THE NEUROPSYCHOLOGICAL AND BEHAVIOURAL SEQUELAE OF CHILDREN WITH MYELOMENINGOCELE AND HYDROCEPHALUS

by

Martina O'Connor
B.A., University College Dublin, 1983
M.A., University College Dublin, 1984

A DISSERTATION SUBMITTED IN PARTIAL
FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF DOCTOR OF PHILOSOPHY
in the Department
of
Psychology

We accept this thesis as conforming
to the required standard

Michael Joschko, Ph.D

Otfried Spreen, Ph.D.

Bram Goldwater, Ph.D.

John Hayward, Ph.D.

Honoré France, Ph.D.

Joyce Shaffer, Ph.D

University of Victoria

1989

Supervisor: Dr. Michael Joschko

ABSTRACT

Thirty-six myelomeningocele children with hydrocephalus (between 9-16 years of age) were evaluated on a battery of neuropsychological tests and behavioural measures. The children obtained a FSIQ on the WISC-R of grater than 60 and all were attending school on a regular basis.

Results showed that the myelomeningocele children, as a group, performed as well as the normative sample on measures of auditory comprehension, fine motor speed, accuracy on a visuomotor speeded task, stereognosis, and single-word reading.

Although there was substantial variability within the myelomeningocele sample in terms of level of cognitive performance, as a group, with the exception of the above mentioned measures, they performed below the level expected for their age on the remaining measures in the neuropsychological test battery (83.63% of tests administered).

The mean composite scores on the WISC-R (FSIQ, VIQ, and PIQ) fell within the low average range of psychometric intelligence (IQ 80-89).

In general, the children exhibited significant difficulty on many tests. The measures that presented the most difficultly were: 1) those requiring perceptual-motor skill and processing speed, 2) those requiring attention, and 3) those involving learning and memory of verbal and visually presented material. Poor performance on a measure of computational mathematics as well as a measure of verbal fluency (reflecting word-finding difficulties) were also characteristic of this

group. These results were compared with findings obtained from studies of other groups of brain-injured children.

Information obtained from the behavioural measures showed delayed achievement in social competence skills, (e.g., interpersonal skills), daily living skills, as well as a tendency to be inattentive and exhibit more internalizing type of behaviours (e.g. social withdrawal). These findings are not surprising in light of the neuropsychological deficits in this sample. The myelomeningocele children as a group did not exhibit a negative self-concept.

Variations in outcome appeared to be related to both medical and social-environmental influences. Results showed that the degree of neuropsychological and adaptive impairment was related to a number of factors: the level of lesion, a history of ocular abnormalities and/or intrauterine hydrocephalus. That is, the pattern of neuropsychological impairments was similar for the myelomeningocele children as a group, but the degree of impairment appeared to be related, in parts to medical factors. Although there was a general lowering of level of neuropsychological test performance with a history of complications, the effect was more pronounced for the above mentioned variables.

With regard to socioeconomic status, results showed that in general children from families with more education and income were doing better in terms of cognitive abilities and daily living skills. Children from the lower socio-economic group exhibited significant impairment on measures of verbal ability.

Finally, the results of this research indicate that future investigations of learning and behaviour subsequent to myelomeningocele would seem to demand an appreciation for multifactorial models of development.

Examiners:

Michael Joschko, Ph.D.

Otfried Spreen, Ph.D.

Bram Goldwater, Ph.D.

John Hayward, Ph.D.

Honore' France, Ph.D.

Joyce Shaffer, Ph.D

ACKNOWLEDGEMENTS

This research was made possible through the cooperation of the staff of the Izaak Walton Killam Hospital for Children, Halifax, Nova Scotia, Canada. I am indebted to them for providing me with enthusiasm, support, encouragement and assistance in carrying out this project.

I would also especially like to thank the children and their families who participated in this study and who taught me so much.

Many thanks to my supervisor, Dr. Michael Joschko, and my committee members for their guidance and encouragement throughout my research.

Special thanks to John and Donna Rees for their hospitality and moral support. I am especially indebted to Laura Rees for her emotional support, patience, and editorial comments through the final stages of this research.

Finally, many thanks to my parents, Brid and James O'Connor as well as my sisters, Siobhan, Aine, Fiona and Ciara, for their continual support and encouragement throughout my graduate studies.

DEDICATION

To My Parents:

Do m'athair agus mo mháthair, ba mhaith liom míle buíochas a gabhail libh beirt, as ocht a mhuimín asam agus as ocht chuile rud a rinne sibh dom í rith mo shaol go nuighe seo.

Slán go raibh sibh í gconai.

Le Grá,

Martina

CONTENTS

TABLES

FIGURES

CHAPTER 1

INTRODUCTION

The term 'Spina Bifida' covers a group of congenital malformations of the central nervous system (CNS). It results from a defect in neurulation (i.e., development of the neural tube during fetal development) that causes a combination of malformations of the vertebral column and the neuraxis (commonly known as the brain and spinal cord). The symptoms of the disease depend to a large extent on the degree of deformity of the neuraxis. In order to better understand how spina bifida develops, a brief review of neural tube formation and closure is given below.

The human embryo becomes implanted in the uterine wall after the ovum is fertilized by a sperm. At this early stage of development (approximately seven days after conception) the embryo is composed of two layers of tissue, the overlying (i.e., dorsal) ectoderm and the endoderm. At approximately nine days of gestation, a third layer of tissue, the mesoderm, migrates into a medial position between the original layers of tissue. This migratory process is called gastrulation and is critically important to neural development because it is essential to neural induction, that is, to initiating the formation of the neural system. Thus, the process of neurulation is initiated. Neurulation describes the early differentiation of embryonic tissue toward the formation of a closed cylinder of cells called the neural tube. The neural tube eventually differentiates to form the central nervous system (i.e., spinal cord and brain).

Neural tube development can be divided into three phases: neurulation, canalization, and retrogressive differentiation. The first phase, neurulation, applies to closure of the rostral portion of the neural tube which occurs between the 17-25th day of gestation. Phase two, canalization, and phase three, retrogressive differentiation pertain to closure of the caudal neural tube (27th to 59th gestation day).

During phase one, the nervous system is separated from the amniotic space. The first indication of the development of the nervous system is the neuroectoderm comprising the neural plate, which appears in the dorsal midline of the embryo by the 16th day of development. By the 18th day, the neural plate changes into a neural groove with a neural fold along each side; by the end of the third week the neural folds have begun to fuse with one another, thereby converting the neural groove into a neural tube. Fusion of the neural tube begins in the rostral region and proceeds mainly in a caudal direction, with the rostral and caudal neuropores (openings at each end of the neural tube) closing at approximately the 24th and 26th days, respectively. Errors in development during phase one can result in severe anomalies including cranioriachischis, anencephaly, and myelomeningocele (one form of spina bifida).

The second and third phase of neural tube development involve development of the low lumbar, sacral, and coccygeal segment of the spinal cord. During canalization, undifferentiated cells near the end of the neural tube form ependymal cells around vacuoles. These cells then make contact with the centre of the neural tube, resulting in elongation of the caudal neural tube. Retrogressive differentiation is involved with the formation of the filum terminale (end of spinal cord) and ventriculum terminalis. This is accomplished through the repression of some structures formed during canalization.

After the third phase of neural tube development is completed, the neural tube ultimately sinks below the surface of the embryo, as the mesodermal elements begin to proliferate and interpose themselves between the tube and the ectoderm. The vertebra column of the spinal cord develops from this mesodermal tissue, and the vertebral arches normally close from the first cervical to the third or fourth sacral segments by the time the embryo reaches 11 weeks gestation.

THE MAJOR CATEGORIES OF SPINA BIFIDA

There are several ways to classify Spina Bifida (SB), but the most widely used classification system divides this condition into two main subtypes: (1) Spina Bifida Occulta and (2) Spina Bifida Cystica (Smith, 1965).

Spina Bifida Occulta indicates a condition in which the vertebral arches fail to close. It is, however, virtually never associated with spinal cord abnormality (McLone, 1980). With the exception of a slight swelling or a tuft of hair at the site of the spinal defect, there is frequently no other external evidence of the defect. The incidence of spina bifida occulta in the general population is usually estimated to be about 10%, and according to Stark (1977) this condition rarely has any consequence for the everyday functioning of the child.

The diagnosis of Spina Bifida Cystica (SBC) indicates some type of protrusion from an area of the spinal cord into a cyst filled with cerebrospinal fluid (CSF). Thus, it is a condition in which a vertebral defect combines with a cystic lesion on the back. There are two subtypes of this condition: meningocele and myelomeningocele (also less frequently called meningomyelocele). Of the two varieties, meningocele is the less serious and less common type, affecting between 15 to 25% of all children born with SB (Laurence & Tew, 1971). In this condition, although the meninges are herniated through the spinal column defect, the neural tissue of the spinal cord is not involved. Although the lesion requires surgical repair, it appears that there is no significant degree of impairment (Laurence & Tew, 1971) associated with this deficit.

In contrast, myelomeningocele is much more severe in its effect. In addition to the meninges, the neural tissue of the spinal cord is also herniated through the defect. This protrusion of spinal cord tissue frequently produces permanent and irreversible neurological disability (e.g., paralysis and loss of sensation of the extremities). The clinical picture depends on the location of the spinal cord defect.

Myelomeningocele occurs most frequently, in 80 to 90% of the cases, in the lumbo-sacral region. If the defect is located in the sacral region, bladder and bowel functioning may only be affected. Paraplegia and sensory loss usually follow if the defect is located in the lumbar and lower dorsal regions. In rare instances, the defect occurs in the upper dorsal or cervical region and produces paralysis and sensory loss in all functions below that level. Major spinal deformities such as kyphosis and scoliosis may also be present. Finally, encephalomyelocele may occur.

There is also evidence to suggest that myelomeningocele is frequently accompanied by gross malformations of the cerebral hemispheres, such as microgyria (Ingram & Scott, 1943). Various other CNS anomalies have frequently been associated with myelomeningocele, such as hydrocephalus and the Arnold-Chiari malformation.

Hydrocephalus describes a condition in which there is an excessive accumulation of cerebro-spinal fluid (CSF) within the head due to disturbance of its secretion, flow and/or absorption. It has been observed to occur in 80% of cases of spina bifida (Smith, 1965; Swinyard, Chaube & Nishimura, 1978). In Lorber's (1972) series, the incidence of hydrocephalus was 89% for thoraco-lumbar and lumbo-sacral spina bifida cystica and 96% if the patients also had accompanying paraplegia. Stenosis (incomplete blockage) of the cerebral aqueduct is the most common site of obstruction of the CSF flow. Another type of obstruction is associated with the Arnold-Chiari malformation, which represents a defect characterized by malformation of the brainstem and cerebellum that herniate through the foramen magnum blocking the fourth ventricle (Menkes, 1974). This malformation is an exceedingly common, if not consistent, feature in infants with lumbo-sacral myelomeningocele (Ingram & Scott, 1943). It has been suggested that the Arnold-Chiari malformation is due to traction resulting from the myelomeningocele anchoring the lower end of the spinal cord (Malamud, 1964). To date, there is no alternative explanation for this syndrome.

ETIOLOGY AND INCIDENCE OF SPINA BIFIDA

The exact cause of Spina Bifida is unknown. A number of theories have been advanced and will be discussed below. Based on findings of family and epidemiological studies, the neural tube defects are felt to be related etiologically to multifactorial causes. That is, a combination of environmental and genetic influences, each with perhaps only a small effect when looked at alone, are thought to contribute as a whole to the etiology of spina bifida. Epidemiological factors (both genetic and environmental) will be discussed first, followed by a discussion of embryological factors.

The incidence of spina bifida varies greatly depending on such diverse factors as geographic location, ethnic background, sex, year, season of birth, maternal age and parity, as well as socioeconomic status.

First, variation is reported according to geographic region. The reported incidence of neural tube defects ranges from 0.5 per 1,000 live births in a black population in Los Angeles between 1973 and 1977 (Strassburg, Greenland, & Portigal, 1983), through 4 per 1,000 births in Ireland (Elwood, 1976), and 5.1 per 1,000 births in a white population in West Scotland in 1976 (Ferguson-Smith, 1983), to 14.2/1,000 in a group of offspring in consanguineous marriages in Alexandria, Egypt (Carter, 1974). There is an East-to-West gradient in the United States and Canada, with the highest prevalence rate in the East (Hewitt, 1963). The highest rates in general are found in the United Kingdom. However, there is significant variation within similar regions in the United Kingdom. For example, Rogers (1969) reported a 2.5 fold difference between the Southeast (the London area), where the prevalence is low, and the West (South Wales) and

Northwest, where it is high. Of considerable epidemiological interest is the fact that spina bifida is very rare in Japan, occurring at the rate of .2 per 1,000 live births. Worldwide, there is a slight sex difference, with a preponderance of females being affected, at a ratio of 1:1.3.

The number of either monozygotic or dizygotic twins with spina bifida has been so small, that twin studies have not been helpful in defining the role of genetic transmission in spina bifida. Record and McKeown (1951) examined 69 pairs of monozygotic and dizygotic twins and found a risk to the co-twin of about 11 percent. Hence, neural tube defects are to some degree genetically determined (Elwood & Elwood, 1980). However, the lack of concordance in both identical and fraternal twins suggests subtle environmental influences.

In studies of families, Carter (1974) noted that the proportion of siblings affected is approximately 5%. This rate is no greater in the sibling born immediately after the affected child, than in those separated from the affected sibling by other normal births (Lorber, 1965). This is approximately ten times the incidence of the malformation in the general population (Carter, 1974). Carter also reported that the incidence in the offspring of affected parents is approximately 3%, and is equal for both male and female survivors. Among cousins, the children of the mother's sisters appear to be affected twice more often than in the general population.

