic and spastic. Diagnosis indicated a double spastic ataxic hemiplegia with greater involvement of the left side. An intention tremor was evident in the right hand, and impaired fine finger coordination was evident in both hands.

He has subsequently been placed in a special class for children with learning problems. Progress is encouraged at a slower rate. Teacher reports indicate progress is adequate although he has difficulty in word-finding.

CASE #2 PATIENT-PB

Preinjury:

Birth history was unremarkable and developmental milestones were reported to be within normal limits. Prior to injury PB was enrolled in a regular Grade 9 class. He had performed at an average to above average level with little problem. Favorite activities included sports and drama. He had no history of hearing problems.

Injury:

PB sustained a head injury when he was hit by a car while
riding his bike. On admission to the hospital he was in a comatose state with bilateral decerebrate posturing. Diagnosis indicated a severe head injury.

A CT scan at time of admission revealed a hematoma in the left frontal region with compression of the left lateral ventricle. There was some evidence of contusion in the left parietal lobe in close relationship to a linear skull fracture, and an associated contusion in the right frontal parietal area.

His course of recovery was complicated by pneumonia and a tracheal aspirate growing stapholacoccal infection. He had no apparent seizures but was said to be tremulous and shivery for which he was treated with Valium.

Recovery:

PB was in a comatose state for two weeks. Up to the 5th day post-injury his Glasgow Coma Scale Score was 5. Although there was no eye-opening in response to pain, limb flexion was noted in both limbs. By the 11th day post-injury he opened his eyes to voice, but did not obey commands.

On the 19th day post-injury he attempted to articulate and feed himself. He responded to simple commands. He started verbalizing at 23 days post-injury. At this time conversation was inappropriate; he talked in long rambling sentences. He tended to perseverate, talk compulsively, and "have difficulty finding the words for what he wanted to say".
One Month Post-Injury:

Paraphasias were noted in expressive language. i.e. "Killip" for "Phillip".

Two Months Post-Injury:

Empty speech- i.e. when asked to point to grey, he responded, "Grey, watch the Bismark, I'll give you grey now, the grey squirrel."

Many literal and verbal paraphasias- i.e. "You're snoring my breath", when he tired of the task.

Reduced auditory comprehension, fair naming, and good repetition skills. Word reading adequate but problems with sentence reading. Writing was moderately impaired.

Three Months Post-Injury:

Word-finding problems were still present. He continued to produce literal and verbal paraphasias. Auditory comprehension was still reduced, particularly processing linguistic concepts. Short term memory was weak, but reading and writing had improved.

At six months post-injury he is in Grade 9 and receives Learning Assistance in all subjects. Academic skills are reported to be well below those before the accident. Comprehension is adequate and paraphasias are reduced. Word finding and processing of abstract information are still significant problems.

Case #3 PATIENT — SK

Preinjury:

SK had early language training in Austria (1974-1976) in the German language. Upon return to Canada, he enrolled in Kindergarten and adjusted very well. During his early school years his comprehension and expression of language was average to above average. His motor development was also average for
his age.

**Injury:**

SK was involved in a motor vehicle accident, in which he incurred a severe brain trauma. The accident left his comatose for approximately one month, and hospitalized for six months following this state.

**Recovery:**

SK was gradually integrated into the school system. He continues to require special class placement.

**CASE #4_PATIENT--JA**

**Pre-injury:**

JA was described as a good student prior to the accident. He had no difficulty in school and performed at an average level. He was left-handed prior to, and after, the accident. Hearing was reported to be within normal limits.

**Injury:**

JA sustained a head injury when he was driving a motorcycle on which he was in a head-on collision with a truck. He was wearing a helmet, which came off in the accident. The accident left him in a deep unconscious state.

On admission to hospital he was diagnosed as having a severe head injury with no fractures or observed convulsions. A right angiogram was performed which showed nothing abnormal;
the left angiogram failed. A CT Scan revealed a left frontal
parietal sub-dural hematoma with no shift of midline
structures. He had increased intracranial pressure which was
treated with hypoventilation. He was also reported to have a
right comminuted fracture of the right femur.

Recovery:
There was little change in JA's deep unconscious state for 3
weeks during which time no seizures were noted. On day 5 post-
injury his GCS was reported to be 5. His condition lightened
after 3 weeks but it wasn't until 45 days post injury that he
showed conscious responsitivity. At that time he started oral
feeding.

Two__months__post_onset: he began indicating "yes" and "no" with
his fingers but was still unable to talk.

Two_and_a_half_months__post_onset: he was starting to self-feed,
whisper words and could stand with assistance. He progressed
from using single word responses to talking in complete
sentences over a 2 week period. During this stage JA received
speech therapy 3 times weekly.

Three_months__post-onset: he was talking well with a low voice,
and self-feeding.

Four_months__post-onset: Test results indicated difficulty
comprehending longer and more complex demands. Language age
for all auditory comprehension tasks was 3 years below age
level. Expressive language skills were in excess of receptive
skills by 18 months. Reading skills were very good. He had
difficulty in writing down his thoughts and sentence structure
was poor.

