FACTORS AFFECTING COGNITIVE FUNCTIONING OF HEMIPLEGIC CHILDREN

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Unilateral cerebral lesions that occur perinatally or in early childhood have been reported to have different effects on cognitive functioning than later acquired lesions. Most notably, persistent aphasias frequently follow left hemisphere damage in adults, but rarely do so in children (Basser 1962; Lenneberg 1967; Woods and Teuber 1973, 1978; Woods and Carey 1979). Such differences have been ascribed to the plasticity of the developing brain, enabling intact cortical regions to take over functions usually localized in the damaged areas. It is clear, however, that there are limitations to this functional plasticity. Early unilateral brain lesions have been shown to depress over-all level of intellectual functioning. Although occasional single cases with high intelligence have been reported (Smith and Sugar 1975), the average IQ of patients with infantile hemiparesis or early hemispherectomy is about 20 points below normal (Perlstein and Hood 1955, St. James-Roberts 1981). Also, the nature of deficits varies with lesion laterality. Certain language functions are more disrupted after early damage to the left hemisphere (Dunsdon 1952, Annett 1973, Dennis and Kohn 1975, Dennis and Whitaker 1976, Rankin *et al.* 1981), whereas certain spatial functions are more impaired after early damage to the right hemisphere (Wood 1955, Wedell 1960, Nielsen 1966, Kohn and Dennis 1974).

The relationship between early brain damage and cognitive functioning can be examined more closely by the use of computerized axial tomography of the brain (CT). Two recent CT studies have found a correlation between lesion location and IQ. Cortical lesions and lesions extending from the surface of the cortex to the lateral ventricle (true porencephaly) were found to be associated with lower intellectual level than were lesions confined to subcortical white matter and basal ganglia (Cohen and Duffner 1981, Kotlarek *et al.* 1981). However, lesion size was not measured in these studies, and it is possible that differences in the average size of the different types of lesions account for the reported IQ differences.

In addition, several studies suggest that depressed cognitive functioning of hemiplegic children may be due to the effects of abnormal electrical activity or seizure-related cerebral anoxia on the developing brain (Byers 1941, Perlstein and Hood 1955). However, Cohen and Duffner (1981) found EEG abnormalities to have little predictive value for intellectual ability in their group of patients with congenital hemiplegia.

The present study was undertaken to answer some of the remaining questions regarding the effects of lesion location,

TABLE I
Summary of patients

Case	*Sex*	*Age at acquisition*	*Aetiology*	*Mean age at testing (SD)*
Left-hemisphere lesion (right hemiplegia)				
L1-19	9M, 10 F	Congenital/perinatal	Mostly uncertain	8 yrs 8 mths (4 yrs)
L20	M	11 mths	Astrocytoma	
L21	M	9 mths	Head trauma	
L22	M	1½ mths	Meningitis	
L23	M	7 mths	Embolic stroke during cardiac catheterization	9 yrs 3 mths (4 yrs 4 mths)
L24	M	2½ yrs	Stroke	
L25	M	9 yrs	Head trauma	
L26	F	6 yrs	Chronic focal encephalitis	
L27	F	11 mths	Sickle-cell disease, stroke	
Right-hemisphere lesion (left hemiplegia)				
R1-R6	4 M, 2 F	Congenital/perinatal	Mostly unknown	7 yrs 8 mths (5 yrs 1 mth)
R7	M	3 yrs	Head trauma	
R8	M	9½ yrs	St. Louis encephalitis with stroke	
R9	M	19 mths	Vasculitis	
R10	M	6 yrs	Sickle-cell disease, stroke	7 yrs 7 mths (2 yrs 9 mths)
R11	M	5 yrs	Moya Moya disease, stroke	
R12	F	5 yrs	Sickle cell disease, stroke	
R13	F	7 mths	Stroke with febrile illness	
R14	M	8 mths	Head trauma	

lesion size, and seizure activity on cognitive functioning of children with hemiplegia of early onset. Our findings are consistent with the hypothesis of considerable functional plasticity of the developing brain, but also indicate significant intellectual deficits related to early unilateral loss of brain tissue.