Environmental factors that may play a part in the etiology of spina bifida need to be teased out of the following findings. As mentioned previously, seasonal variations have been reported. Some studies of spina bifida have shown an increased incidence among births in the winter months (especially February) compared with births during the summer months, the relative increase being about one-third (Renwick, 1972).

Socioeconomic class also shows a strong association with risk of spina bifida, with the lowest class having the highest incidence and recurrence rates. In data from Scotland, Edward's (1958) found that there is a twofold difference for spina bifida in offspring of wives of men in professional and managerial occupations (0.17) as compared with wives of unskilled workers (0.31). However, the interpretation of these data is difficult and must remain speculative. Naggan and MacMahon (1967) have not noted this social gradient in an investigation of Jewish families from various backgrounds. Hence, socioeconomic class differences that have been noted may reflect genetic differences, but may also reflect differences in nutrition or exposure to infection.

The effects of maternal age and parity on the etiology of SB are difficult to disentangle. When maternal age and birth order have been examined, most studies show peaks in incidence in children born to young mothers (less than 20 years of age), and in those born to mothers older than 35 (Janerich, 1973). There is also a U-shaped distribution curve for these factors, with an excess of cases in first births, and possibly also an excess in birth orders of five or more (Janerich, 1973).

Several theories have attempted to define the pathophysiology of spina bifida as deviant embryologic development. The most widely accepted theory on the pathogenesis of spina bifida attributes the lesions to failure of closure of the neural tube, specifically focusing on the disturbance of the ectodermal tissue. Many theories have been proposed to explain this mechanism of failure and include such diverse views as:

a primary developmental lesion (von Recklinghausen, 1886); adhesions between the amnion and the edges of the neural groove (Padget, 1970) and; as a result of an overgrowth of neuroectodermal tissue near the defect. Other investigators, such as Hall and his associates (Hall, Kenna & Pupkin, 1986) and Martin and his colleagues (Martin, Fineman & Jorde, 1983) have postulated that the process is not homogeneous and that lesions above the lumbar level are due to faulty neurulation, whereas those at or below the lumbar level are secondary to problems with canalization.

Most theories on the pathogenesis of spina bifida ignore the disturbances of mesodermal tissue, considering them secondary to lesions of the neural tube. Considering the features common to the various lesions of spina bifida, the most universal trait appears to be a lack of coordination involving either one or both of the tissue layers (i.e, ecto-dermal or mesodermal tissues). There is evidence to suggest that retardation of mesodermal and neuroectodermal growth may be associated with either retardation or acceleration of neuroectodermal growth. To what degree one disturbance depends on the other, or is induced by the other, cannot be decided on the basis of available evidence (Barson, 1970).

Many agents, both chemical and infectious, have been suggested as possible causes of neural tube defects in humans. Those chemical agents that are known to affect neurulation are: 1) aminopterin (Milunsky, Graef & Grayner, 1968); 2) LSD (Jacobsen & Berlin, 1972); 3) thalidomide (Taussig, 1962); trimethadione (Nichols, 1973); and 4) valporic acid (Robert & Guibaud, 1982). Spina Bifida has been noted more commonly than expected in conjunction with maternal diabetes (Soler, Walsh & Malins, 1976); after a maternal episode of hyperthermia resulting from illness or hot tub bathing during the first month of pregnancy (Chance & Smith, 1978); hormonal and ovulatory changes (Layde, Edmonds & Erickson, 1980); and in association with both Trisomy 18 (Passarge, Tru & Sueoka, 1966) and triploidy (Creary & Alberman, 1976). In addition, there appears to be an increased incidence of neural tube defects in families in which there have been other birth defects, such as cleft palate, extrophy of the bladder, diaphragmatic hernia, and tracheoesophageal fistula (Fraser, Czeizel & Hanson, 1982). One interesting and unaccepted theory, suggested that spina bifida may result from exposure to the teratogenic blight found in potatoes (Renwick, 1972). Dietary factors have been examined, most recei. with a focus on vitamin intake. For example, Smithells and his associates (Smithells, Shepard, Schorah, 1976) found that postnatal levels of serum vitamin C and red blood cell folate were found to be lower in women who had spina bifida children. On the basis of a later study (Smithells et al., 1983), these investigators suggested that diet counselling and diet supplementation may reduce the risk of recurrence of defects in families with an affected child.

In summary, there is still much to be learned about the etiology of this group of disorders, including how large a part is played by genetic factors and what environmental factors are relevant.

NEUROPATHOLOGY ASSOCIATED WITH SPINA BIFIDA AND HYDROCEPHALUS

As mentioned earlier, as a result of the abnormal fusion of the posterior aspect of the developing neural tube, there is a disturbance in the normal relationship between the spinal cord segments and the vertebrae (i.e., herniation of spinal cord and its membranes into a cyst filled with cerebrospinal fluid (CSF).

Human cortical biopsies and necropsy material have been examined using myelin stains. Detailed histology of the neural plaque displays a gross disorganization of the white matter (long myelinated fibers). More specifically, although short internuncial tracts exist, the longer tracts are frequently not recognizable (Emery & Naik, 1968). The disorganized development appears to prevent afferent and efferent long tracts from developing between the plaque and the normal spinal segments. These findings highlight the strong likelihood of an upper motor neuron lesion developing downwards from the lesioned segment involved in the plaque. Furthermore, it has been shown that when the spinal cord above the level of the lesion is examined with myelin stains, the posterior columns are strikingly narrowed, reflecting again the failure of development of these long conducting tracts throughout the plaque.

Hydrocephalus is believed to occur in about 80% of children with myelomeningocele (Lorber & Salfield, 1981). Menelaus (1980) estimated that approximately 25% of SB children are found to have hydrocephalus at birth, while 77% of those that develop hydrocephalus, show this by the first month of age.

As outlined earlier, hydrocephalus in its broadest sense, means an increased amount of fluid in the cerebral ventricles. A disturbance in circulation of cerebro-spinal fluid (CSF), results from a disproportion or a disequilibrium between the rates of production and absorption.

Bell and her colleagues (Bell, Gordon & Maloney, 1980) examined twenty-one fetuses with spina bifida between 14-23 weeks gestation for the presence of hydrocephalus and Arnold-Chairi malformation. They noted that the amount of neural tissue at the site of the lesion was very variable. Open and closed lesions at all levels of the cord were seen. Hydrocephalic brains (found in eleven fetuses) showed depression of the tentorium, abnormalities in the corpus callosum and the absence of the lateral fissure. In addition, these authors noted that the higher and more extensive the lesion, the more likely it was to be accompanied by brain abnormalities (i.e., microgyria, hypoplasia of cerebellum and thalamic fusion). They noted that while Spina Bifida, Hydrocephalus and Arnold-Chiari malformation can occur independently of each other, they were more frequently found together.

Confirming earlier reports, Lorber (1981) reported that while the skull circumference may not be abnormally increased in the newborn with SB, dilation of the ventricles is usually found in all cases. A number of studies have found that dilation of the lateral ventricles may result in thinning of the cortex, primarily of the vertex, the occipital pole and the frontal pole (Emery & Svitok, 1968; Epstein, Maidich, Kricheff & Ransohoff, 1977). It has been suggested that these dilations may result not only in stretching the components of the limbic lobe, but also in the stretching of the long fronto-parietal association fibers of the hemispheres. In addition, it has been noted that there may be dilation of the third ventricle, thinning of the corpus callosum, as well as delayed myelination of the callosal fibers (Gadsdon, Variend & Emery, 1979; Milhorat, 1972).

The enlargement of the cranial vault frequently follows ventricular dilation and raised intracranial pressure. Particularly striking may be the distension and protrusion of the frontal lobes which often produces some flattening of the orbital roof.

In general, abnormal distension of the hemispheres in hydrocephalus causes an abnormal rate of increase in hemispheric surface, while the growth in cortical surface may be normal. Consequently, a much greater portion of the intrasulcal cortex is exposed, resulting in redundant gyration, particularly during the first two years of life when the growing cortex can still adapt to the abnormal distension in hemispheric surface. The cortical surface of the normal newborn approximates 700 cm, which is about 43% of the adult value; the latter is reached by the second year of life. The postnatal growth in cortical surface normally occurs in proportion to the growth in hemispheric surface, so that approximately 66% of the newborn cortex and 65 to 67% of the adult cortex are intrasulcal.

If the hydrocephalus remains untreated, the chronic distension of the cerebral hemispheres inevitably induces tissue damage and hemispheric atrophy. Several mechanisms may be involved in producing degenerative changes in the white matter: 1) stretching and tearing of nerve fibers affect long tracts in particular; preferential displacement and stretching of the upper portion of the internal capsule by the bulging ventricles explains the paraplegia and spasticity of hydrocephalic patients (Yakovlev, 1947); 2) An increased diffusion of CSF into the periventricular white matter causes chronic edema and local damage to nerves (Weller, Wisniewski, Shulman & Terry, 1969); 3) Edema of the periventricular white matter may be locally superimposed by the mechanical stress of rounding, stretching and flattening of the ventricular corners.

Early shunting is of utmost importance for the prevention of secondary tissue damage. Postmortem examinations of children with long standing decompression by shunting show that the hemispheres restituted to near normal, with some evidence of residual damage; the corpus callosum may be thin, and there may be cortical atrophy and widening of the sulci; displacement of the internal capsule; and the leptomeninges may be thickened and gelatinous, apparently serving as a space-filling tissue (Emery, 1965; Emery & Svitok, 1968; Gadsdon, et al., 1978; Rubin, Hochwald & Liwnicz, 1972).

In general, there is evidence to suggest that this pathological process affects white matte (long myelinated fibers) more than grey matter (nerve cells and short unmyelinated fibers) (Blackwood, McMenemry, Meyer, Norman & Russell, 1963; Rubin et al., 1972). According to Gur and his associates (Gur, Parker, Hungerbuhler, Reivich, Amarnek & Sackheim, 1979) the ratio of white matter to grey matter is greater in the right than in the left hemisphere.

Neural tube defects and hydrocephalus have been produced by teratogens in a variety of experimental infrahumans; namely rodents, utilizing tryan blue (e.g. Lendon, 1968); rabbits (Page, 1975); chicks (Rokos, 1979); and cats (Donauer, Wussow & Rascher, 1988). Such investigations provide a wealth of information.

Michejda and McCollough (1987) produced spina bifida in rhesus monkeys by treating the pregnant females with an anticonvulsant drug, valproic acid, during the early stages of gestation which coincides with the critical period of neural tube fusion. It was found that both the dosage and timing of VPA administration were crucial in the development of lesions which are similar to human spina bifida. The neonate monkeys were evaluated on measures of cognitive, somatosensory and motor functions especially adapted for the monkey. Results indicated extensive neurological deficits; motor function and somatosensory reflexes in both limbs were impaired; had poor coordination and both limbs exhibited moderate spastic paraplegia. Autopsy results revealed mild ventricular dilation and Arnold-Chiari type malformation, with malformations of the cerebellum such as downward elongations of cerebellar tonsils.

In another experiment, with hydrocephalic-induced rabbits, Page (1975) with the aid of light and electron microscopy, noted flattening and loss of cilia from ependymal cells, disruption of ependymal cell junctions, and edema and astrocytosis of periventricular white matter. Other investigators (e.g., Del Bigio & Bruni, 1985) have also demonstrated how hydrocephalus can be caused by a variety of different pathological processes, the cytological changes, which follow in the periventricular region being essentially the same in experimental and human hydrocephalus.

McAllister and his colleagues (McAllister, Maugans, Shah & Truex, 1985) demonstrated neuronal changes in neonatal rats with kaolin-induced hydrocephalus, especially in the parietal-occipital region of the brain. These changes included decreases in the number and length of dendritic branches, reduction of dendritic spines and increases in dendritic varicosities, as well as degeneration of neurons in deeper layers of the cerebral cortex. These results are important because it is well known that the majority of intrinsic and extrinsic cortical afferents terminate in dendritic spines of neurons. These investigators contended that changes could be caused directly by increased CSF pressure, or they could be mediated secondarily by vascular changes, axonal damage, or deafferentation.

Pathological alterations in neurochemistry have also been reported. In a recent study (Chovanes, McAllister, Lamperti, Salotta & Truex, 1988), the monamine changes that occur during infantile hydrocephalus were investigated. The severity of the experimental hydrocephalus varied from mild dilation of the lateral ventricles to severe ventriculomegaly with thinning particularly of the occipital cortex. They also noted that portions of the tectum and cerebellum were vacuolated and that the neostriatum was compressed.

Perturbations in levels of different monamines in several brain regions were noted. Marked decreases in the monamines norepinephrine, dopamine and serotonin were noted in the frontal cortex, neostriatum and cerebellum, respectively. An increase in concentration of both norepinephrine and serotonin were found in the brain stem. All these structures are important for integrated functioning of the brain for activities such as initiation and control of movement.

Finally, Chovanes and his colleagues cited Purpura's (1975) intriguing hypothesis that varicose dendrites which have been shown to have prolonged conduction times may contribute to neuronal dysfunction underlying neurobehavioural retardation. Chovanes and his colleagues wondered if the presence of such dendrites leads to mental retardation that has been reported in hydrocephalic children. This area warrants further research.

In conclusion, of particular concern is how the neuropathology associated with SB and hydrocephalus translates into cognitive, social and behavioural deficits. The following section addresses this issue.