Five_months__post-onset: Vocalization was still at a low
intensity level. He had severe problems in recall and
processing of auditory cues and in word-finding. Ability to
organize thoughts was mildly impaired.

Six_months__post-onset: His cognitive abilities continued to
improve. Ability to read and comprehend was at age level.
Math was still somewhat delayed (6 months).
Eight months post-onset: He started to attend some regular classes. He still had a right-sided weakness and right hemiparesis in his hand. Thinking was still slow, and short term memory was still poor. Word-finding was still a problem, particularly in a testing situation. Overall intellectual functioning was reported to be in the average range.

Nine months Post-onset: A school report indicated that while JA was regaining old verbal cognitive skills at a reasonable rate, the learning and retention of new verbal material was moderately to severely impaired. Learning assistance was required in the school program.

CASE #5 PATIENT - KP

Preinjury:

Birth history was reported to be normal. Development milestones were within normal limits. There is no history of hearing problems. Prior to the accident he was said to do well both in school and socially; academic standing was average. School report indicates "K has maintained an achievement level that is above average as well as participating in many extracurricular activities".

Injury:

KP sustained a severe head injury in a high speed motorvehicle accident. He was unconscious immediately and had multiple small lacerations to the anterior right forehead. He was found to have a fracture of the right frontal and parietal skull extending to the base of the skull at the level of the orbital roof. Initial CT scan revealed brain shift from midline to the left involving the right lateral ventricles. Mild dilation of the left lateral ventricle and hematoma in right frontal
parietal area were also indicated.

**Recovery:**

KP remained in an unconscious state for 10 days, at which time he started to obey simple commands. He was not talking but did try to mouth some words. He also wrote his name. Reflexes were intact however an overall left-sided weakness was evident.

**Two Weeks Post-injury:** he was nodding his head for "yes" and pointing when he wanted something. Comprehension was improving rapidly.

**Three weeks post-injury:** He was speaking words, but at low intensity, and answering simple questions.

**One month post-injury:** He began using one and two word sentences with a very soft voice. Speech rapidly began to improve. He started to use sentences more often; most were incomplete or perseverative. i.e. "Me get better fast". Attention span and perceptual abilities were limited. Short term memory was particularly weak. He was able to write words and sentences.

**Two months post-injury:** KP still had word-finding difficulties. Language tests revealed abilities close to premorbid levels. Intellectual abilities were at age level, although he was still expressing difficulty on higher level functions. At two months he began attending some regular classes at school.

**Three months post-injury:** On testing, receptive language abilities were within normal limits. Expressive language was circumlocutory and often socially inappropriate. Word finding problems were evident in conversational situations.

At 7 months post-injury KP is attending a regular class. He has received individual tutoring at home in all subjects up to this time. He is progressing adequately although memory lapses are still apparent.
CASE #6 PATIENT-CG

Injury:

Clint was involved in a motorvehicle accident, in which he incurred a severe head injury. He was struck on the right side of his head, and was left unconscious. After the accident he remained in intensive care for forty days.

Recovery:

Clint was initially mute, and confused. He had problems recognizing and remembering friends and family. After one month he began acquiring single words, and then gradually he combined them into short sentences. It wasn’t until approximately two months post-injury that he began conversing in simple sentences. Memory continues to be impaired.

Clint began receiving speech therapy, in addition to occupational and physiotherapy shortly after the accident. His gait is impaired due to muscle damage, and hence he continues to need physiotherapy.

CASE #7 PATIENT-CY

Preinjury:

Developmental milestones were reported to be normal; he started talking at 0:18 months. His progress in school was reported to be above average for all skills.

Injury:
CY was involved in a motorvehicle accident which left him in a comatose state for two weeks. A CT Scan revealed a fracture on the left side. Secondary to this fracture, he had a weakness on the right side of his body.

Recovery:

He had to learn to walk again during the first few months post-injury. He was initially mute, but started producing speech sounds 6 weeks post-onset. Recovery of speech was prolonged beginning with sounds, followed by gradual acquisition of words and finally sentences. He received speech therapy for two years post-onset. Short term memory was particularly weak.

He was right handed prior to injury but switched to the left-hand because of a right side weakness. Progress in school has been slow, and he has encountered much difficulty at 2 yrs.-5 mths, post-injury. His performance is average although he receives extra assistance at home. Reading has improved but is not at pre-injury level.

CASE #8 PATIENT - LD

Preinjury:

Birth history was unremarkable; her developmental milestones were reported to be normal. By 2:0 years she is reported to have spoken 2 word utterances. LD was competent in pre-academic skills including colors, counting, and printing her
Injury:

LD sustained a mild head injury after falling from a fourth floor window. There was approximately one minute loss of consciousness, and multiple seizures (Rt. side). No cerebral edema was noted on medical examination, but passive venous congestion was mentioned secondary to medication. No skull fractures were found.

Recovery:

LD was initially mute after the injury. One day post-injury she was orientated and made a few verbal responses. At this time GCS was scored at 10: 4(eye) 2(Verbal) 4(Motor). Two days post-injury she was alert and cooperative and GCS was 13. Five days post-injury conversation was confused. She skipped around from topic to topic in rambling sentences. She appeared to be orientated and asked to go home.