Method

Neurological examinations, psychological testing, EEG readings and CT-scans were obtained for 41 children seen in the Pediatric Neurology Clinic at Wyler Children's Hospital, University of Chicago, between 1976 and 1984. Table I summarizes some of the characteristics of these patients.

Degree of hemiparesis was assigned a grading of 1 to 3, depending on its severity. In all cases the impairment was more severe in the upper than the lower extremities; all the children were ambulatory, without assistance, but with hemiparetic limp. Hand function was most easily gradable and this was used for assignment of severity of hemiparesis, as follows: grade 1 = able to grasp with thumb-forefinger; grade 2 = able to grasp with whole-hand; grade 3 = unable to grasp.

Each child was assigned an EEG and seizure rank from 0 to 4, with 0 = normal EEG and no recurrent seizures (N = 11); 1 = focal slowing on EEG without epileptic foci and without recurrent seizures (N = 9); 2 = normal EEG or focal slowing and recurrent seizures (N = 4); 3 = unilateral focal spikes on EEG and recurrent seizures (N = 8); 4 = bilateral spikes on EEG and recurrent seizures (N = 9). Thus 21 (51 per cent) of the 41 hemiplegic children in this study had epileptic seizures, which compares closely with previous reports (Perlstein and Hood 1955, Ingram 1964).

The CT scans were used to identify the locus of the lesion and also to estimate its size, which was done in two ways. First, the horizontal extent of the lesion was estimated by selecting the slice on which the lesion was largest, and calculating the ratio of the maximal anterior-posterior extent of the lesion to the anterior-posterior diameter of the slice (maximal diameter ratio). Second, the vertical extent of the lesion was estimated from the number of sections in standard CT plane of 1cm thickness on which the lesion was evident. Based on these two estimates, lesions were assigned to one of four size categories, as follows: 0 = no detectable lesion; 1 = lesions visible in only one or two sections and maximal diameter ratio below 0·2; 2 = lesions visible in three or four sections, and maximal diameter ratio between 0·2 and 0·4; 3 = lesions visible in five or more sections and maximal diameter ratios above 0·4. Two cases that did not fit these limits were classified separately: one was a case in which four sections were involved but with a maximal diameter ratio of only 0·14; this was classified as category 2. The other case had five abnormal sections and maximal diameter ratio of 0·32; this was classified as category 3. Cases in which ventricular enlargment was the only finding were classified according to the number of sections that showed the enlarged portion of the ventricle.

Finally, lesions were classified into one of six grades, based on lesion location, using a method devised by Cohen and Duffner (1981): grade 1 = normal scan; grade 2 = unilateral ventricular enlargement contralateral to the hemiparesis, with preservation of normal ventricular outline, and without shift of structures; grade 3 = unilateral areas of decreased density extending superiorly from the centrum semiovale inferiorly into the basal ganglia (white matter lesions); grade 4 = unilateral areas of decreased density in the periphery of the cortex (gray matter lesions); grade 5 = areas of decreased density extending from the surface of the cerebral hemisphere into the subjacent ventricle (white and gray matter lesions); grade 6 = unilateral small hemisphere with shift of midline structures to that side, with or without increased size of ipsilateral ventricular system.

All the patients were given a psychological test battery including a standardized intelligence test (either the Wechsler Intelligence Scale for Children—Revised (WISC-R) (Wechsler 1974), the Wechsler Preschool and Primary Scale of Intelligence (WPPSI) (Wechsler 1967), the Wechsler Adult Intelligence Scale (WAIS) or the Stanford-Binet, Form L-M (Terman and Merrill 1962), depending on age at testing). The Draw-a-Person Test (Koppitz 1968), the Bender-Gestalt Test of Visuo-Motor Integration (Koppitz 1964), the Peabody Picture Vocabulary Test (Dunn 1965) and the Northwestern Syntax Screening Test (Lee 1969) were also administered.