COGNITIVE ABILITIES OF SPINA BIFIDA CHILDREN

With regard to the mental development of children with myelomeningocele and hydrocephalus numerous studies have been published. The remainder of this introduction is a literature review of the current research pertaining to this topic.

Before the results of these studies are reviewed, it must be emphasized that the term spina bifida encompasses a number of different disorders and levels of involvement, and the nomenclature can be confusing because multiple names have been applied to each of the various manifestations.

Research to Date: Comparison of Studies

As Shaffer and her associates (Shaffer, Friedrich, Shurtleff & Wolf, 1985) have documented, much of the research carried out to date is difficult to compare and contrast for many reasons. First, comparison among these studies is complicated by sampling and other methodological problems. For example, much of the literature on myelomeningocele describes heterogenous samples, and as such complicates the interpretation of the results. Many investigators have indiscriminately included in their sample children with hydrocephalus without myelomeningocele and groups of children with hydrocephalus and myelomeningocele (e.g., Connell & McConnel, 1981; Lonton, 1979; Tew & Laurence, 1975). In addition, investigators such as Halliwell and his associates (Halliwell, Carr & Pearson, 1980) included in their sample children with encephalocele.

Another complication for research centers around the fact that different investigators have used various procedures to classify children with myelomeningocele into groups. Such procedures include: 1) functional motor level (Badell-Ribera, Shulman & Paddock, 1966; Shurtleff, Hayden, Chapman, Brog & Hill, 1975); 2) sensory level of lesion (Soare & Raimondi, 1977); and 3) type of anatomic placement of the lesion (Laurence & Tew, 1971; Raimondi & Soare, 1974).

A third limitation of the research relates to the observation that the majority of studies conducted to date have not controlled for complications such as infections and bleeding (Badell-Ribera et al., 1966; Carr, Halliwell & Pearson, 1981; Laurence & Tew, 1971; Spain, 1974). There is evidence to suggest from the studies which have controlled for these confounding variables, that the cognitive deficits described as associated with hydrocephalus and SB may actually be secondary to CNS complications (McLone, Czyzewski, Raimondi & Sommer, 1982; Shurtleff, Foltz & Loeser, 1973; Venes, 1980).

A final problem associated with intra and inter-study comparisons, revolves around the use of a variety of assessment instruments that are not directly comparable. For example, Soare and Raimondi (1977) assumed equivalence of the Cattell Infant Intelligence Scale and the Stanford-Binet.

In spite of the many problems cited above, as reviewed in the following sections, some findings seem to be consistent.

General Intellectual Status of Spina Bifida Children

This section addresses the question "Are children with myelomeningocele cognitively impaired?" Many investigators have concluded that the answer to this question is yes.

Laurence and Tew (1967) published the first of a series of studies reporting the results of a long-term follow-up of a sample of children born with neural malformations. These children (n = 465) were born in South Wales between 1956 and 1962, and included children with encephalocele, meningocele, and myelomeningocele. These authors considered this sample to reflect the natural history of myelomeningocele in that these children received little or no medical treatment. A follow-up assessment was carried out when the surviving children (n = 47) were between four and ten years of age. To assess intellectual capacity, the Griffith's Mental Development Scale and the Stanford Binet were administered. Analysis of the results revealed that the mean IQ for the total group of children was 86, with 54% of the children exhibiting IQs of less than 85. These children were retested on the Wechsler Intelligence Scale for Children when they were between 10 and 16 years of age. The results obtained were similar to the initial assessment (i.e., Full Scale IQ (FSIQ) = 89; Verbal IQ (VIQ) = 94; Performance IQ (PIQ) = 85. It should be noted that although the mean IQ scores did not differ significantly from expected normal values, the standard deviations (SD) of the IQ scores were slightly larger than expected values (SD for FSIQ = 18; VIQ = 20; PIQ = 19; expected value would be 15). Laurence and Tew interpreted this finding as an indicator of the marked variability among these children with regard to general intellectual capacity.

In another study, Spain (1974) assessed the intellectual capacity of three year old survivors of a cohort of myelomeningocele children born in London between 1967 and 1969. Results of the assessment with the Griffith's Scale of Mental Development revealed that 56% of the children attained IQ scores below 80. Similar findings have been reported by Mawdsley, Richkham and Roberts (1967) and Diller, Gordon and Swinyard (1969).

Around the 1970's, selection procedures were introduced in Britain in an effort to reduce the number of surviving children with gross multiple handicaps. Lorber (1972), one of the main advocates of this procedure, proposed that when certain adverse criteria were apparent at birth, nonaggressive treatment should be the policy adopted for the wellbeing of the child. Such adverse criteria include: 1) thoracolumbar lesion; 2) severe paralysis; 3) kyphosis; 4) severe clinical hydrocephalus; and 5) other gross congenital defects. In a follow-up study, Lorber and Salfield (1981) found that those children who did not exhibit any of the adverse criteria at birth and who received aggressive treatment (i.e., closure of back wound and/or shunt for hydrocephalus if required), were less physically handicapped and most performed within the normal range of intelligence. Moreover, they noted that 25 of 29 shunt-treated hydrocephalic children were of normal or superior intelligence.

Without a doubt, the application of aggressive approaches to the physical and developmental needs of children with myelomeningocele have significantly improved intellectual outcome. In less than a decade the percentage of severely retarded children (50%) (Lorber, 1971) has dropped dramatically to approximately 15% (McLone et al.; 1982).

However, many investigators, have demonstrated that children that receive treatment after a period of conservative care are not necessarily of poorer physical and mental status than those receiving immediate help (Guiney & MacCarthy, 1981; McLaughlin, Shurtleff, Lemire, Hayden & Stuntz, 1982). More recently, Tew and his associates (Tew, Evans, Thomas & Ford, 1985) investigated the cognitive abilities of a cohort of SB children born between 1973 and 1978 who had received surgery. They divided this sample of SB children into two groups. One group consisting of children who met specific physical criteria at birth and hence were offered immediate treatment. The second group was composed of children who because of adverse criteria had delayed treatment. Although these investigators reported a significantly higher level of intelligence among children treated immediately, they found that one fifth of those children in the delayed treatment group had normal levels of intelligence. The investigators concluded that to date, there is no available method of predicting precisely the outcome in every individual SB case, especially with reference to future intellect.

In many of the studies cited in the literature, hydrocephalus has been reported to be a limiting factor in the cognitive functioning of children with SB (Hunt & Holmes, 1975; Shurtleff, Foltz & Loeser, 1973; Soare & Raimondi, 1977; Tew & Laurence, 1975). There is ample evidence to suggest that factors associated with hydrocephalus, rather than severity of physical handicap per se, are most important in producing the intellectual impairment.

In an effort to elucidate more clearly the impact of factors potentially affecting psychological capabilities, Dennis and her associates (Dennis, Fitz, Netley, Sugar, Harwood-Nash, Hendrick, Hoffman & Humphreys, 1981) investigated the cognitive status of a group of hydrocephalic children in relation to various parameters and symptoms of their condition. They collected data pertaining to demographic variables (e.g., sex, handedness), early developmental status, symptoms (visual, motor, and seizure), formative pathology, type of hydrocephalus, site of CSF obstruction, extent and configuration of cortical thinning, and shunt treatment. The findings suggested that the consequence of early hydrocephalus is an uneven growth of intelligence during childhood, primarily affecting nonverbal intelligence. More specifically, they noted that cortical thinning which appeared to occur along an anterior-posterior direction (such that the vertex and occipital lobes are proportionally thinner than the frontal area), as well as the presence of hydrocephalus of the intraventricular form, adversely affected Performance IQ (PIQ) but not Verbal IQ (VIQ).

Many investigators have attempted to determine the effects of hydrocephalus by comparing the psychological test performance of SB children with and without histories of hydrocephalus. In one such study (Badell-Ribera et al., 1966) the non-hydrocephalic spina bifida children attained a significantly higher mean Full scale IQ (FSIQ) of 87. Further, it was apparent that there was an inverse relationship between the severity of physical handicap and the Wechsler FSIQ. These investigators noted that whereas the mean IQ of the most severely handicapped child was 91, a mean FSIQ of 108 was attained by the least severely handicapped child. Additionally, it was found that the incidence of hydrocephalus was much higher among the severely handicapped children.

In another study, Tew and Laurence (1975) also reported significantly lower scores on the Wechsler Preschool and Primary Scale of Intelligence among the shunted hydrocephalic children (mean IQ = 70) compared to the nonhydrocephalic SB children (mean IQ = 89.9). Similarly, Soare and Raimondi (1977) reported that children without hydrocephalus had a mean IQ of 102, whereas those with hydrocephalus had a mean IQ of 87.

In addition, many investigators exploring the relationship between hydrocephalus and spina bifida have noted a split between the verbal IQ (VIQ) and performance IQ (PIQ) scores attained by children with SB and hydrocephalus. For example Badell and his associates, (Badell et al., 1966) found that the Verbal IQs of spina bifida children with hydrocephalus were significantly higher (more than 10 points) than their Performance IQ. In addition, Diller and his colleagues (Diller et al., 1969) reported that these verbal-performance differences increase with age (e.g, a five-point difference found in children of ages 5 to 7 increases to 18 points when a sample of ages 11 to 15 is examined). These investigators also found that the verbal-performance differences found in hydrocephalic children are independent of IQ level; i.e., they are found in hydrocephalus children with IQ's above and below 90. This observation of a lower PIQ has been interpreted to reflect greater impairment of perceptual-spatial abilities relative to verbal intellectual skills among these children.

Some investigators, however, have not found this verbal-performance discrepancy. For example, administering the McCarthy Scales of Children's Abilities to a sample of preschool children, Bawden and Gates (1985) reported that these children did not evidence a verbal-performance split.

Rather, they exhibited pervasive rather than selective deficits. The authors suggested that the discrepancy in reports may be related to differences between test measures. They also postulated that the below average verbal ability noted may reflect a transient lag in the development of this ability. Furthermore, analysis of the results found that children with a history of intrauterine hydrocephalus were also more likely to exhibit the poorest scores.

Another approach to understanding the effects of hydrocephalus on intellectual status is to relate test performance to measures of the effectiveness with which hydrocephalus has been controlled by shunting. The description of the use of ventriculoperitoneal shunting to minimize brain damage from hydrocephalus, was provided by Nulsen and Spitz (1952). In a follow-up study twenty-two years later (Young, Nulsen, Weiss & Thomas, 1973), the investigators found that although the cortical mantle increased dramatically in the infants shunted in the first several months, with increasing age at the time of shunting this mantle thickness restoration appeared to diminish.

Other investigators have also demonstrated, that although shunting frequently restores the ventricular system to a normal size (Rubin, Hochwald, Liell, Bolek & Epstein, 1975) and allows myelination of the corpus callosum (Gadsdon et al., 1979), there still remain histological changes in the cortical mantle before shunt insertion. Rubin and his colleagues speculated that the disruption of myelin may be the factor which limits repair.

In another study, Grant and his associates (Grant, Goldberg, Guiney & Fitzgerald, 1986) investigated the neuropsychological data of two groups of hydrocephalic children with shunt placements. The groups differed in terms of the hemisphere in which the shunt was placed. They reported that the profile evidenced by a small group of right-shunted hydrocephalic children with reverse hemispheric specialization, that is, a right hemisphere dominant for language and a left hemisphere dominant for visuo-spatial processing, parallelled that of the left-shunted group. These investigators supported the view that a right hemisphere advantage for word-naming plus a left-hemisphere advantage for manipulo-spatial recognition was evidence of a reverse hemispheric specialization. Of particular interest in this study was the lower reading accuracy scores exhibited by these two groups. Grant and his colleagues concluded from their findings that shunting frequently has a "measurable but localized impact over and above the generalized impact of the hydrocephalic condition" (p. 130). They also postulated that the left hemisphere is more robust relative to the right and that shunting is associated with limited regional insult.

In general, it has been reported that uncomplicated unshunted myelomeningocele children vary in intelligence scores as a function of the level of lesion. Perhaps one of the most convincing investigations aimed at examining the cognitive and achievement status of children with myelomeningocele was conducted recently by Shaffer and her associates in Seattle (Shaffer et al., 1985). In this study, only children within an average range of intellectual functioning and who had not experienced CNS complications (i.e., infections or bleeding) were sampled. The children were grouped according to their functional motor level and whether or not they had received a shunt placement. Analysis of the results indicated that there was a relationship between the functional motor level and IQ scores. More specifically, these investigators found that the higher the lesion, the lower the FSIQ and PIQ score attained (particularly for the Information, Block Design and Picture Arrangement subtests of the WISC-R). This mediating influence of motor level, however, was not reported for children with shunts.

Moreover, the group of children with shunts also had exhibited a significantly lower Performance than Verbal IQ. The investigators speculated that this loss of predictive power with shunting may be related to several factors, i.e., CNS structural differences in those who develop hydrocephalus severe enough to require shunting, changes subsequent to brain wall expansion that is characteristic of the hydrocephalic process, alterations in the corpus callosum with the buildup of CSF and/or, differences in the technique and/or location of intervention.

There are relatively few studies which have addressed the association of perceptual-motor performance with IQ scores. In one such study, the investigators (Tew & Laurence, 1972), noted a correlation of the Wechsler Preschool and Primary Scale of Intelligence (WPPSI) scores with scores on the Frostig test. Sand and his colleagues (Sand et al., 1973) noted in children with lower IQ scores greater chronological age-performance discrepancies. Soare and Raimondi (1977) found lower scores on the Developmental Visual Motor Integration Test (DTVMI) for children with myelomeningocele than age and IQ-matched controls. Finally, Brunt (1987) found that IQ accounted for 32% of the variance in a composite perceptual-motor factor score. One-third of his sample had IQ scores below 80. Brunt suggested that his findings may be related to the statistical nature of the IQ test as IQ tends to correlate more reliably with perceptual-motor skill in the lower ranges. Thus, as suggested by Thompson and her colleagues (1988), "although many studies have noted the relationship between intelligence and perceptual-motor performance, it appears that these skills may be defective in children with spina bifida beyond what can be accounted for by the IQ score" (p. 33).