At the time of writing 10 months post-injury, she is placed in a modified Kindergarten-Grade 1 class. Kindergarten report states that L.D. is "slow in learning", and is below average in understanding abstract concepts. Immediate and long term memory are weak. Psychological testing indicated general intellectual functioning to be in the average range.
<table>
<thead>
<tr>
<th>Subject/Sex</th>
<th>Present Time</th>
<th>Post-Onset Etiology</th>
<th>Area of Damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. JB (M)</td>
<td>17;8</td>
<td>2;9 M/C A (1)</td>
<td>Right occip. swelling</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Brain stem injury</td>
</tr>
<tr>
<td>2. PB (M)</td>
<td>15;3</td>
<td>0;6 M/V A (2)</td>
<td>Lft. Frontal Hematoma</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lft. Subgial Hematoma</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rt. Frontal Concussion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lft. Parietal Fracture</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lft. Tibial Fracture</td>
</tr>
<tr>
<td>3. SK (M)</td>
<td>13;2</td>
<td>7;5 M/V A</td>
<td>Diffuse cerebral damage</td>
</tr>
<tr>
<td>4. JA (M)</td>
<td>12;11</td>
<td>2;10 M/C A</td>
<td>Lft. frontal parietal hematoma</td>
</tr>
<tr>
<td>5. KP (M)</td>
<td>12;6</td>
<td>0;7 M/V A</td>
<td>Rt. pariet. frt. fract.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rt. contusion, hematoma</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lft. dilation Ventricle</td>
</tr>
<tr>
<td>6. CG (M)</td>
<td>10;0</td>
<td>4;0 M/V A</td>
<td>Diffuse cerebral damage</td>
</tr>
<tr>
<td>7. CY (M)</td>
<td>6;1</td>
<td>2;5 M/V A</td>
<td>Lft. fracture</td>
</tr>
<tr>
<td>8. LD (F)</td>
<td>6;10</td>
<td>0;10 Fall</td>
<td>Venous congestion</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Rt. side seizures</td>
</tr>
</tbody>
</table>

(1) M/C A = motorcycle accident  
(2) M/V A = motorvehicle accident
TABLE 2
SUBJECTS' PERFORMANCE ON RECEPTIVE LANGUAGE TASKS

1. P.P.V.T. (Raw Score)  2. TOKEN TEST (Total 41)

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Controls</th>
<th>Subjects</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. JB</td>
<td>125*</td>
<td>148</td>
<td>37*</td>
</tr>
<tr>
<td>2. PB</td>
<td>128</td>
<td>136</td>
<td>35*</td>
</tr>
<tr>
<td>3. SK</td>
<td>92*</td>
<td>129</td>
<td>CNT</td>
</tr>
<tr>
<td>4. JA</td>
<td>123</td>
<td>127</td>
<td>38</td>
</tr>
<tr>
<td>5. KP</td>
<td>131</td>
<td>124</td>
<td>37</td>
</tr>
<tr>
<td>6. CG</td>
<td>95</td>
<td>107</td>
<td>24*</td>
</tr>
<tr>
<td>7. CY</td>
<td>91</td>
<td>81</td>
<td>31</td>
</tr>
<tr>
<td>8. LD</td>
<td>48*</td>
<td>80</td>
<td>23*</td>
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3. A.C.T.S.

<table>
<thead>
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<th>Subjects</th>
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<tbody>
<tr>
<td>1. JB</td>
<td>17*</td>
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<tr>
<td>2. PB</td>
<td>18</td>
</tr>
<tr>
<td>3. SK</td>
<td>12*</td>
</tr>
<tr>
<td>4. JA</td>
<td>16</td>
</tr>
<tr>
<td>5. KP</td>
<td>19</td>
</tr>
<tr>
<td>6. CG</td>
<td>15</td>
</tr>
<tr>
<td>7. CY</td>
<td>10</td>
</tr>
<tr>
<td>8. LD</td>
<td>6</td>
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</tbody>
</table>
TABLE 3
SUBJECTS' PERFORMANCE ON SENTENCE FORMULATION TASK
(Mean Latency- secs.)

<table>
<thead>
<tr>
<th>SUBJECTS</th>
<th>CONTROLS</th>
</tr>
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<tbody>
<tr>
<td>1. JB</td>
<td>19.3</td>
</tr>
<tr>
<td>2. PB</td>
<td>31.2</td>
</tr>
<tr>
<td>3. SK</td>
<td>31.1</td>
</tr>
<tr>
<td>4. JA</td>
<td>9.1</td>
</tr>
<tr>
<td>5. KP</td>
<td>101.1 *</td>
</tr>
<tr>
<td>6. CG</td>
<td>48.6</td>
</tr>
<tr>
<td>7. CY</td>
<td>CNT</td>
</tr>
<tr>
<td>8. LD</td>
<td>CNT</td>
</tr>
</tbody>
</table>
### TABLE 4