Results

An exact probability test on the distribution of patients with regard to laterality of lesion and aetiology was marginally significant ($p = 0·085$). There were equal numbers of children with acquired left- and right-hemisphere lesions ($N = 8$), but there were about three times as many with congenital lesions in the left hemisphere ($N = 19$) than in the right ($N = 6$). In addition, a t-test indicated that left-hemisphere lesions tended to be larger than lesions in the right hemisphere ($t = 1·66$, $df = 40$, $p = 0·10$). There was no difference in lesion size between congenital and acquired cases.

Correlational analyses show that both Verbal and Performance IQs decrease with increasing lesion size (Fig. 1)*. Table II gives the correlations of Verbal IQ (VIQ), Performance IQ (PIQ) and Full-scale IQ (FIQ) in relation to lesion size. The correlation of IQ with lesion size is slightly higher when lesion size is estimated from its maximal diameter on CT-scan than when it is estimated from the number of CT slices on which the lesion appears. However, the correlation of the two lesion size measures is extremely high ($r = 0·92$, $df = 33$, $p < 0·001$).

*Two children are omitted from all figures and analyses of Verbal and Performance IQ since they were administered the Stanford-Binet because of their age.

TABLE II
Correlations of lesion size with IQ

	Maximal diameter ratio[1]	*Number of CT slices*[2]	*Lesion size category*[3]
VIQ	r = −0·51 df = 30 p<0·01	r = −0·34 df = 37 p<0·05	r = −0·47 df = 37 p<0·01
PIQ	r = −0·42 df = 30 p<0·02	r = −0·31 df = 37 p<0·05	r = −0·48 df = 37 p<0·01
FSIQ	r = −0·46 df = 32 p<0·02	r = −0·33 df = 39 p<0·05	r = −0·43 df = 39 p<0·01

[1]Used to measure horizontal extent of lesion; [2]used to measure vertical extent of lesion; [3]derived from 1 and 2 (see text).

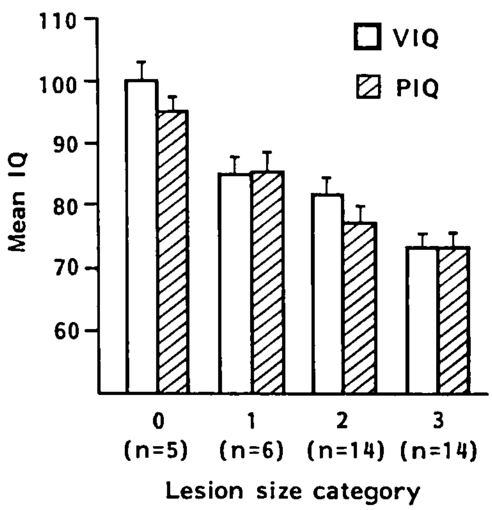

Fig. 1. Mean VIQ and PIQ as function of lesion size.

Further analyses showed that the degree of hemiparesis and EEG grade both increase with increasing lesion size ($r = 0{\cdot}67$, $df = 39$, $p < 0{\cdot}01$; $r = 0{\cdot}36$, $df = 39$, $p < 0{\cdot}05$, respectively) (Figs. 2 and 3). The EEG results suggest that the likelihood of seizures is markedly greater for those with the largest lesions (Fig. 3). In addition, both degree of hemiparesis and EEG grade are related to cognitive functioning. Degree of hemiparesis correlated significantly with VIQ ($r = -0{\cdot}51$, $df = 37$, $p < 0{\cdot}01$), PIQ ($r = -0{\cdot}46$, $df = 37$, $p < 0{\cdot}01$) and FIQ ($r = -0{\cdot}61$, $df = 39$, $p < 0{\cdot}01$) (Fig. 4). EEG grade also correlated significantly with VIQ ($r = -0{\cdot}37$, $df = 37$, $p < 0{\cdot}05$), PIQ ($r = -0{\cdot}40$, $df = 37$, $p < 0{\cdot}05$) and FIQ ($r = -0{\cdot}38$, $df = 39$, $p < 0{\cdot}02$). However, a one-way analysis of variance revealed no significant main effect of EEG grade on VIQ, PIQ or FIQ when lesion size was entered as a covariate.