It is important to note that the subscales that make up the PIQ score emphasize speeded motor performance, with bonus points for rapid completion on several performance subtests (Block Design, Object Assembly, Picture Arrangement and Coding). Hence, it may be that the low PIQ is related to poor motor abilities rather than to a visuo-spatial deficit, per se. Thompson and her colleagues (Thompson et al., 1988) found that a sample of preschool children with myelomeningocele and hydrocephalus performed poorly on tasks requiring figure copying (DTVMI) relative to an age appropriate level of performance on a task requiring figure matching (Recognition-Discrimination). Thus, the latter finding is consistent with the hypothesis that problems in the area of perceptual skills and perceptual-motor integration are related to the documented fine motor coordination deficits (Anderson & Plewis, 1977).

In summary, given these results, it is apparent that children with myelomeningocele and hydrocephalus manifest cognitive deficits. The next question is whether or not there is a typical pattern of impairment associated with myelomeningocele.

Selective Deficits Associated with Myelomeningocele

There is a paucity of studies that evaluate the neuropsychological pattern of functioning in children with myelomeningocele. In one study (Glasscock, 1978), analysis of the results indicated that children with myelomeningocele and hydrocephalus who had required shunts, obtained significantly lower scores on all tests administered relative to those children who did not develop hydrocephalus. No significant difference between the children with myelomeningocele without shunts and control subjects was found. Further analysis revealed no evidence of selective intellectual deficits among the shunted children with myelomeningocele. Rather, the results indicated a highly generalized pattern of intellectual impairment among the shunted children, involving abilities in the areas of word-knowledge, verbal and visual spatial problem-solving, verbal and visual spatial memory and manipulative skills. It was noted that symptoms of hydrocephalus of two months duration or longer prior to shunt revision were related to poor performance on tests of visual and verbal memory, intellectual control and flexibility as well as fine manual dexterity.

Administering a neuropsychological battery of tests, Prigatano and his associates (Prigatano, Zeiner, Pollay & Kaplan, 1983) provide additional information regarding the effects of hydrocephalus on the developing brain of myelomeningocele children. As strict criteria were established for entry into the study, the resulting neuropsychological deficits exhibited by this sample are probably the mildest that can be expected with the clinical population of hydrocephalic children. For a sample of 4-9 year old children with uncomplicated hydrocephalus, these investigators reported deficits in verbal and nonverbal memory, fine motor speed and coordination as well as nonverbal problem-solving abilities. A one-year follow-up (Zeiner, Prigatano, Molloy, Biscoe & Smith, 1985), noted that changes were not apparent on tests of vocabulary, speed of information processing, hand-eye coordination and nonverbal memory. Noticeable improvements to within normal limits were observed on the verbal recall measure, fine motor speed, and complex information processing task. In contrast, the block design score and the speed of both motor scanning and simple information processing were significantly impaired relative to controls. Of particular importance is the observation that with increasing age, hydrocephalic children appeared less able than normal peers to maintain age-appropriate performance increments (i.e., these children did improve their performance but at a lesser rate than their peers).

The results of this study also found a relationship between neuropsychological functioning (for both verbal and visuospatial material) and ocular mobility and acuity abnormalities. Zeiner and his colleagues (1985) criticized Dennis and her associates (Dennis et al., 1981) for ascribing poor visuomotor test performance to cortical dysfunction alone. Rather, they believe that any interpretation of these results in terms of neuropathology should take into account other levels of CNS dysfunction such as eye muscle dysfunction, brainstem, and midbrain tectum (cranial nerve) dysfunction.

Grant (1985) assessed right-hemisphere function in SB hydrocephalic children by administering a colour-naming divided field task and a matching-to-sample manipulo-spatial task. The results obtained indicated that hydrocephalus is not characterized by a general right hemisphere dysfunction. Instead, the results suggested that the right hemisphere is selectively impaired, affecting only the visual modality (i.e., a reduced left visual field performance on the colour-naming task was noted).

In an effort to explain why no manipulo-spatial deficits were apparent, Grant cited from earlier research (Dennis et al., 1981) which demonstrated that hydrocephalus can have an impact on cerebral tissue in regional, as well as in global terms. As mentioned previously, Dennis and her co-workers found that cortical thinning or stretching in a child with hydrocephalus is often asymmetric in an anteroposterior direction and, as such, it is more likely to disrupt visual rather than somatosensory processes.

In another investigation, Hurley and her associates (Hurley, Laatsch & Dorman, 1983) compared the performance of SB-hydrocephalic children and matched IQ controls of different aetiology on a battery of neuropsychological tests. They reported that the SB-hydrocephalic group demonstrated a pattern of higher verbal than performance IQ on the Wechsler tests. In addition, it was noted that while the performance of the SB-hydrocephalic group was significantly slower for the left hand on the Finger Tapping Speed Test, their performance was superior to the matched IQ controls on a complex motor task (i.e., The Tactual Performance Test, TPT). From this finding the investigators postulated that for SB-hydrocephalic children, the impairment noted on complex perceptual motor tasks may be more indicative of visual perceptual and visual organizational problems than motor difficulties per se (since TPT is done blindfolded).

Although the difference between the groups did not reach significance (because the variability was quite large) there was a trend which suggested that the SB subjects had more difficulty with nonverbal concept formation measures (e.g., Halstead Category Test).

Recently, there are many studies cited in the literature which suggest that despite the absence of enlarged ventricles (i.e., CT and neurosurgical normalcy), and the presence of an average academic performance and normal intelligence, hydrocephalic children may still evidence neuropsychological deficits. In one such study, Torkelson and his associates (Torkelson, Leibrock, Gustavson & Sundell, 1985) investigated the neurological and neuropsychological effects of CSF shunting in children with assumed "arrested" hydrocephalus. These investigators suggested that there is a group of asymptomatic children with apparent clinically stable (arrested) hydrocephalus in whom abnormal performance on a neuropsychological battery of tests indicates the need for CSF shunting. Consistent with earlier findings, these authors reported higher VIQ compared to PIQ. On the Luria-Nebraska Battery, impaired performance was noted on certain subtests which assessed psychomotor functioning, and short and intermediate term memory. Improvement was noted on these measures subsequent to shunt placements.

These findings are in accord with the earlier work of Hammock and her colleagues (Hammock, Milhorat & Baron, 1976) and Laatsch and his associates (Laatsch, Dorman & Hurley, 1984). All of these authors underscored the fact that ventriculomegaly, normal CSF pressure, stable head size and non-progressive neurological symptoms can no longer be considered an optimum physiological condition in the child who manifests neuropsychological deficits. In addition, Laatsch and her associates (Laatsch et al., 1984) noted that behavioural changes such as higher levels of aggression, increased moodiness and somatic complaints were frequently observed by caretakers and neurologists without the concomitant occurrence of definitive neurological change.

More recently, Vaishnav and MacKinnon (1986) presented evidence which suggested that in children with hydrocephalus, a second rise in intra-cranial pressure (ICP) may occur around puberty. Consequently, children who may have had shunts since birth and had no reason for shunt revisions, may need surgery in the second decade. Similarly, these authors observed that children who may never have had a shunt, may require one around puberty due to the rise in ICP. It is not known precisely why the problem may develop around puberty, although it has been postulated that it may be related to physiological changes in the CSF or related anatomical changes in the base of the skull which usually occur at this time.

However, considerable evidence has been amassed to strongly suggest that the mere presence of hydrocephalus does not necessarily signify a poor intellectual prognosis. For many investigators, the major reason for a decrement in intellectual capabilities is the association of complications of shunting or infection (e.g., anoxia, ventriculitis, porencephaly).

In one study, Mapstone and his associates (Mapstone, Rekate, Nulsen, Glasser & Taffe, 1984) reported that the mean IQ of children with myelomeningocele and hydrocephalus which did not require a shunt placement was 104. In contrast, these investigators noted that those children who were shunted but without complications attained a mean IQ of 70. These findings are in accord with the earlier conclusions of McLone and his associates (McLone et al., 1982) and more recently those of Shaffer and her colleagues in Seattle (Shaffer et al., 1985).

The mechanism by which these infections affect the ultimate development of the child's intellect remains obscure. From animal research it would appear that several factors are probably involved. For example, it has been postulated that the ventricular infection exacerbates the rate and the severity of the hydrocephalus. In addition, a significant spread of periventricular edema along the white matter of the brain has also been noted. In general, a significant amount of destruction of myelin and fragmentation of cellular processes has been reported. McLone and his associates (McLone et al., 1982) postulated that in the clinical situation, the point at which the child begins to develop seizures is an indicator of CNS complications. This view is also held by Bartoshesky and his colleagues (Bartoshesky, Haller, Scott & Wojick, 1985). In the latter study, the charts of 111 children with myelomeningocele were reviewed. Approximately 20% of this sample were reported to have seizures. Moreover, this group of children was found to be the most developmentally delayed.

There are several studies cited in the literature which focus on one aspect of neuropsychological functioning. These are as follows.

A. Visual Perception

Many investigators report that children with myelomeningocele show deficits in visual perception. For example, Sand and his associates (Sand, Taylor, Rawlings & Chitnis, 1973) found that these children performed significantly below their age level on the Frostig Developmental

Test of Visual Perception (DTVP). In addition, these authors observed that the children with high level lesions, particularly if they were accompanied by hydrocephalus, produced the poorest scores. Correlations ranging from .62 to .82 have been found when the performance on the Frostig DTVP and WISC-R have been correlated.

Another aspect of visual perception, the ability to distinguish figure and ground, has also been reported to be impaired in children with myelomeningocele and hydrocephalus (Miller & Sethi, 1977; Parsons, 1972).

However, many investigators do not support these findings. For example, Gressang (1977) found that children with myelomeningocele with and without hydrocephalus, performed within the normal limits on the Frostig Development Test of Visual Perception. Likewise, analysis of findings obtained on the Southern California Sensory Integration Test (Land, 1977) and the Motor Free Visual Perception Test (a test with minimal motor response) (Eng, 1981) indicated average visual-perceptual abilities.

In an effort to explain these discrepant findings, Eng (1981) noted that children with myelomeningocele who possessed good eye-hand coordination performed similarly on the Frostig DVPT and the Motor Free Visual Perception Test. In contrast, children with poor eye-hand coordination exhibited lower scores on the Frostig DTVP than on the Motor Free Visual Perception Test. This suggests that the DVPT scores may be biased in that they are lowered by poor eye-hand coordination.

Shurtleff and his associates (Shurtleff et al., 1973) also administered the Motor Visual Perception Test to a group of children with myelomeningocele associated with low-lumbar or sacral level lesions, and found that the performance of these children was within normal limits. This adds strength to the argument that for children with low level lesions and adequate general cognitive skills, their visual-perceptual performance (with motor components eliminated) tends to fall in the normal range.

Simms (1986) investigated the relationship between perceptual-cognitive skills and driving performance in a group of learner drivers disabled by SB and hydrocephalus. He reported that while no perceptual measures per se were found to be reliable indicators of traffic driving, all the subjects in this sample exhibited low average performance on the majority of the perceptual-cognitive measures given. For example, he found that scores were particularly low on a visual memory test (Visual Reproduction of the Wechsler Memory Scale).

There are many other studies demonstrating deficits on nonverbal perceptual tasks in spina bifida children. Unfortunately, these studies frequently fail to control adequately for intelligence levels and involve an excessively broad age range. In addition, insufficient attention is given to variables that influence the severity of the child's overall condition, particularly factors that complicate hydrocephalus (e.g., infections) and increase the overall sensitivity of the CNS insult.

B. Language Skills

The term "Cocktail Party Syndrome", first described by Hadenius (1962), was applied to children with hydrocephalus who demonstrated increased verbalization. Since that time, it has been described by several authors. Literature on the cocktail party syndrome was reviewed by Tew (1979), who provided a set of five criteria for selecting children with the disorder:

1) perseveration of response, either echoing the examiner, or repetition of an earlier statement made by the child.
2) An excessive use of social phrases in conversation.
3) An over-familiarity in manner, not normally expected in a five year old child.
4) A habit of introducing personal experience into the conversation in irrelevant and inappropriate contexts.
5) Fluent and normally well articulated speech (p. 92).

In addition, Tew used these criteria to identify children with this syndrome from a group (n = 49) of 5 year old spina bifida children. He then administered a battery of cognitive and behavioural measures to this subgroup of children and compared their performance to a group of cerebral palsied children matched for age, sex, social class, and other demographic variables. He found that the subgroup of children with the cocktail party syndrome had significantly lower scores in all areas assessed. He concluded that the presence of this syndrome did not appear to be associated with better language skills on objective tests and that it seemed to be primarily related to lower intelligence scores.

Spreen and his colleagues (Spreen, Tupper, Risser, Tuokko & Edgell, 1984) propose another explanation for the relatively good verbal intelligence of hydrocephalic children. They suggest that "the cocktail party syndrome is the result of frequent hospitalizations and illness as well as frequent physical handling because of paralysis, circumstances providing many more superficial child-adult interactions than retarded children with or without hydrocephalus would normally receive" (p. 144).