SUBJECTS’ PERFORMANCE ON WORD-FINDING TASKS

<table>
<thead>
<tr>
<th>Word-Fuency</th>
<th>Pic Naming</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Subjects</strong></td>
<td><strong>Controls</strong></td>
</tr>
<tr>
<td>1.JB 29*</td>
<td>63</td>
</tr>
<tr>
<td>2.PB 31*</td>
<td>52</td>
</tr>
<tr>
<td>3.SK 14*</td>
<td>42</td>
</tr>
<tr>
<td>4.JA 27*</td>
<td>38</td>
</tr>
<tr>
<td>5.KP 40</td>
<td>51</td>
</tr>
<tr>
<td>6.CG 16*</td>
<td>34</td>
</tr>
<tr>
<td>7.CY 21</td>
<td>31</td>
</tr>
<tr>
<td>8.LD 14</td>
<td>16</td>
</tr>
</tbody>
</table>
### TABLE 5

SUBJECTS PERFORMANCE ON C.E.L.F.-PRODUCTION

<table>
<thead>
<tr>
<th>BLOCK</th>
<th>SUBJECT</th>
<th>Sentence Repetition</th>
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<th>Sentence Formulation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>SUBJECTS</td>
<td>CONTROLS</td>
<td>SUBJECTS</td>
</tr>
<tr>
<td>1. JB</td>
<td>42</td>
<td>50</td>
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<td>2. PB</td>
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<td>59</td>
</tr>
<tr>
<td>3. SK</td>
<td>28*</td>
<td>46</td>
<td>CNT</td>
<td>--</td>
</tr>
<tr>
<td>4. JA</td>
<td>42</td>
<td>45</td>
<td>46</td>
<td>45</td>
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<td>5. KP</td>
<td>48</td>
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<td>6. CG</td>
<td>34</td>
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<td>51</td>
<td>48</td>
</tr>
<tr>
<td>7. CY</td>
<td>32</td>
<td>38</td>
<td>40</td>
<td>38</td>
</tr>
<tr>
<td>8. LD</td>
<td>41</td>
<td>38</td>
<td>CNT</td>
<td>--</td>
</tr>
</tbody>
</table>
Test Results:

5.1 RESULTS:

Receptive language abilities were mildly reduced in three (*) subjects (Table 2). Expressive language abilities, however were adequate across all subjects (Table 5). Sentence Formulation proved to be difficult for only one subject (KP). Visual-perceptual problems could have contributed to lowered performance for this subject. Finally, word-finding difficulties persisted across most subjects (Table 4).

5.2_TOKEN_TEST:TABLE_2

The Token Test (TT) results, consistent with results on the P.P.V.T. (receptive vocabulary), indicate reduced receptive abilities in three subjects. All subjects made more errors on Part 4 and 5 of the TT, in which there are increased demands for retention of detail. Greater difficulty was encountered on Part 5, (relative to Part 4) which tests primarily syntactic comprehension.

An item analysis was conducted for the three subjects who performed below the level of normal children. All three failed to respond correctly to the following commands:

2. Put the white square behind the yellow circle.
2. (Subjects placed the square under the circle).

6. Pick up the blue circle or the red square.
6. (Subjects performed both actions).

21. Before touching the yellow circle, pick up the red square.
21. (Subjects reversed the order, indicating a sequencing problem).
Two of these commands (2,21) are among the eight missed by aphasic children as reported by Rankin et al., (1981). For commands 2, 6, and 21 retention of two separate events is required in addition to comprehension of a linguistic concept ("behind", "or", "before"). They performed correctly on those commands which required two similar actions, unlike the above which require two distinct ones.

Perseveration and sub-vocalization were two common strategies used by four subjects. The subjects (J.B. C.Y. P.B. and L.D.) used sub-vocalization during a response presumably in an attempt to retain detail in short term memory. Perseveration from test item to test item (i.e. color, shape) was observed in the same subjects.

(1) JB pointed to both green and red tokens incorrectly during a command which had been preceded by a command in which these colours were included.

(2) CY had difficulty retaining more than two critical items in one command. His perseverations were of the type in which he repeated the same two items incorrectly in one command. For example for item 9 "Touch the small red square and the small yellow circle", he touched the small red square and the large red square. For item 10 "Touch the small white square and the large red square", he touched the small white square and the large white square.
5.3 WORD FINDING: Table 4

The Word Fluency Subtest revealed word-finding problems in three subjects, consistent with the Picture Naming Test. First, the total number of attributes named within a certain category (Food, Animals) in one minute was lower than that of the controls. Second, the strategy used by each of these subjects was different from that used by the controls. Subjects did not consistently name from a semantic subclass but instead moved randomly from subclass to subclass. (e.g. from vegetables to meats, to staples).

Picture Naming was more successful in revealing word-finding problems, since only one answer was considered correct. The results indicated moderate problems in two subjects (JB and PB) and mild problems in three others (CY, JA, and KP). One insight into this problem comes from frequent comments of the type "I know the word but I can’t think of it". Some indication of the strategies being employed to access the correct item included the use of semantically or phonemically similar words, and/or the use of actions to "describe" the use of the pictured word. We shall refer to this later.