Because degree of hemiparesis, lesion size and EEG grade correlated with each other, as well as with IQ, the question arose as to which of these factors accounted for more of the variance in IQ. A step-wise linear regression revealed that degree of hemiparesis accounted for significantly more of this variance than either lesion size or EEG grade. Moreover, the use of lesion size or EEG data together with hemiparesis data did not significantly increase the amount of IQ variance accounted for, suggesting that all three factors are similar indices of underlying neurological impairment.

Possible effects of lesion location on IQ were also examined. We compared the IQs of patients with damage to cortical regions to those of patients with damage to cortical and subcortical regions (two patients whose lesions were confined to subcortical regions were not included in this analysis). There were no significant differences in VIQ, PIQ or FIQ. We also compared the IQs of patients with temporal and/or parietal lesions, which are likely to impinge on classic language comprehension areas, to those of all other patients: again, no significant differences were found. Finally, the IQs of patients categorized according to the lesion grades of 1 to 6 (Cohen and Duffner 1981) were examined. In agreement with Cohen and Duffner's report, the IQs of patients with grades 4 to 6 ($N = 15$) were lower than those with grades 1 to 3 ($N = 24$) ($F = 4{\cdot}07$, $df = 1, 38$, $p < 0{\cdot}05$). Degree of hemiparesis was also more severe in patients with lesion grades of 4 to 6 ($F = 14{\cdot}96$, $df = 1, 38$, $p < 0{\cdot}0004$). However, when lesion size was entered as a covariate, these effects disappeared (FIQ: $F = 0{\cdot}14$, NS; degree of hemiparesis: $F = 1{\cdot}65$, NS). Thus the differential effects of type of lesion reported by Cohen and Duffner may be accounted for by differences in the average size of lesions.

Mean VIQ, PIQ and FIQ scores are shown in Figure 5: the scores of all groups are well below the population mean of 100. An analysis of variance was performed with IQ scale score (Verbal, Performance) as a within-subjects factor, lesion laterality (left, right) and aetiology (congenital, acquired) as between-subjects factors, and lesion size as a covariate. No significant main effects or interactions involving lesion laterality or aetiology were found, but lesion size was a significant covariate (F=7·70, df=1, 32, p<0·01).

Possible effects of lesion laterality and aetiology on the various WISC-R subtest scores were also investigated. There were no significant main effects or interactions involving lesion laterality. There were marginally significant main effects of aetiology, such that congenital cases performed better than acquired cases on three WISC-R verbal subtests: Vocabulary (F=4·12, df=1, 31, p<0·06); Information (F=3·64, df=1, 31, p<0·07); and Comprehension (F=2·76, df=1, 31, p<0·11). Lesion size was a significant covariate on all verbal subtests (p<0·03 or better), except Similarities and Digit Span, and was significant or marginally significant on all Performance subtests (p<0·07 or better).

Separate analyses of variance with lesion laterality and aetiology as between-subjects variables and lesion size as a covariate were performed on patients' scores on the Bender-Gestalt Test, the Peabody Picture Vocabulary Test (PPVT), the Northwestern Syntax Screening Test, and the Draw-A-Person Test. Consistent with their below-average IQ levels, all patient groups scored below average on these tests. The only significant effects occurred on the PPVT. There was a main effect of aetiology in that congenital cases performed better than acquired cases (F=5·67, df=1, 27, p<0·025) (mean Peabody IQ of congenital group 90·0; acquired group 72·4). There was also a main effect of lesion side, in that those with left hemiplegia performed significantly better (90·0) than those with right hemiplegia (72·4) (F=6·99, df=1, 27, p<0·02).