Although these children perform well on standardized tests of vocabulary comprehension which present very distinctive examples of concepts (e.g., Culatta & Egolf, 1980), there are indications that such tests may overestimate their language comprehension. Frequently, the most generally observed deficits are related to the comprehension of written and spoken language, as well as the appropriate use of language (Anderson & Spain, 1977; Menelaus, 1980).

In an effort to explain the paradoxes noted in the language functioning of children with SB and hydrocephalus, Horn and her associates (Horn, Lorch, Lorch & Culatta, 1985) suggested that these children have difficulty in attending to relevant aspects of a situation. Furthermore, these authors postulated that this distractibility is responsible, at least partially, for the deficits on language functioning. For example, they noted that on occasions when irrelevant information was intermittently introduced during the administration of a test of comprehension of relational words, these children exhibited vocabulary deficits.

Dennis and her associates (Dennis, Hendrick, Hoffman & Humphreys, 1987) assessed the development of five language domains (word finding, fluency and automaticity, immediate sentence memory, understanding of grammar, and metalinguistic awareness) in 75 hydrocephalic children and adolescents. Analysis of the results indicated that the effects of early hydrocephalus have only a limited impact on language development.

Hydrocephalic children were noted to improve their language performance with age, but frequently it developed at a lesser rate relative to their peers. The level of particular language functions varied with different forms, manifestations, and treatments of early hydrocephalus. It was noted that although myelomeningocele impaired word fluency, it was not associated with other deficits in language function.

C. Memory Abilities

There appears to be little agreement in the research on the learning and memory capacity of children with myelomeningocele and hydrocephalus.

Parsons (1969) failed to find a significant difference between hydrocephalic and nonhydrocephalic children on a vocabulary learning test when all scores were adjusted for age and intelligence.

In contrast, Glasscock (1978) found evidence which suggested that certain aspects of memory may be more marginally impaired in children with myelomeningocele who had received shunt placements relative to children with myelomeningocele without shunts. She noted that while there was no significant difference found between the two groups on a Digit-Learning task, the children with myelomeningocele and shunts performed significantly lower on tests of paired-associate learning, paragraph memory and visuospatial memory. It must be noted, however, that this investigator did not control for differences in IQ in her sample.

In a more sophisticated study, Cull and Wyke (1984) assessed many different memory functions of a group of hydrocephalic SB children to an age and IQ matched group of non-physically handicapped children (mean IQ was 76-79 in these two groups) as well as to a control group of normal children. The conclusions were that, compared to children with normal intelligence, children with hydrocephalic spina bifida showed deficits in ability to learn, store, and retrieve information, except for meaningful verbal information. According to the authors, this deficit may reflect an inability to use appropriate semantic strategies at the level of encoding. This hypothesis is based on the evidence which suggests that recall of verbal material depends on the organization at the level of encoding (Howe, 1978).

In summary, based on the limited findings in this area, more research is clearly warranted, especially on homogenous groupings of spina bifida children by disorder and handicap.

D. Motor Capacity

The majority of evidence suggests that SB children are deficient in certain motor capacities and that these children may be at risk for the development of difficulties in upper extremity co-ordination (Grimm, 1976; Wallace, 1973). In addition, it has been suggested that these difficulties may affect the development of visual-perceptual deficits (Thompson et al., 1988).

In particular, most investigators have reported a high frequency of uncoordinated and immature hand function. These children often manifest an awkward, immature grasp of a pencil, and have difficulty regulating the force and direction of movement (Anderson & Plewis, 1977; Sand & Taylor, 1973). For example, administering the Jebsen Taylor Hand Function Test as a measure of fine motor performance, Grimm (1976) reported that 82% of his sample performed at least two standard deviations below the mean.

Similar findings were reported by Sand and his associates (Sand et al., 1973). In addition, these investigators noted that children with higher lesions and/or more marked hydrocephalus exhibited the most difficulties. Shurtleff and his associates (Shurtleff et al., 1975) confirmed this finding. In their sample, 67% of the high-level lesion children (thoracic-high lumbar group) demonstrated impaired hand function. This finding contrasts with the 23-29% of the lower level lesion groups which manifested impairment. Moreover, these authors confirmed the earlier reports of a higher incidence of hand function impairment among the children with shunts and/or complications associated with hydrocephalus. Of particular interest in this study was the finding that handedness did not appear to influence performance on the Jebsen Taylor Hand Function Test.

It has frequently been observed that a high percentage of children with myelomeningocele possess mixed hand dominance (Lonton, 1976). Lonton found that the mixed handers (i.e., those who demonstrated no specific hand preference in a simple drawing and writing test) exhibited significantly lower verbal IQ's on the WISC and obtained a low reading attainment score as well. In addition, this group of children were more likely to have thoracic-lumbar lesions. Anderson and Plewis (1977) found that although children with myelomeningocele exhibit poor scores in a simple timed tapping task, they appear to demonstrate some improvement with practice.

E. Academic Performance

Despite the importance of academic skills for the adaptive functioning of the child, few investigators have examined this area in children with myelomeningocele. Shaffer and her associates (Shaffer et al., 1985) reported that children with myelomeningocele performed in the average range for the WRAT-Reading (word recognition, $\bar{X} = 96.8$). Adequate analysis of their verbal comprehension was not carried out. The latter warrants some attention in light of the known interaction between reading and adequate abilities in areas such as scanning, perceptual-motor ability, and concept-formation. As mentioned previously, deficits in these areas have been reported, thus placing the child with myelomeningocele at risk for difficulties relating to the acquisition of reading skills.

With regard to spelling ability, Shaffer and her colleagues found that children with myelomeningocele performed significantly below the normative data for WRAT-R spelling ($X = 88.8$).

In terms of arithmetic skills, there is evidence to suggest that this is a more impaired area of difficulty relative to other academic abilities (Anderson & Elkins, 1981; Tew & Laurence, 1972). It might be pointed out that this kind of differential impairment in arithmetic has been associated with right cerebral dysfunction in learning disabled children (Rourke, 1975; 1985). Whether this finding can be generalized to children with myelomeningocele is an issue requiring investigation.

SOCIAL AND EMOTIONAL ABILITIES OF CHILDREN WITH SPINA BIFIDA AND HYDROCEPHALUS

There are few studies cited in the literature which focus on the social and emotional adjustment of children with SB and hydrocephalus. This is surprising considering the reports that these children are at considerable risk of developing psychological disorder (Dorner, 1976). Epidemiological surveys also show that about 30% of all children with chronic illness may be expected to develop psychosocial maladjustment (Pless & Roghmann, 1971).

Before the results of these studies are reviewed, it must be reemphasized that the term spina bifida is applied to a rather broad set of spinal cord lesions and complications. Generalizations from any study consequently become difficult at best, especially since sample characteristics are often poorly described.

Considering general adjustment first, research conducted by Wallander and colleagues (Wallander, Varni, Babani, Banis & Wilcox, 1988) had 270 mothers of chronically ill and handicapped children, aged 4 to 16 complete the Child Behaviour Checklist (Achenbach & Edelbrook, 1983). Of these children, 77 had undifferentiated spina bifida. Children in all disorder groups were perceived by their mothers as evidencing more behavioural problems and social incompetence than expected on the basis of norms for physically healthy children. Children with spina bifida did not differ in their level of adjustment from children with other chronic disorders (e.g., juvenile diabetes, hemophilia, cerebral palsy, chronic obesity). They were, however, better adjusted than children referred to mental health services. Breslau (1985) reported similar findings for a sample of 304 children with congenital physical disabilities, including 63 with spina bifida. Although these children were at increased risk for maladjustment, the presence of brain damage or mental retardation exacerbated this risk considerably.

There are good reasons for hypothesizing that children with SB with or without hydrocephalus will have an increased liability to psychiatric disorder. The Isle of Wight Study (Rutter, Graham & Yule, 1970) demonstrated that a group of 9-11 year old children with a variety of physical handicaps, were about twice as likely to have psychiatric disorder compared with non-disabled children. These investigators noted that children with a confirmed lesion above the brainstem with a history of seizures, had the highest susceptibility to psychiatric disorder (58.3%). The rate of psychopathology was less if there was no history of seizures associated with the organic lesion (37.5%). Furthermore, the specific effect of a brain lesion was underscored by the observation that the children with non-neurological physical disorders had an incidence of psychopathology close to average (i.e., 6.6%). Seidel and his associates (Seidel, Chadwick, & Rutter, 1975) confirmed these findings.

The study by Laurence and Tew (1971) had 400 teachers of children aged 5 to 11 with non-hydrocephalic spina bifida complete a teacher questionnaire. Based on their findings, they classified about 45% as well adjusted, 35% as unsettled, and 20% as maladjusted. The figure for maladjustment is about twice the rate for the general population. However, these investigators noted that hydrocephalus significantly increases the rate of maladjustment in children with myelomeningocele, whereas uncomplicated myelomeningocele, does not differ from meningocele

(Laurence & Tew, 1971). In addition, Kolin and his colleagues (Kolin, Scherzer, New & Garfield, 1971) related adjustment to the severity of the physical and mental handicap in children. This finding is consistent with the observation that maladjustment is increased in hydrocephalic children, since this complication will typically produce more handicaps.

Connell and McConnel (1981) investigated the psychiatric sequelae in children treated operatively for hydrocephalus in infancy. The findings suggested that hydrocephalic children, relative to normal peers, are at particular risk for the development of a psychiatric disorder, primarily of the neurotic type. These authors however, stressed that although psychiatric disorder was found to be associated with low intelligence, perceptual and attentional problems, the coping mechanism of the child with SB appeared to be closely related to parental attitudes toward them, as well as the parental management of difficulties associated with their handicap. This finding is in accord with results obtained by Kolin and his colleagues (Kolin et al., 1971), and more recently by Johnson (1984). In the latter study, the author reported that a delay in reaching the important physical milestones of independent locomotion and continence, hindered the achievement of standard psychosocial developmental goals. Johnston noted that the degree to which the SB child was capable of accepting his condition was associated with the ability of the parents not only to show an acceptance of the child's condition and a willingness to discuss his feelings about it, but also to be able to recognize and acknowledge the child's strengths that he shares with his more able-bodied peers.

In terms of more specific aspects of psychological functioning, several investigators (Dorner, 1976; McAndrew, 1979) have noted that from 65% to 85% of spina bifida children report feeling miserable or unhappy at least as often as once a month. For the majority of cases, independent interviews with mothers confirmed depressed feelings (Dorner, 1975). In addition, Dorner found that contrary to expectations, depressed affect appears not to be related to mobility or severity of overall handicap.

Diminished self-esteem is a characteristic that pervades most psychological profiles of children with SB. Campbell, Hayden and Davenport (1977) administered the Tennessee Self-Concept Sca,' and the Offer Self-Image Questionnaire to a sample of SB adolescents and controls matched for sex and age. In general, the control group exhibited a more favourable self-concept relative to the SB group. Furthermore, these authors noted that adolescent SB boys and girls manifested different scoring patterns. Adolescent males with SB demonstrated major concerns centering on sexual adequacy and social mastery. Adolescent females on the other hand, show more symptoms of emotional disturbance, particularly depression and social isolation.

Shurtleff and his colleagues (1975) described depression, low self-image and poor motivation for achievement as the greatest impediments to psycho-social adaptation among adolescent myelomeningocele patients. In a later study, Shurtleff (1977) suggested that 'delayed adolescence' occurred "because physical impairment interfered with mobility, socialization and acceptance into the process of growing up" (p. 21). According to Patterson and McCubbin (1983), with the advent of formal operations, adolescents with myelomeningocele realize more fully that their impairments are going to be with them for the rest of their lives. This view is also held by Beck (1976). He speculated that a common outcome of this stage of cognitive development is a decrease in hope for change which for many adolescents may lead into a depressive episode.

Anderson (1979) in a study of 119 young people, 89 with cerebral palsy, 30 with myelomeningocele and hydrocephalus, reported that only 48% of the sample were without marked or borderline psychological disorders. The nature of the disorder was most frequently described as neurotic (75%). In a follow-up study, Anderson and Clarke (1982) confirmed these findings. As before, depression, fearfulness, anxiety, lack of self-confidence and low self-esteem were most frequently mentioned. It should be noted, however, that despite the presence of many predisposing factors such as cortical damage, seizure disorder and unsupportive families, one-third of this sample did not manifest any apparent psychological problems.

Tew and Laurence (1985) found that SB children reported significantly more emotional problems on the Rogers Personality Adjustment Inventory relative to normal peers. Of particular interest was the observation on the Teachers Bristol Social Adjustment Scale, that these problems were not perceived in the classroom. In addition, the results confirmed earlier findings that suggested that girls with myelomeningocele manifest increased vulnerability to emotional problems.

Wicks and his associates (Wicks, Varzos & Wicks, 1985) administered the Personality Inventory for Children (PIC) to primary caregivers of 30 adolescents with myelomeningocele. Examination of the mean PIC profile revealed that although one-third of the respondents (parents) demonstrated elevated 'L' scores (defensiveness), 60% noted difficulty with intellectual activities and/or development. Other elevated clinical scales included social withdrawal (25-30%), psychosis (40%) and somatic concerns (27%).

Self-esteem has also been related to severity of physical handicap. Based on a comparison between a group of SB children born after the introduction of selective surgery and a group born prior to this point when surgery was implemented unselectively, Hayden and her colleagues, (Hayden, Davenport, & Campbell, 1979) found that the "before" group, which included more children with severe handicaps, scored lower on average on a self-esteem questionnaire than the "after" group. In fact, the latter group obtained a distribution similar to the normal standardization sample for the measure used.