Subject JB made errors in the Picture Naming Test indicative of word-finding problems; instead of naming the picture correctly he described and gestured its action. These words were named correctly given a phonemic cue. (First two segments of the word). Comments such as "I know the word, but I can’t think of it" were common. Some errors included:
Subject PB produced both articulation errors and word-finding errors during the picture-naming test. He also made such comments as "I know it, but I can't remember it." His word-finding errors can be grouped into two types:
1. word-retrieval and articulation errors—short latency.
2. word-retrieval—descriptors of action, longer latency.

1. Word Retrieval with articulation errors; short latency.
6. "stefiscope" (stethoscope)
7. "dinominoes" (dominoes)
8. "wreaf" (wreath)
9. "spinx" (sphinx)
These words were retrieved quite rapidly with a mean latency of 1.14 seconds.

ii. Word Retrieval: Description of actions, longer latency.
10. "ice-breakers" (tongs)
11. "moving staircase" (escalator)
12. "door locker" (bolt)
Semantic cues e.g. "you ride on it" were not helpful in attempts to retrieve these words, however giving the subject the first two segments was sufficient to enable him/her to correctly name the item. e.g."to" for tongs.
Some errors indicative of word-finding problems were also found on testing KP and CY. For example, KP made the following errors:

13. "thingamijig" (accordion)
14. "hang-man rope" (noose)

Given a phonemic cue i.e. "acc" for "accordion", he was able to name theses pictures correctly. Gestures accompanied his attempts to name "accordion".

C.Y. made the following errors:

15. "so you won"t bite people" (muzzle)
16. "pencil holder" (compass)

5.4 SENTENCE_REPETITION:

In this test, there were three common types of errors:

i. Sequencing Errors
ii. Ommisssion of segments.

iii. Conversion of semantically anomalous sentences into semantically appropriate sentences.

Four subjects (JB, PB, CY and KP) had common sequencing errors. For example, they incorrectly sequenced the adjectives when repeating the following sentences:

1. The woman has read the twelve big heavy brown books. (#25)
2. The big twelve brown heavy packages have carried the man. (#29)

Subjects (CY, PB and LD) converted semantically anomalous sentences into semantically appropriate sentences, indicating
reduced expressive syntax. For example, the following conversions occurred:

3. The picture that painted the person was very kind. (#16) > "The person who painted the picture was very kind."

4. Were delivered the flowers by the messenger? (#2) > "Were the flowers delivered by the messenger?"

These errors in sentence repetition are most critical for subjects JB and PB. Both of these subjectws are older and therefore more advanced syntax is expected from them, relative to the rest of the subject sample.

It should be noted that omission errors for all subjects might be the result of memory constraints. This did not appear to be a major factor in the results since, although they sequenced words incorrectly, they did appear to remember most of them.

5.5 SUMMARY OF INDIVIDUAL SUBJECTS:

Subjects JB and PB who suffer from diffuse brain trauma, have similar language deficits. Their expressive language is adequate for their age level when considered in terms of syntactic complexity. It is apparent, however, that they both have word-finding problems and reduced receptive vocabulary. Measures of auditory comprehension show reduction in the retention of linguistic detail, which may be attributed to memory constraints.

Subjects SK and CG, who both incurred diffuse cerebral damage and concommitant physical disabillity had similar language problems. Expressive language in terms of syntax and
linguistic complexity was adequate for age level. Comprehension, was moderately impaired, however this reduced ability was probably due partly to limited memory. Word-finding problems were pronounced in both these subjects; they were exemplified in both picture naming and word fluency tasks.

Subject JA exemplified the most clear case of lexical disturbance accompanied by otherwise normal language abilities. Both comprehension and expression of language were well intact. Problems were evident on picture naming and word fluency tasks.

Subject KP who sustained a right-sided lesion performed at age-appropriate levels in both receptive and expressive language tests. Some word-finding problems were evident in picture naming but not in a conversational setting.

Subject CY who incurred a left-sided fracture performed at low average levels on most tests; prior to injury language skills were above average. Receptively and expressively his language abilities were considered adequate. There was evidence of reduced retention of detail in short term memory.

Subject LD who revealed right seizures at injury presented with a mild processing problem of detail in orally presented information. Her limited vocabulary also contributed to this difficulty in understanding language. Sentences are of appropriate length for her age and are considered to be of
appropriate syntactic complexity.
DISCUSSION

6.1 PROBLEM #1:

There is no difference between the language deficits of head-injured child when compared with the head-injured adult.

From the results obtained it appears that the prominent linguistic deficits in the head-injured child are similar to those of the head-injured adult. The deficits observed in this study are consistent with those found by Sarno (1980) in studying aphasic adults with closed head injury. She reported naming and Token Test performance to be most affected in aphasic adults, followed by word fluency and sentence repetition.