Discussion

In agreement with previous studies (*e.g.* Perlstein and Hood 1955, Annett 1973, St. James-Roberts 1981, Cohen and Duffner 1981), we found that unilateral

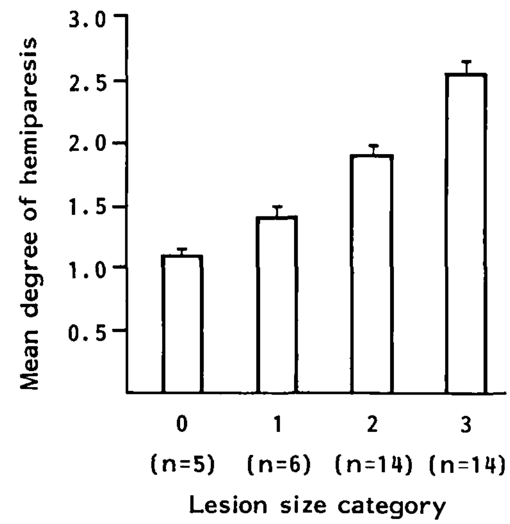

Fig. 2. Mean degree of hemiparesis as function of lesion size.

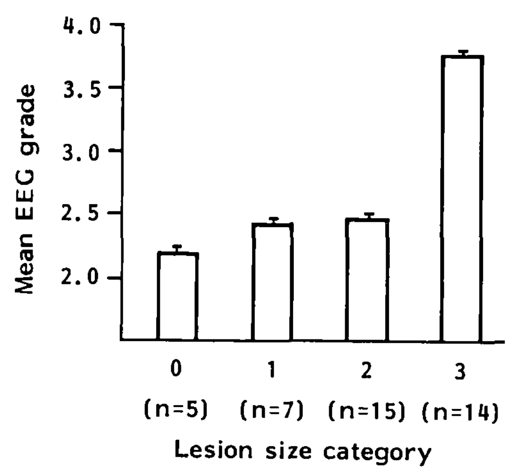

Fig. 3. Mean EEG rank as function of lesion size.

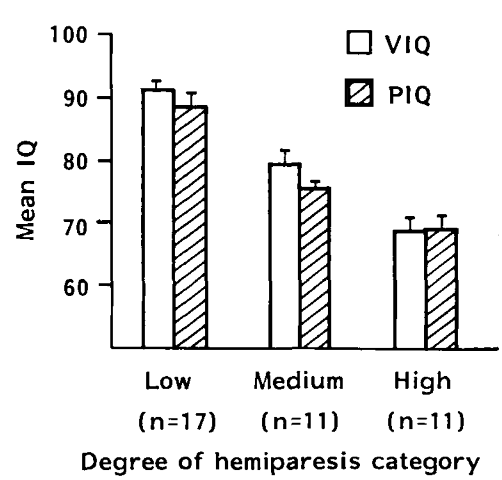

Fig. 4. Mean VIQ and PIQ as function of degree of hemiparesis.