In terms of social isolation, many investigators report that about 50% of adolescents with spina bifida tend to be socially isolated (Dorner, 1976; McAndrew, 1979). For example, Dorner found that many in her sample had no social contact with peers for at least a month. About 26% had not visited or been visited by a friend in one year and about 9% could name no friends. Dorner reported that social isolation was significantly more common in those adolescents who had restricted mobility due to physical handicap and who attended special schools. However, even though social problems occur, both Dorner (1976) and McAndrew (1979) found that approximately 27% of their independent samples of adolescents claimed to have a boyfriend or girlfriend, and 29% had been out on a date in the last year. Some investigators (Andrew, 1967; Morales, 1966) found that emotional disturbances stem from low self-esteem related to motor deficits and elimination problems, poor motivation, lack of opportunity for heterosexual intimacy and poor sexual identity. However, Hayden and her associates (Hayden et al., 1979) reported no differences between a spina bifida group and a group of healthy controls in perceived sexual development. There are discrepancies in expectations for marriage among samples of adolescents with spina bifida, with between 23% (Dorner, 1976) and 65% (McAndrew, 1979) having reported this expectation for themselves.

Finally, competence and independence in performing activities of daily living are dependent on motoric skills, and essential for normal socialization in school, at home and in the community. In the normal population, children by the age of 8-10 years are essentially independent for basic personal care skills. However, research by Sousa and her colleagues (Sousa, Gordon & Shurtleff, 1976) has pointed out that many children with myelomeningocele and intelligence in the normal range exhibit marked developmental delays in self-help skills such as dressing, grooming, feeding, meal preparation, and hygiene. More research is needed in this area, especially focusing on homogenous groupings of spina bifida children by disorder and handicap.

In summary, the evidence suggests that children with myelomeningocele and hydrocephalus are faced with a host of problems including concerns about evolving sexual changes, intellectual function, stature and mobility, ability to cope with the chronic problems generated by the condition itself and the psychosocial impact of all these factors. Furthermore, due to the social withdrawal and isolation associated with factors such as poor self-image and low self-concept, these children frequently do not obtain the necessary opportunities for separateness, identity formation and role taking tasks necessary for normal development (Anderson & Clark, 1982; Hayden et al., 1979).

In addition to the concerns listed above, SB-hydrocephalic children may have other causes for emotional difficulties. More recently, the role of the integrity of brain-dependent functions which enable an individual to understand, think about and perceive social cues and social consequences has been emphasized. It has been suggested that if 'right-hemisphere' abilities are compromised in a child, a social-emotional handicap would be expected to develop (Rourke, 1982).

As pointed out by Rourke and Fisk (1981), to the extent that different patterns of cognitive strengths and weaknesses translate into different patterns of academic performance, then the type of pattern of central processing deficits may also directly determine the type of vulnerability to social problems. This topic warrants investigation.

1.1 Rationale of the Study

The study was designed to extend previous research dealing with the developmental outcome of children with a specific type of spina bifida, namely, myelomeningocele. In addition, all the participating subjects have hydrocephalus.

The first goal of the study is to provide a comprehensive and objective description of the cognitive and behavioural outcome in myelomeningocele children with hydrocephalus. The second goal is to expand our knowledge of the degree to which medical variables in addition to the myelomeningocele, per se, may be related to that outcome. It is hoped that the results will lead to the development of realistic and carefully tailored remediation programs in educational, social and vocational settings.

Specific issues addressed by the study are presented below under the objectives that the study investigated:

Objective 1: Nature of Ability Structure

Objective 2: Behavioural Sequelae

Objective 3: Influence of Socio-Demographic Variables

Objective 4: Influence of Medical Variables

The rationale for the above objectives is outlined below.

Objective 1: Nature of Ability Structure

Objective 1 addresses the question: Do children with myelomeningocele and hydrocephalus show a characteristic profile of cognitive abilities as determined by neuropsychological testing?

More specifically, among the neuropsychological skill areas that were examined in this study are there certain cognitive skills that can be identified as more impaired than others?

Since spina bifida involves an abnormality of the cental nervous system (CNS), there has long been a concern for its impact on intellectual functioning and academic performance. Based on the literature review, the study postulated that the performance of the myelomeningocele children on the following test domains would be impaired relative to age norms (i.e., available normative data was utilized instead of a control group):

a) Intellectual capacity - on all of the measures especially Performance IQ

b) Language - on all of the measures except the Token Test

c) Visual - Spatial and Constructional Skills - on all of the measures

d) Memory and Learning - on all of the measures

e) Attention and Psychomotor Efficiency - on all of the measures

f) Motor Skills - on all of the measures

g) Problem Solving, Concept Formation, and Reasoning - on the one measure used

h) Tactile - Perceptual Skills - on all of the measures

i) Academic Achievement - on all of the measures with the exception of the Reading Recognition Subtest of the PIAT.

Many investigators have noted a split between the Verbal IQ (VIQ) and Performance IQ (PIQ) scores obtained by children with spina bifida and hydrocephalus. As indicated in the introductory chapters, a variety of cognitive and behavioural sequelae have been associated with spina bifida. It is not yet clear whether developmental deficiencies reflect specific or diffuse problems in cognitive functioning. The majority of the studies in this area have focused mainly on impairments in terms of intellectual impairment and/or academic functioning. Considered in isolation, IQ tests do not assess a broad range of skills (Taylor, Fletcher & Satz, 1984). The majority of the research findings are inconclusive due to sampling and methodological problems. Past research has tended to ignore the potential of neuropsychological testing for elucidating the nature and extent of the deficits exhibited by spina bifida children.

This study attempts to fill this gap by employing neuropsychological tests chosen specifically for their sensitivity to the effects of various types of early brain insults (Bordeaux, Dowell, Copeland, Fletcher & van Eys, 1988; Copeland, Fletcher, Pfefferbaum-Levine, Jaffe, Ried & Maor, 1985; Fletcher & Taylor, 1984; Taylor, Fletcher & Satz, 1982, 1984). The use of such a comprehensive battery of tests with a group of myelomeningocele children will make it possible to observe any skill dissociations that are known to occur in children with brain injuries (e.g., ways in which language or memory can break down, and contrasts in performance across several dimensions).

Objective 2: Behavioural Sequelae

The aim of objective 2 is to investigate behavioural sequelae that may be associated with myelomeningocele.

This objective was accomplished through information gleaned from teacher and parent behavioural questionnaires, a semi-structured interview focusing on adaptional skills, and measures of self-esteem. It was hypothesized that children with myelomeningocele will have low self esteem, an external locus of control (i.e., low degree of perceived control over life events), and obtain a high score on scales for internalizing behaviours.

Objective 3: Influence of Socio-Demographic Variables

Objective 3 addresses the issue of whether or not there is a relationship between certain socio-demographic variables and cognitive test performance.

The variables investigated included;

1) socio-economic status

2) age at testing.

Specifically, two hypotheses will be addressed:

a) Myelomeningocele children from poorer socio-economic backgrounds will display a poorer cognitive profile than those children with a higher socio-economic status level.

The effects of social and cultural factors on learning and development are well documented (Sameroff & Chandler, 1975). Previous research (Soare & Raimondi, 1977) suggests that myelomeningocele children from poorer backgrounds perform at a significantly lower intellectual level of functioning relative to those children from families with more education and income.

b) Older myelomeningocele children will perform more poorly on cognitive tests than younger children.

It is hypothesized that the older children will have more difficulty on the neuropsychological battery because of the increased complex cognitive demands for successful performance.

Objective 4: Influence of Medical Variables

Objective 4 addresses the issue of whether or not there is a relationship between certain medical variables and cognitive test performance.

The medical variables were chosen on the basis of the literature review concerning the psychological outcomes of spina bifida children. These include the following variables:

1) a history of complications
2) ocular abnormalities
3) level of myelomeningocele lesion
4) the onset of hydrocephalus.

Although these variables are partially confounded with one another, the purpose of this study will be to determine which variables might serve as the best indices of neuropsychological functioning.

Specifically, the following four hypotheses will be addressed:

a) Children with complicated myelomeningocele and hydrocephalus will display a poorer cognitive profile than the remainder of the sample who did not experience such complications.

Complications are defined as evidence of infections and/or seizures associated with a shunt placement. Many investigators postulate that the decrement in intellectual capabilities frequently noted in spina bifida children, is associated with complications of shunting and infection (McLone et al., 1982; Shaffer et al., 1985).

b) Children with a history of visual problems will perform significantly worse on measures of cognitive development, particularly on visual-spatial type tasks, relative to the remainder of the sample who do not exhibit such problems.

The incidence of ocular difficulties is known to be high in children with hydrocephalus (Wybar & Walker,1985). Previous research suggests a relationship between neuropsychological functioning and abnormalities in ocular mobility and acuity in a pediatric hydrocephalic sample, half of whom were children with myelomeningocele (Prigatano et al., 1983).

c) There will be a relationship between cognitive functioning and level of motor lesion.

Specifically, the group of myelomeningocele children with lesions at the lumbar and higher spinal cord level (i.e., L2 and above), will exhibit significantly more impairment relative to the remainder of the sample. For example, Diller and his colleagues (Diller et al., 1969) noted that as the lesion occurs at a higher level of the spinal cord, cognitive function decreases.

d) Children with a history of intrauterine hydrocephalus will perform significantly worse than children who develop hydrocephalus after birth.

Specifically, the duration of cortical compression might be of greater importance than the degree of hydrocephalus, as it may significantly alter neural circuitry during intrauterine stages of development (Rakic, 1979; Rubin et al., 1975).

Classification of children with intrauterine hydrocephalus versus those children who develop hydrocephalus after birth was based on head circumference. Children with a head circumference at birth above the 98th percentile will be classified as having intrauterine hydrocephalus.

Menelaus (1980) estimated that approximately 25% of spina bifida children are found to have hydrocephalus at birth. Few studies cited in the literature have alluded to the possible effects of intrauterine hydrocephalus on the developing child. In one such study, Bawden and Gates (1985) noted that those spina bifida children with a history of intrauterine hydrocephalus when compared to spina bifida children with a negative history of intrauterine hydrocephalus were likely to exhibit the poorest General Cognitive Index score on the McCarthy Intelligence Scales of Children's Abilities.

CHAPTER 2

METHOD

2.1 SUBJECTS

One hundred and fifty medical files of spina bifida children actively seen or followed at some point at the Spina Bifida Clinic at the Izaak Walton Killam Hospital (IWKH) for Children, in Halifax, Nova Scotia, were reviewed in order to identify myelomeningocele children with hydrocephalus. Appendix A provides a summary of the information obtained from the IWKH files. Following this review, 50 subjects were identified, and of this group 45 were located and contacted by telephone regarding participation in the study. Forty families agreed to participate in the study.

Prior to the commencement of the study, all parents or legal gua lians of the children received a description of the proposed study and were requested to sign a consent form (see Appendix B). Following this, the families were contacted by phone and arrangements were made for a one-day neuropsychological assessment at the I.W.K. Hospital.

The children were between 9 and 16 years of age and attending school on a regular basis. Each child was administered the Wechsler Intelligence Scale for Children-Revised (WISC-R). Based on the findings from this test, children with severe mental retardation (IQ less than 60) were not seen for further testing because they would not possess the cognitive abilities to perform at an adequate level on the tests chosen for this research. Four children were excluded on the basis of this criterion (mean IQ = 44). Thus, the final sample size for this study consisted of 36 myelomeningocele children with hydrocephalus (16 males and 20 females).

Demographic information for the myelomeningocele sample is summarized in Tables 1 to 6. The mean age of the sample was 13.27 years (SD = 2.37) and the mean grade level was 6.25 (range grade 2 to grade 10) (see Tables 1 & 2). In the myelomeningocele sample, 30.6% (n = 11) of the children were left-hand dominant. Handedness was established on the basis of preferred writing hand.

The hydrocephalus was treated in each child by an insertion of a shunt before the first birthday. All of the children had a ventriculoperitoneal (VP) shunt, with one exception. The latter case had a ventriculoatrial (VA) shunt. The average number of shunt revisions in this sample was 2.97 (range 0-9) (see Table 3).

Because families came from a variety of socioeconomic backgrounds, the Hollingshead Socioeconomic Index was used to assess this variable/ information. This index ranges from 1 to 5 and allows for grouping into 5 socioeconomic intervals (see Appendix C). The mean Hollingshead Socio-ecomonic Index was 2.7 (SD = 1.21) (see Table 4). Note that 25% of this sample were rated at the lowest level. The mean level of paternal education was grade 10.3, and 11.0 for maternal education (see Tables 5 & 6).