In this study, word-retrieval (lexical access) was severely affected in four subjects (JB PB CY SK) and mildly impaired in three (CY KP JA). Auditory comprehension was mildly impaired in four subjects (JB PB LD CG SK); perseveration and weak retention of detail appeared to contribute to lowered comprehension during testing. Perseveration, in addition to sequencing problems, was observed in sentence repetition by three subjects (KP PB SK). As in the head-injured adult, the syntax remains intact in our sample of head-injured children; no word-order inversions or grammatical errors were observed in the expressive language of these subjects. We suggest that what is being observed is a lexically motivated, rather than a syntactically motivated language disorder.
6.2 WORD-FINDING:

Our findings of a specific linguistic disturbance associated with the lexicon (naming), are in accord with studies of adult aphasia after closed head trauma (Heilman et al., 1971; Levin et al., 1976; Levin et al., 1981; Najenson et al., 1978; Sarno, 1980). Levin et al. (1976) assessed fifty adults with closed head injury and results disclosed that word finding difficulty was a prominent deficit; half of their subjects tested had reduced scores on naming and/or word association.

The psychological framework of word-retrieval has been considered by investigators since the turn of the century. The earliest researchers, like Wernicke, believed that naming disturbances were the result of deficit memory. In 1888 Carl Freund refuted Wernicke's memory hypothesis when he described a patient who only exhibited word-retrieval problems only when asked to name visually presented material. Later researchers focused on the conceptual aspects of naming and indicated the need to include some process which conceptualizes the "idea" of a word. This attitude is best exemplified by Goldstein:

"In point of fact, the patient has not lost the words but his words appear to have lost to him the peculiarity requisite for use in a categorical sense to be employed as symbols. It may indeed be thought that the words have become for the patient empty sounds, which may belong to a definite object as this object's property, but which can no longer serve as a symbol for an idea, i.e. cannot be used as a generic name". (p.307)

Opposing this conceptually based hypothesis Lotmar (1919)
suggested an explanation for the deficit based on word frequency; thus the more frequent a word is in the language, the faster it is retrieved. He also posited a prelexical classification which includes a sound (phonological) and a meaning (semantic) component for directing retrieval. Rochford and Williams (1962, 1963, 1965) also emphasized the effect of word frequency on word retrieval. They showed that names first learned by children were least or last lost by aphasic adults. They also found that word retrieval in younger children seemed best cued by phonological prompts, rather than semantic associations.

Wolf (1982) presented a model of word retrieval based on investigations up to 1980. In this model there are four components with the following functions:

1. The **Perceptual** component sorts and identifies stimuli on the basis of a) perceptual features, b) stimulus familiarity and c) rate of presentation.

2. The **Conception** operation functions to provide a semantic set and connect perceptual information with a concept.

3. The **Lexicon** has two aspects; a phonological and semantic one.

4. The last component, the **Motor system** involves the execution of motor commands to the articulators.

Studies of lexical categorization have broadened the notion of the lexicon. Investigators have pointed to the phonological form of the lexicon as the root of word-retrieval problems. For example, Pease and Goodglass (1978) showed that the most successful cueing in adults and aphasics on picture-naming
tests is phonological. Similarly, Rochford and William's findings (1962) suggest that normal young children rely more on a phonological system of organization than a semantic system. Wolf (1982) showed that word-retrieval and poor reading was closely correlated in children; poor readers were deficient in measures of phonological fluency.

Other investigators have emphasized the semantic basis of the lexicon as the influential factor in word-retrieval. For example, Goodglass and Baker (1977) in a study of semantic fields and word associations found that the words named most easily were also the ones with the most intact association networks. They concluded that ability to name is influenced by an elaborated semantic field.

In summary, from the studies presented (and others) one can posit first a modality-differentiated component which sorts the incoming perceptual stimuli. The concept of a word referred to by Goldstein as "empty sounds" is then classified phonologically and semantically in the lexicon. Finally the motor system executes the spoken word.

6-3_GESTURE_AS_A_FACILITATOR_IN_WORD-RETRIEVAL:

Gestures have been recognized as successful in facilitating language in aphasic adults. This facilitatory effect is in accord with Goodglass' Cumulative-Modality hypothesis; the stimulation of different modalities summate to aid in the arousal of perceptual processes.
Helm & Benson (1978) have studied the use of gesture in a program called Visual Action Therapy. This program is arranged into steps which are aimed at shaping patients into producing symbolic gestures for pictures. They showed that using this method, all patients improved in auditory comprehension and pantomime. Improvement was also noted in naming and writing among individuals.

Other investigators who view deficits in word-retrieval as faulty retrieval mechanisms, have attested to the facilitatory effects of gesture. For example, Weisenberg & McBride (1935) reported that a patient was able to say "scissors" after wiggling his fingers back and forth as in cutting. Oldfield (1966) observed that anomic patients may show that they know what an object is by referring to the function of objects during speech.

6.4 THE RELATIONSHIP BETWEEN TRAUMA AND LINGUISTIC DEFICIT:

The results reported here are consistent with some of the available data concerning word-retrieval. Word frequency was clearly a factor influencing performance on the Picture-Naming task. As words became less frequent in the lexicon errors increase. Phonological cues definitely assisted in retrieval of target words whereas semantic cues did not. These findings i.e. the effectiveness of phonological prompts, are consistent with those of Pease & Goodglass (1978) and Rochford & Williams (1962) and suggest a phonologically based lexicon in the
retrieval of words.