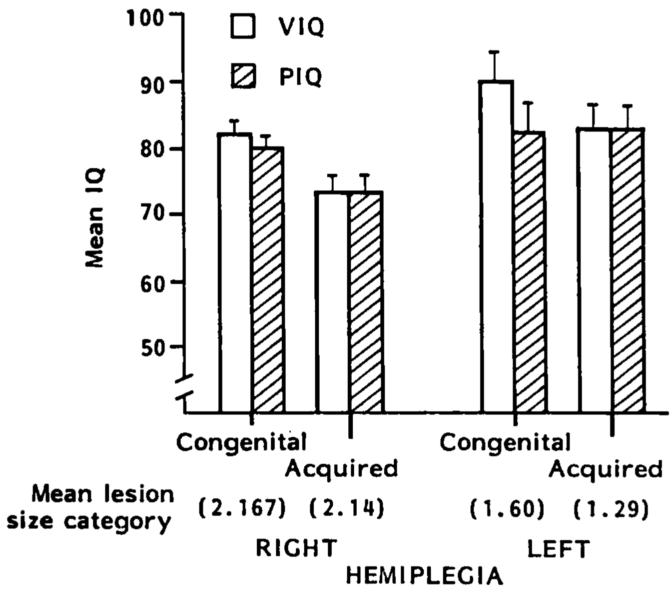

Fig. 5. Mean VIQ and PIQ of children with right hemiplegia and left hemiplegia with congenital and acquired lesions. Note that lesion size is greater with right than left hemiplegia and with congenital than acquired lesions.

cerebral lesions in infancy or early childhood resulting in hemiparesis are associated with a significant decrease in IQ. Teuber and Rudel (1962) have suggested that certain tasks show functional plasticity after early brain-damage, while others do not. Tasks that do show plasticity are characterized as those on which adult brain-damaged patients show deficits after damage to specific areas. In contrast, tasks for which no functional plasticity is evident are characterized as those on which adult patients show deficits that are not area-specific. On such tasks, children with more severe (and perhaps larger) lesions are more impaired, and this may apply to many of the tasks included on IQ tests.

The magnitude of IQ depression in children with early unilateral lesions is considerable. Mean IQ in the largest lesion category was 20 to 30 points below the norm. Consistent with previous reports, 49 per cent of our sample obtained FIQ scores above 80 as compared to 51 per cent in the study by Cohen and Duffner (1981) and 90 per cent of normal children (Sattler 1974). The FIQ standard deviation of our sample is 17·8 (variance 316·8) compared to a standard deviation of 15 (variance 225) for the normal population. These variances differ significantly ($F=1\cdot41$, $df=40, \infty$, $p<0\cdot05$). Lesion size (as measured by maximal diameter ratio) was found to account for 21·2 per cent of the between-subject variance in IQ. Removing this percentage from the variance of our sample, the remaining variance no longer differs significantly from the normal population. In fact, after the variance due to lesion size is removed the standard deviation of our sample is 15·8, which is extremely close to that for the normal population. Lesion size therefore appears to account for all of the IQ variation in our sample, aside from the normal population variation related to genetic endowment, education and other environmental factors.

Our findings suggest that left-hemisphere lesions tend to be larger than those in the right hemisphere. This may explain the small over-all IQ advantage of left-hemiplegic children in the present study, as well as in previous studies which did not have access to information on lesion size (Perlstein and Hood 1954, Annett 1973). Our findings also suggest that the left hemisphere is more susceptible than the right to congenital lesions. Perlstein and Hood (1954) suggest that this may be attributable to the higher percentage of babies born with left occiput anterior. Metabolic differences between the left and right hemispheres may also be a factor (Levy, personal communication).

The classification of lesions into different types, as proposed by Cohen and Duffner (1981) and by Kotlarek *et al.* (1981), did not have predictive value for IQ, EEG or degree of hemiparesis that was not accounted for by differences in lesion size. The association of some lesion types with low IQ, in particular grades 4 to 6 of Cohen and Duffner, appears to be due to the fact that such lesions are on average larger than are those in grades 1 to 3. Thus, with respect to IQ level, the immature cerebral cortex appears to have equipotentiality, as proposed many years ago by Lashley (1929).

Significant effects of size of unilateral lesions on cognitive functioning are supported by previous studies of both children and adults. In particular, Woods and Carey (1979) reported no deficits in language production or comprehension in children with partial perinatal damage to the left hemisphere, whereas Dennis and Kohn (1975) report significantly impaired syntactic comprehension in patients with more severe left hemisphere lesions and subsequent hemispherectomy. Similar effects of the extent of lesions have been reported in adults. For example Kertesz *et al.* (1979) found that the degree and speed of recovery of language functions in adults with aphasia was correlated with lesion size.