TABLE 1

Frequency Analysis of Age at Time of Testing

Age	Frequency in Age Group	Frequency Male	Frequency Female
9	6	4	2
10	3	1	2
11	5	1	4
12	3	1	2
13	8	5	3
14	5	1	4
15	4	2	2
16	2	1	1
Total	36	16	20

TABLE 2

Frequency Analysis of Grade at Time of Testing

Grade	Absolute Frequency	Relative Frequency	Cumulative Frequency
2	1	2.8	2.8
3	5	13.9	16.7
4	4	11.1	27.8
5	3	8.3	36.1
6	6	16.7	52.8
7	7	19.4	72.2
8	2	5.6	77.8
9	4	11.1	88.9
10	4	11.1	100.0

TABLE 3

Frequency Analysis of Shunt Revisions

No. Revisions	Frequency	Percentage	Cumulative Percentage
0	8	22.2	22.2
1	5	13.9	36.1
2	4	11.1	47.2
3	6	16.7	63.9
4	4	11.1	75.0
5	3	8.3	83.0
6	2	5.6	88.9
7	1	2.8	91.7
8	1	2.8	94.7
9	2	5.6	100.0

TABLE 4

Frequency Analysis of SES

SES Level	Frequency	Relative Frequency	Cumulative Frequency
1	9	25.0	25.0
2	5	13.9	38.9
3	13	36.1	75.0
4	7	19.4	94.4
5	2	5.6	100.0

TABLE 4

Frequency Analysis of SES

SES Level	Frequency	Relative Frequency	Cumulative Frequency
1	9	25.0	25.0
2	5	13.9	38.9
3	13	36.1	75.0
4	7	19.4	94.4
5	2	5.6	100.0

TABLE 5

Frequency Analysis of Father's Education (n = 36)

Grade Level Achieved	Absolute Frequency	Relative Frequency	Cumulative Frequency
4	1	2.8	2.8
5	1	2.8	5.6
6	2	5.6	11.1
7	1	2.8	13.9
8	2	5.6	19.4
9	5	13.9	33.3
10	7	19.4	52.8
11	4	11.1	63.9
12	10	27.8	91.7
University degree	3	8.3	100.0

TABLE 6

Frequency Analysis of Mother's Education (n = 36)

Grade Level Achieved	Absolute Frequency	Relative Frequency	Cumulative Frequency
6	2	5.6	5.6
8	3	8.3	13.9
9	2	5.6	19.4
10	4	11.1	30.6
11	4	11.1	41.7
12	19	52.8	94.4
University degree	2	5.6	100.0

2.2 TEST MATERIALS

Each child was administered a neuropsychological battery of tests. Tests in this battery were derived from neuropsychological tests commonly used in pediatric settings. These tests have been demonstrated to be sensitive to developmental issues, and have been applied to many different patient groups including children with learning problems, meningitis, head trauma and other similar problems (Taylor et al., 1982, 1984).

Skills and abilities in the following nine cognitive skill areas were assessed: 1) Psychometric Intelligence; 2) Language; 3) Visual-Spatial/Constructional; 4) Memory and Learning; 5) Attention and Psychomotor Efficiency; 6) Problem Solving and Reasoning; 7) Tactile-Perceptual; 8) Motor; and 9) Academic Achievement. In addition, questionnaires and interview-based assessments of behaviour at school and at home were obtained (Behaviour and Social Competence skill area), along with measures of self-esteem (Self-Concept).

The selection of specific neuropsychological and cognitive tests, as well as the behavioural measures was guided by five considerations:

1) the need to obtain a thorough evaluation of a wide range of abilities in view of the absence of systematic studies in this area. As stated by Shaffer and her associates (Shaffer et al., 1985) "future research that provides a more fine-grained, neuro-psychological based description of children with myelomeningocele is clearly warranted" (p. 334). In addition, measurement of diverse functions is considered especially appropriate in light of the evidence that early brain disorders

lead to variable patterns of cognitive impairment (Taylor, 1984);

2) previous research demonstrating impairment of specific abilities in spina bifida children. For example, difficulties on measures involving copying of geometric designs, such as the designs found in the Test of Visual-Motor Integration, have been reported by many investigators (e.g., Soare & Raimondi, 1977);

3) research showing the importance of the above nine domains for the cognitive development of children. For example, research has shown that the development of memory and other information processing skills may have more direct implications for educational functioning than traditional psychometric measures (Taylor, 1984);

4) availability of normative information and reliability studies; and

5) time constraints that made it necessary to attempt to collect the information in one visit without excessively fatiguing the child.

The tests contained in each cognitive skill area are listed in Table 7. The selection of measures within each skill area was based on past research indicating that variables within each area are more similar to one another than to variables in between domains (e.g., Copeland and her associates, 1985; Joschko & Rourke, 1985; and Taylor, Albo, Phebus & Bierl, 1987).

TABLE 7

Test Battery

A. Intellectual Capacity

i) Wechsler Intelligence Scale for Children-Revised (WISC-R) Full Scale IQ [2]
ii) WISC-R Performance IQ
iii) WISC-R Verbal IQ

B. Language

i) Peabody Picture Vocabulary Test-Revised (PPVT-R) [1]
ii) Expressive One-Word Vocabulary Test [9]
iii) Verbal Fluency Test [5]
iv) Token Test (part 5)[14]

C. Memory and Learning

i) Verbal Selective Reminding Test [17]
ii) Nonverbal Selective Reminding Test [11]
iii) Sentence Memory Test [12]
iv) Rey-Osterrieth Complex Figure Test Recall (6)

D. Visuospatial and Constructional

i) Developmental Test of Visual-Motor Integration [13]
ii) Rey-Osterrieth Complex Figure Test [4]

E. Attention and Psychomotor Efficiency

i) Continuous Performance Test [18]
ii) Underlining Test [16]

F. Problem Solving, Reasoning, Concept Formation

i) Halstead Category Test [19]

G. Motor

i) Finger-Tapping Test [8]
ii) Grooved Pegboard Test [15]
iii) Trails A and B [10]

H. Tactile-Perceptual Examination [20]

i) Agnosia
ii) Dysgraphesthesia
iii) Astereognosis

I. Academic Achievement

i) Wide Range Achievement Test-Revised (WRAT-R) Spelling and Arithmetic subtests [3]
ii) Peabody Individual Achievement Test [7]
Reading Recognition subtest
Reading Comprehension subtest

J. Behaviour and Social Competence

i) Vineland Adaptive Behaviour Scale
ii) Personality Inventory for Children
iii) Child Behaviour Checklist
iv) Teacher's Version of the Child Behaviour Checklist

K. Self-Concept

i) Piers-Harris Children's Self-Concept Scale [21]
ii) Nowicki-Strickland Locus of Control Scale for Children [22]

Note: Arabic numerals indicate the order in which tests were administered.

A brief description of these materials and procedure for their administration is provided in Appendix D. In addition, information pertaining to the basic psychometric properties of the materials is provided. It is well known that test instruments should be standardized, reliable and valid for the age level at which they are used (American Psychological Association, 1977). For many of the measures employed in this study, the normative data is lacking and little information is available about the reliability and validity of the measures. As such, some results (i.e., means and standard deviations) may well be over- or underestimates of normal performance, and hence this may affect the results particularly when an age- and IQ-matched control group was not used in this study. Consequently, variances in pattern of performance may not be as reliable as they seem. This issue is addressed more fully in Chapter 4.

These tests were administered to each subject in the same order, by the same examiner (see Table 7). The total test battery required about 3½ hours to administer. With a morning and afternoon break of about 15 minutes as well as an hour long lunch break, the testing session lasted no more than 5 hours. The tests are simple to administer and generally engage the child's interest. They are short, with the changes in material preventing boredom and disinterest. The order of tests was chosen because it was clinically efficient and maximized the cooperation of the children.

TABLE 8

Medical Variables Characterizing the CNS of the Sample

A. **HISTORY OF COMPLICATIONS**
   1. **Infections**
      a) Age of onset
      b) Causative Organism
         i) Gram positive
            Staphylococcus Virdans
            Staphylococcus Albus
         ii) Gram Negative
            Escherichia Coli
            Cutrobacter Diversus
      c) Number of infections
   2. **History of Seizure(s)**
      a) Number of seizures
      b) Type of seizures
         Generalized
         Focal
         Focal then Generalized

B. **OCULAR SIGNS**
   1. **Gaze and Movement Group**
      a) Heterotropias
         Esotropria
         Exotropia
      b) Heterophorias
         Esophoria
         Exophoria
      c) Nystagmus

   2. **Refraction and Accommodation Group (+/- Gaze and Movement Deficit)**
      a) Hyperopias
      b) Astigmatism

   3. Normal Vision or Optic Papilla Disturbance only

C. **FUNCTIONAL MOTOR LEVEL**
   1. Severe Paraplegia (wheelchair or parapodium for mobility); L2 and above
   2. Moderate Paraplegia (involved spastic diplegia gait or use of leg braces or splints); L3-L5
   3. Mild Motor Problems (poor coordination; tight hamstrings; wide-based gait; hypermobile feet); S1 and below.

D. **HISTORY OF INTRAUTERINE HYDROCEPHALUS.**

2.3 MEDICAL VARIABLES

A large number of medical variables which were noted in the medical documentation, were selected for analysis for each subject (see Table 8). This selection of medical variables was based in part on the seminal work of Dennis and her associates (Dennis et al., 1981). These investigators have collected similar information on children with hydrocephalus and other early brain injuries. Through the use of statistical techniques, they have reduced the voluminous data of medical variables to a set of factors that can then be correlated with behavioural data (e.g., IQ scores).

In this study, using the categorization of variables approach taken by Dennis, the variables were grouped and analyzed under the following headings: 1) history of complications; 2) ocular abnormalities; 3) level of lesion; and 4) onset of hydrocephalus.

2.3.1 History of Complications

As outlined earlier, complications were defined as evidence of infections and/or seizures associated with a shunt placement.

According to laboratory reports based on the analysis of a collection of cerebro-spinal fluid, the presence or absence of a particular type of bacterial infection was noted (indicating the shunt was infected).

Seizure type was based on the Classification System of the International League Against Epilepsy. For the purpose of this study, seizures were classified as one of the following: a) focal seizure; b) focal then generalized seizure; c) generalized seizure.

(a) Focal Seizure

Focal seizures are those in which, the first clinical and electroencephalographic changes indicate initial activation of a system of neurons limited to part of one cerebral hemisphere. A focal (partial) seizure is classified primarily on the basis of whether or not consciousness is impaired during the attack. When consciousness is ot impaired, the seizure is classified as a simple partial seizure. When consciousness is impaired, the seizure is classified as a complex partial seizure. In addition, a partial seizure may progress to a generalized motor seizure.

(b) Generalized Seizure

Generalized seizures are those in which the first clinical changes indicate initial involvement of both hemispheres. Consciousness may be impaired and motor manifestations are bilateral. The initial electroencephalographic patterns in children with generalized seizures are bilateral, and presumably reflect neuronal discharge which is widespread in both hemispheres.

2.3.2 Abnormalities in Ocular Mobility and Acuity

Ocular abnormalities were classified into one of two groups described below: 1) Gaze and Movement group; 2) Refraction and Accommodation group.

(1) Gaze and Movement Group:

This group includes all children suffering from heterotropias, heterophorias, and/or nystagmus. Heterotropias (also referred to as strabismus or squint) refers to a condition in which there is a constant lack of parallelism of the visual axes of the eye. Heterotropias are generally one of the following varieties: (a) an esotropia or convergent strabismus in which the visual axes converge and (b) an exotropia or divergent strabismus in which the visual axes diverge.

Heterophorias can be classified as either an esophoria or an exophoria. An esophoria is a tendency of one eye to deviate inward whereas an exophoria is a tendency of one eye to deviate outward. Nystagmus is defined as a rhythmical oscillation of the eyeball, either horizontal, rotary or vertical.

(2) Refraction and Accommodation Group

This group of ocular abnormalities includes all children suffering from hyperopias and/or astigmatism. Hyperopia (farsightedness) is a condition, by which an error in refraction or flattening of the globe of the eye, results in parallel rays being focused behind the retina. Astigmatism is a condition of unequal curvatures along the different meridians in one or more of the refractive surfaces of the eye. The consequence of this, is that the rays are not focused at a single point on the retina, but are spread out in one or more directions.

2.3.3 Level of Lesion

The ability to ambulate is closely related to the level of the lesion (Asher & Olson, 1983). For this study, based on criteria selected by Sharrard (1964) and Shurtleff and his associates (Shurtleff, Hayden et al., 1975), the subjects were grouped by functional motor activity, i.e., L2 and above; L3-L5; and S1 and below. L2 and above indicates that the lesion is at or above the second lumbar vertebra. All patients in this group are wheelchair bound. L3-L5 indicates that the lesions are between the third and fifth lumbar vertebra. Most of these patients walk effectively with aids, surgical operation, and/or extensive bracing. S1 indicates lesions at or below the first sacral vertebra. Essentially all of these children walk with minimal aids.

2.3.4 Onset of Hydrocephalus

Classification of childrn with intrauterine hydrocephalus versus those children who develop hydrocephalus after birth was based on head circumference. Children with a head circumference at birth above the 98th percentile were classified as having intrauterine hydrocephalus.

CHAPTER 3

RESULTS

3.1 PRELIMINARY CONSIDERATIONS AND OBSERVATIONS

3.1.1 Statistics

Due to the nature of the clinical population investigated, a large sample size was unobtainable. All raw scores were converted into T-score form (mean = 50, standard deviation = 10), using available normative data. This enabled ease of comparison between tests and provided some consistency in the levels of performance between the various age groups.

All statistical analysis were performed using the Statistical Package for the Social Sciences (1986). Different portions of the data set were used to evaluate the hypotheses of the study.

To aid interpretation, the analyses are divided into four sections. These can be summarized as follows: Section 1 investigates the hypothesis outlined earlier under Objectives 1. To recapitulate, objective 1 addresses the question: Do children with myelomeningocele and hydrocephalus show a characteristic profile on neuropsychological testing?. Section 2 involves an investigation of the behavioural sequelae that may be associated with myelomeningocele. Section 3 investigates the issue of whether or not there is a relationship between socio-demographic variables and cognitive test performance. Finally, Section 4 investigates the issue of whether or not there is a relationship between certain medical variables and cognitive test performance.