The fact that subjects could retrieve words given these phonological cues, and their comments that they "knew the word", suggest a conclusion similar to that of i.e. Goldstein; "that the words have become empty sounds which may belong to a definite object as this object's property". That is, the words are not lost from the lexicon but a faulty retrieval system prevents an accurate match between the phonology and the motor programme for these sounds.

Gestures and "function descriptions" in accord with Oldfield (1966) are facilitatory mechanisms, which substitute for the target word. These two strategies; gestural access and articulatory access may be processed through alternate, less disruptible routes than those through which the word is executed.

Finally, the extent of the semantic field, consistent with Goodglass and Baker (1977) could be an influential factor in the speed or percentage correct. Results on the Word Fluency Test indicate a clear semantic disorganization, when these results are compared with strategies used by normal children; that is, subjects randomly named from various semantic categories.

Figure 1 outlines a proposed model for word-retrieval, based on present results. The sensory input is modality specific and is categorized into a concept accordingly. This first concept
FIGURE 1. MODEL OF WORD RETRIEVAL
component sorts incoming stimuli into semantic sets, and cognitively sorts out the generic attributes. If disorganization does exist at this level, sorting would delay retrieval time.

The second component, the lexicon is divided into a phonological form and a semantic form. At level three disruption is presumed to be most critical after head-injury. The accessing at this level depends on the matching of a phonological form to its motor program (articulatory) form. At the fourth level, the motor system, the word is executed.

The semantic component of the lexicon, which includes the function and inherent properties of the word enters an alternate route. This semantic form is accessed through either gesture or the motor system by an associative or function word.

6.5 PERSEVERATION:

Perseveration has been viewed as "the continuation or recurrence of an experience without the appropriate exciting stimulus" (McNalty, 1961). Hudson (1968) and Luria (1966) argue that perseveration occurs in different forms and may be related to the severity of injury.

Helmick & Berg (1976) studied perseveration in brain-injured adults on a number of experimental tasks. They found that significantly more perseveration was observed in the brain-injured adult than was noted in the normal subjects. There was
no relationship between the amount of perseveration on a task and either age or educational level of the brain-damaged subjects. Results did indicate that most perseverative behaviour occurred on naming and reversing a series. The authors suggest that tasks that are "least automatic" i.e. reversing a series, drawing designs from memory, are most effective at eliciting perseverance.

From our test results, we found perseveration to be a repetition of a sequence of words or actions, without the appropriate stimulus. The tasks most effective at eliciting perseveration were the Token Test and Sentence Imitation. In both tasks, a series of similar actions must be repeated or performed in order to correctly complete a task. It seems that from our results, stimuli which are most similar in nature will cause the most perseverative behaviour. Furthermore, when the head-injured subject has word-retrieval problems in the lexicon, he may use the perseverative response as a substitute for those words which are more difficult to retrieve.

6.6 PROBLEM #2 RECOVERY:

There is no difference between the extent of recovery in the head-injured child when compared with the head-injured adult.

From our data on recovery from and long term linguistic consequences of head injury it seems that recovery is faster in children i.e. 1 month when compared to adults for whom spontaneous recovery is generally set at 6 months. The extent
of linguistic recovery after head injury is similar however in both the child and adult. Comprehension is first to recover, and given a linguistic disturbance it is more likely to involve the lexicon rather than phonology or syntax. Similar to our findings in children, word-finding problems have been noted to persist in head-injured adults.

In the past the head-injured child has more commonly been described as recovering quickly and completely after a spontaneous recovery period. This is not true according to our sample of head-injured children and adolescents. In our sample of children complete recovery of language abilities was not evident up to four years post-injury. As in the adult persistent deficits were particularly striking in word-retrieval.

6.7 SCHOOL PERFORMANCE:

Long term follow-up of performance in head-injured children is in most cases limited to descriptions of school performance. In most cases, children who have suffered head injury require extra assistance or special class placement. Alajouanine & Lhermitte (1965) reported six children who after head-injury, regained previous acquired academic skills but were unable to advance further, and eventually dropped out of school. All of the children they tested failed to follow a normal progression in school. Fuld & Fisher (1977) similarly reported that several of the children they studied required special class placement several years after their injury.
The results of this study (and others) suggest that regardless of chronological age, children who suffer head injury may require significant time to adjust to their altered state before being placed back in the school system, and that, in addition, recovery to pre-injury performance levels appears never to occur. Continuing inadequate performance in school is probably related not only to a continuing disruption of the lexicon but also to behavioural and attentional sequelae related to the injury, which may themselves be responsible for lexical disruption. Black et al. (1969) observed that impaired attention, particularly in boys, was a common continuing problem following head injury. It would appear reasonable to suppose that this attention deficit, in addition to aggression and frustration could initially prevent the child from functioning satisfactorily. If at the same time too many demands are placed on the child when he/she is not ready to cope, a vicious circle of school failure and discontinued interest would be a natural result. Thus, slow and careful integration is probably vital if the head-injured child is to benefit from return to a regular school program. On the basis of present (and past) results continual monitoring and assistance are necessary if progress is to continue.