No significant effect on IQ of EEG abnormalities or of seizures was found in our patients when lesion size was entered as a covariate. Very frequent intractable seizures occurred in only one of our patients. Our data and those of Cohen and Duffner (1981) suggest that seizures are rarely a factor in the depressed IQ of hemiplegic children. The early reports of such an association (Byers 1941, Perlstein and Hood 1955) are limited by the fact that possible correlations between seizures and lesion size were not considered.

The highly significant correlation between lesion size and degree of hemiparesis may be attributable to the increased probability of more severe motor area involvement with larger lesion size. Alternatively, it may indicate that motor functions in childhood are subserved by more widespread areas than in adulthood. Some suggestive evidence supports this latter possibility, in that the only identifiable lesion in three of the hemiparetic patients appeared to be confined to the parietal lobe and in two to the temporal and parietal lobes. It should also be noted that degree of hemiparesis correlated just as highly with VIQ as with PIQ, suggesting that it is an index of general neurological impairment rather than simply motor impairment.

The finding that left and right brain-damage had similar effects on Verbal and Performance IQ is consistent with most previous studies (Annett 1975, St. James-Roberts 1981; but see Kershner and King 1974) and suggests that IQ tests are relatively insensitive measures of the specific deficits associated with lesion laterality. Studies comparing early right *vs.* left hemisphere lesions clearly show that there are limits to equipotentiality. For example patients with early left hemispherectomy are differentially impaired in the understanding of passive sentences ('the girl is pushed by the boy') (Dennis and Kohn 1975, Dennis and Whitaker 1976). In contrast, those with early right hemispherectomy (Kohn and Dennis 1974) are differentially impaired on those visuospatial abilities that normally develop after age 10. Earlier-developing visuospatial abilities showed no effects of lesion laterality. In the present study, children with left hemisphere lesions had a more restricted receptive vocabulary than those with right hemisphere lesions. However, the latter group did not perform more poorly on any of the tests of visuo-spatial ability. In view of the Kohn and Dennis findings that patients with right hemispherectomy only show differential deficits on spatial tasks that are beyond the 10-year level, the absence of differential visuospatial deficits in our group with left hemiplegia may be attributable to their relatively young age (mean 8 years 4 months).

There is some indication from our data, as well as from other studies (Woods and Carey 1979), that the effects of cerebral lesions on language functions depend on the age at which the lesion is acquired, even during childhood. Our children with acquired lesions performed significantly worse than those with congenital lesions on several WISC-R verbal subtests, as well as on the Peabody Picture Vocabulary

Test. Similarly, Annett (1973) and Woods and Carey (1979) reported a higher incidence of language difficulties among children with lesion onset after age one than during the first year of life.

In contrast to our findings for a variety of language tasks, effects of lesion aetiology (congenital/acquired) on visuospatial ability, as assessed by the Performance subtests of the WISC-R and the Bender-Gestalt, were not significant. Considered together, these results suggest that the time-course of functional plasticity may be somewhat different for verbal and spatial abilities. For verbal abilities it appears to be less harmful if the lesion occurs during the first year of life, whereas for spatial abilties the timing of the lesion during the infancy-childhood period seems to be less important (Woods 1980).

The present study suggests that functional plasticity following early, unilateral brain damage has certain limitations. First, the larger the lesion size the greater the depression of over-all intellectual functioning. Second, specific deficits are superimposed on this lower intellectual functioning, and the nature of these deficits depends on lesion laterality. Finally, functional plasticity during development is not an all-or-none phenomenon, and the time-course of plasticity may differ for verbal and spatial tasks. Delineating the factors that affect intellectual functioning following early brain damage, and the extent to which particular functions are spared or impaired, may contribute to our understanding of developmental changes in brain-behavior relations.

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SUMMARY
The results of psychological testing, EEGs and CT scans were examined for 41 children with congenital or early acquired hemiplegia. On average, IQ was depressed and the magnitude of this depression was highly correlated with lesion size, degree of hemiparesis and EEG abnormality, but not with location of lesion. There were no significant effects of lesion laterality on Verbal *vs.* Performance IQ on Wechsler tests. However, receptive vocabulary, as measured by the Peabody Picture Vocabulary Test, was differentially depressed by left-hemisphere damage. Further, on a variety of verbal tasks, patients with congenital lesions performed better than those with acquired lesions. In contrast, no significant differences were found between the two groups on spatial tasks.

RÉSUMÉ
Facteurs altérant les fonctions cognitives chez les enfants hémiplégiques
Les résultats de tests psychologiques, EEG et scanners ont été analysés chez 41 enfants présentant une hémiplégie congénitale ou acquise précocément. En moyenne, le QI était abaissé et l'importance de la baisse était hautement corrélée avec l'étendue de la lésion, le degré d'hémiparésie et les anomalies EEG mais non avec la localisation des lésions. Il n'y avait pas d'effets significatifs de la latéralité de la lésion sur le rapport QI verbal sur QI de performance aux tests de Wechsler. Cependant, la compréhension de vocabulaire mesurée par le Peabody Picture Vocabulary Test présentait une baisse plus importante en cas d'atteinte de l'hémisphére gauche. Par ailleurs, au cours de tâches verbales variées, les patients atteints de lésions congénitales avaient de meilleurs résultats que ceux qui présentaient des lésions acquises. En revanche, aucune différence significative entre les deux groupes n'a été notée pour les tâches spatiales.

ZUSAMMENFASSUNG
Faktoren, die die kognitiven Funktionen bei Kindern mit Hemiplegie beeinflussen
Die Ergebnisse von psychologischen Tests, EEGs und CT Scans von 41 Kindern mit angeborener oder früh erworbener Hemiplegie wurden ausgewertet. Im Allgemeinen war der IQ unterdurchschnittlich und in den meisten Fällen bestand eine hohe Korrelation zwischen dieser IQ-Erniedrigung und der Größe der Läsion, dem Grad der Hemiparese und den EEG-Veränderungen, jedoch nicht mit der Lokalisation der Läsion. Die Seite der Läsion hatte keinen signifikanten Einfluß auf den verbalen vs. praktischen IQ beim Wechsler

Testverfahren. Das rezeptive Vokabular jedoch, das mit dem Peabody Picture Vocabulary Test bestimmt wurde, war bei Läsionen in der linken Hemisphäre unterschiedlich stark beeinträchtigt. Außerdem haben Patienten mit angeborenen Läsionen bei verschiedenen verbalen Testaufgaben besser abgeschnitten als die mit erworbenen Läsionen. Dagegen fanden sich keine signifikanten Unterschiede zwischen den beiden Gruppen bei den Aufgaben zur räumlichen Wahrnemung.

RESUMEN

Factores afectando las funciones cognitivas en niños hemiplégicos

Se examinaron los resultados de tests psicológicos, EEG y TAC aplicados a 41 niños con hemiplegia congénita o precozmente adquirida. Como promedio, CI estaba disminuído y la magnitud de esta disminución estaba altamente ralacionada con la dimensión de la lesión, el grado de hemiparálisis y la anormalidad en el EEG, pero no con la localización de la lesión. No habían efectos significativos de la lateralidad de la lesión sobre el lenguaje frente al CI manipulativo del test de Wechsler. Sin embargo el vocabulario receptivo, medido por el 'Test Peabody de vocabulario con dibujos' presentaba una depresión diferente en las lesiones del hemisferio izquierdo. Además, en una variedad de tareas verbales los pacientes con lesiones congénitas las realizaban mejor que los que tenían una lesión adquirida. En contraste con esto no se hallaron variaciones significativas entre los dos grupos en las tareas espaciales.

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Developmental Medicine and Child Neurology, 1987, 29, 27–35