6.8 CONCLUSIONS:

1. The symptomatological deficits of language are similar in the head-injured child and adult. They include reduced auditory comprehension, perseveration, word-finding, and sequencing problems.
2. If any level of language is seen to be continually disturbed regardless of age, it is the lexicon, which continues to be affected even after spontaneous recovery.

3. Despite a quicker recovery in children, complete recovery of all language abilities is not evident in this sample of children up to 4 years post-injury.

4. There appears to be no relationship between length of coma and severity of linguistic deficits.

5. There appears to be no relationship between age and severity of linguistic deficits.

6. The subjects with associated physical handicaps i.e. spasticity and seizures, displayed the most deficient language skills.

These results present us with a rather interesting view of language. It would appear that the grammar (syntax) is a robust phenomena which is highly resistant to disruption, thus leading us to suggest (speculatively) that it has certain innate properties. On the other hand, the lexicon which is acquired by many different means, i.e. by one or more of the sensory systems, is seen as fragile and most susceptible to disruption when part of the associative network for naming, is disrupted.

It is therefore, for us not surprising, that the language effects of traumatic head injury are similar for both young and old, when injury occurs after the grammatical system has been acquired i.e. around 2;5-3;0 years.

The long term effects of head-injury give us some very interesting insights into the separation between syntax and the lexicon, and therefore force us to reconsider in a new light
the "early means better and faster recovery" hypothesis.
REFERENCES


Bruce D.A., & Schut, L. The Value of Cat Scanning following Pediatric Head Injuries. Clinical Paediatrics, 19, 719-725.


Rasmussen, T., & Milner, B. 1977. The role of early left-brain injury in determining lateralization of cerebral speech


PATIENT PROFILE

NAME:
ADDRESS:
PHONE:
D.O.B.:
HANDEDNESS:

DATE OF TRAUMA:
DATE OF TESTING: 1)

DIAGNOSIS:-----------------------------------------------

LENGTH OF COMA:***************

TEST RESULTS:

1. P.P.V.T

2. TOKEN TEST Noun Verb

3. SYNTACTIC STRUCTURES

4. WORD FINDING
   A. Picture Naming
   B. Word Fluency
   C. Sentence Completion
   D. Aud. Description

5. SENTENCE ORDER TASK

6. SENTENCE IMITATION-
   A. Omissions
   B. Rearrangements

7. M.L.U.
   SYNTACTIC COMPLEXITY  % PARAPHS.
   % PARAPHS.
   TTR
   TTR
AUDITORY SENTENCE COMPLETION:

1. You hang laundry out to dry on a

2. To find out what to eat in a restaurant you look at the

3. You buy stamps from a place called the

4. If you are arrested they will put you in

5. The doctor measures your heartbeat with a

6. To pound a nail in wood you use a

7. A person who has just been born is called a

AUDITORY DESCRIPTION:

1. What is the name for a moving staircase?

2. What do you use to shave with?

3. What is a tool for digging a hole in the ground?

4. What is the name for the thing one sits on?

5. What do you use to cut paper with?

6. What do you put a letter in before you mail it?

7. What is the object used for lighting a fire?
Word Finding—Verbs

AUDITORY DESCRIPTION:

1. What do you do when your hair is messy?  ____________________________________________________________________

2. What do you do when someone tickles you?  ____________________________________________________________________

3. What do you do when you are sick?  ____________________________________________________________________

4. What do you do with soap?  ____________________________________________________________________

5. What do you do on a motorcycyle?  ____________________________________________________________________

AUD. SENTENCE COMPLETION:

1. When I go to bed I  ____________________________________________________________________.

2. A boy runs and an old man  ____________________________________________________________________

3. I open the book and start to  ____________________________________________________________________

4. When I am very unhappy I  ____________________________________________________________________

5. When something falls into pieces it  ____________________________________________________________________
Parental report

Before the accident:

1. When did your child start
   a) walking
   b) toilet trained
   c) saying words
   d) saying sentences

2. Did he perform in his school studies—
   a. below average
   b. average
   c. above average

3. Did he/she need any special help at school, and if so what kind of help?

At Present:

1. What school is your child now attending?

2. What Grade and type of class is he/she in?

3. Is he/she having any particular problems at school since the accident?

4. Does he/she receive Learning assistance or speech therapy?

5. Any noticeable changes in behaviour since the accident?

6. Does she/he have any problems relating to his/her friends?

7. Does he/she have any problems remembering?

8. Has your child had any other serious illnesses in the past?
### Picture Naming

**Name:**

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### Medical Data

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A. Cause of Accident

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SENTENCE ORDER TASK

Name:
Date:

1. the door was not closed by him--------------------- L1V1S3
2. The feline perched on the trough.------------------ L1V3S2
3. This box contains some presents------------------- L1V1S1
4. The eggs were bought by mother--------------------- L1V1S2
5. The girl is writing a note------------------------- L1V1S1
6. The milk was not drunk by her---------------------- L1V1S3

Length
L2V1S1-------
L3V1S1-------

Vocabulary
L1V2S1-------
L1V3S1-------

Syntax
L1V1S2-------
L1V1S3-------