3.2 SECTION 1 - NATURE OF ABILITY STRUCTURE

This section investigates the performance of the myelomeningocele sample on a battery of neuropsychological measures. As outlined earlier, the measures were divided into nine skill areas: 1) Psychometric Intelligence; 2) Language; 3) Memory and Learning; 4) Visual-Spatial/ Constructional; 5) Attention and Psychomotor Efficiency; 6) Problem Solving and Reasoning; 7) Tactile-Perceptual; 8) Motor; and 9) Academic Achievement.

Table 9 rank orders the various neuropsychological means in terms of the degree to which they deviate from the normative mean (i.e., 1 or more standard deviations below the mean T-score). Graphic display of this data is presented in Figure 1. More detailed descriptive statistics of the neuropsychological measures for the myelomeningocele children are presented in Tables 10 through 18. Given the nature of the comparisons, the analyses that follow should be interpreted with caution and subjected to replication.

Hypothesis one predicted that children with myelomeningocele and hydrocephalus would perform more poorly on certain test domains relative to age-norms. This hypothesis was supported. A series of Z-tests were performed comparing the myelomeningocele children on the neuropsychological measures to the normative mean ($\bar{X} = 50$; SD = 10; see Tables 10 to 18).

TABLE 9

Neuropsychological Measures: Summary of Deviations of T-Score From Mean

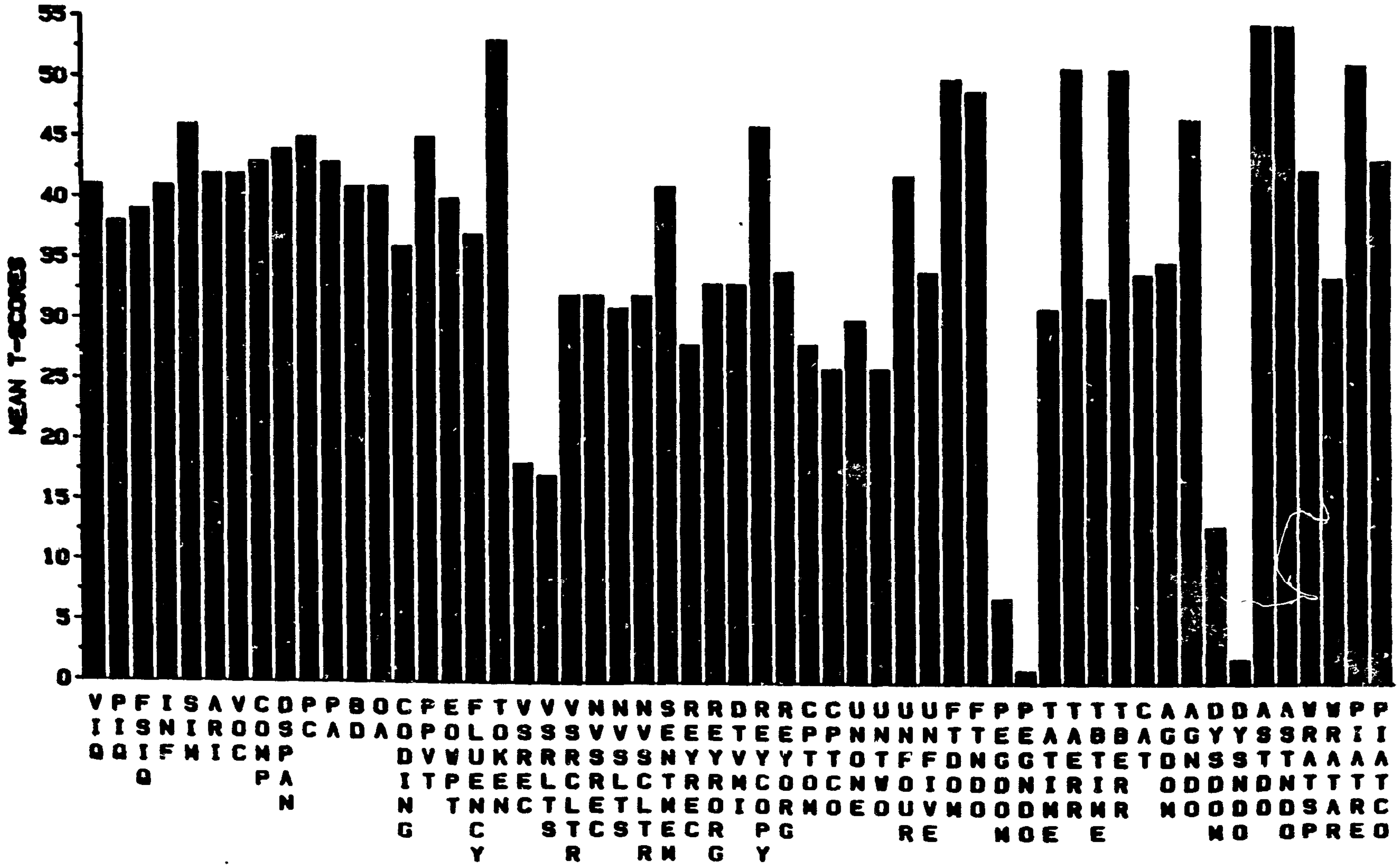
Above 50	50-41 (Average)	40-31 (1 SD Below)	30-21 (2 SD Below)	20-11 (3 SD Below)	10-0 (4 SD Below)
Token (Part 5)	VIQ	PIQ	Rey-Recall	VSRT - Recall	Grooved Pegboard (Bilateral)
	WISC-R Subtests	FSIQ	CPT - Omission and Commission Errors	VSRT - LTS	Dysgraphesthesia (nondominant hand)
	Information	Coding Subtest		Dysgraphesthesia (dominant hand)	
PIAT - Reading Recognition	Similarities	Fluency	Underlining Subtests #1 and #2		
	Arithmetic	EOWPT			
	Vocabulary				
	Comprehension	VSRT-CLTR			
	Digit Span	NVRST-Recall			
	Picture Completion	NVRST-LTS			
		NVRST-CLTR			
	Picture Arrangement	Rey-Figure Reorganization			
	Block Design	DTVMI			
	Object Assembly	Category			
	PPVT-R				
	Sentence Memory	Agnosia (dominant hand)			
	Rey-Figure Copy	Arithmetic Subtest			
	Underlining - Subtest #4	Underlining Subtest #5			
	Finger-Tapping (Bilateral)				

Legend:

CLTR - Consistent Long-Term Retrieval
CPT - Continuous Performance Test
DTVMI - Developmental Test of Visuomotor Integration
EOWPT - Expressive One Word Picture Test
LTS - Long-Term Storage
NVSRT - Nonverbal Selective Reminding Test
PIAT - Peabody Individual Achievement Test
PPVT-R - Peabody Picture Vocabulary Test-Revised
VSRT - Verbal Selective Reminding Test

FIGURE 1

Mean T-Scores for Neuropsychological Tests



See legend on next page.

Legend for Figure 1

AGDOM - Agnosia: Dominant Hand

AGNDO - Agnosia: Nondominant Hand

ARI - Arithmetic

ASTDO - Astereognosis: Dominant

ASTNDO - Astereognosis: Nondominant

BD - Block Design

CODING - Coding subtest

COMP - Comprehension

CPTCO - Continuous Performance Test - Commission Errors

CPTOM - Continuous Performance Test - Omission Errors

DSPAN - Digit Span

DTVMI - Developmental Test of Visual-Motor Integration

DYSDOM - Dysgraphesthesia: Dominant Hand

DYSNDO - Dysgraphesthesia: Nondominant Hand

EOWPT - Expressive One-Word Picture Test

FLUENCY - Fluency Test

FSIQ - Full Scale IQ

FTDOM - Finger-Tapping Test - Dominant Hand

FTNDO - Finger-Tapping Test - Nondominant Hand

INF - Information

NVSCLTR - Nonverbal Selective Reminding Test - Consistent Long-Term Retrieval

NVSLTS - Nonverbal Selective Reminding Test - Long-Term Storage

NVSREC - Nonverbal Selective Reminding Test - Recall Condition

OA - Object Assembly

PA - Picture Arrangement

PC - Picture Completion

PEGDOM - Pegboard Test - Dominant Hand

PEGNDO - Pegboard Test - Nondominant Hand

PIATCO - Peabody Individual Achievement Test - Comprehension Subtest

PIATRE - Peabody Individual Achievement Test - Reading Recognition Subtest

PIQ = Performance IQ
PPVT = Peabody Picture Vocabulary Test
REYCOPY = Rey Figure - Copy
REYORG = Rey Figure - Organizational Skill
REYREC = Rey Figure - Recall Condition
REYRORG = Rey Figure - Recall - Organizational Skill
SENTMEM = Sentence Memory
SIM = Similarities
TAERR = Trails A: Errors
TATIME = Trails A: Time
TBERR = Trails B: Errors
TBTIME = Trails B: Time
TOKEN = Token Test
UNFIVE = Underlining Test: Subtest 5 (4 letter nonsense syllable)
UNFOUR = Underlining Test: Subtest 4 (Gestalt Figure)
UNONE = Underlining Test: Subtest 1 (Number)
UNTWO = Underlining Test: Subtest 2 (Geometric Form)
VIQ = Verbal IQ
VOC = Vocabulary
VSRCLTR = Verbal Selective Reminding Test - Consistent Long-Term Retrieval
VSREC = Verbal Selective Reminding Test - Recall Condition
VSRLTS = Verbal Selective Reminding Test - Long-Term Storage
WRATSP = Wide Range Achievement Test: Spelling Subtest
WRATAR = Wide Range Achievement Test: Arithmetic Subtest

Z-tests comparing mean scores indicate that the myelomeningocele children were significantly different from the normative mean on all measures within each of the following domains: 1) Intellectual (see Tables 10 - 11); 2) Memory and Learning (see Table 11); 3) Construction (see Table 13); 4) Attention (see Table 15); and 5) Problem Solving (see Table 14).

With regard to Language ability, significant differences emerged on three of the four measures: the PPVT ($z = -2.90$. $p<.01$); EOWPT ($z = -5.52$, $p<.001$); and Fluency ($z = -7.61$, $p<.001$) measures (see Table 12). Inspection of the Motor skill area, revealed significant differences on the Grooved Pegboard Test for the dominant ($z = - 25.54$, $p<.001$) and nondominant hand ($z = -33.46$, $p<.001$); amount of time required to complete Trails A ($z = - 10.68$, $p<.001$) and Trails B ($z = -10.59$, $p<.001$ see Table 16). However, no significant differences emerged for the Finger-Tapping measure or the amount of errors on Trails A and B. Within the Academic area, significant differences emerged on the Spelling ($z = -3.84$, $p<.001$) and Arithmetic ($z = -9.48$, $p<.001$) subtests of the WRAT-R; and the Reading Comprehension ($z = -3.34$, $p<.001$) subtest of the PIAT. No significant differences were found on the Reading Recognition subtest of the PIAT (see Table 17).

Within the Tactile-Perceptual skill area, Agnosia for the dominant hand ($z = -8.52$, $p<.001$); Dysgraphesthesia for both the dominant ($z = -21.89$, $p<.001$) and nondominant hand ($z = -28.44$, $p<.001$); the remaining measures did not differ significantly from the norms (see Table 18).

TABLE 10

Intellectual Ability: Descriptive Statistics
(in T-scores) and Z-Test Results

	N	Mean	Stdev	Median	Min	Max	Z-value
VIQ	36	41.611	9.275	40.000	28.000	68.670	-5.03***
PIQ	36	38.907	11.542	40.000	13.330	72.000	-6.66***
FSIQ	36	39.370	9.463	38.667	23.330	62.000	-6.38***
Verbal Subtests							
Information	36	41.944	10.761	41.667	20.000	73.330	-4.83***
Similarities	36	46.111	8.067	43.333	30.000	66.670	-2.33**
Arithmetic	36	42.870	7.608	43.333	30.000	60.000	-4.28***
Vocabulary	36	42.222	10.690	40.000	23.330	76.670	-4.67***
Comprehension	36	43.611	8.669	43.333	26.670	66.670	-3.83***
Digit Span	36	44.167	9.607	43.333	30.000	63.330	-3.50***

Note: All values represent one-tailed tests
** $p<.01$ *** $p<.001$

TABLE 11

Intellectual Ability: Descriptive Statistics
(in T-scores) and Z-Test Results

	N	Mean	Stdev	Median	Min	Max	Z-value
Performance Subtests							
Picture Completion	36	45.185	11.140	46.667	20.000	76.670	-2.89**
Picture Arrangement	36	43.333	10.631	43.333	20.000	63.330	-4.00***
Block Design	36	41.759	10.910	43.333	20.000	63.330	-4.94***
Object Assembly	36	41.204	14.078	41.667	20.000	80.000	-5.28***
Coding	36	36.111	10.063	36.667	20.000	60.000	-8.33***

Note: All values represent one-tailed tests
** $p<.01$ *** $p<.001$

TABLE 12

Language Ability: Descriptive Statistics
(in T-scores) and Z-Test Values

	N	Mean	Stdev	Median	Min	Max	Z-value
Peabody Picture Vocabulary Test	36	45.167	11.561	44.000	28.000	72.670	-2.90**
Expressive One-word Picture Test	36	40.796	10.354	42.[illegible]00	20.000	64.670	-5.52***
Fluency	36	37.321	10.944	38.214	14.290	71.140	-7.61***
Token Test	35	53.547	13.273	56.471	18.300	66.170	2.10

<u>Note</u>: All values represent one-tailed tests
** *p*<.01 *** *p*<.001

TABLE 13

Memory Ability: Descriptive Statistics
(in T-scores) and Z-Test Results

	N	Mean	Stdev	Median	Min	Max	Z-value
<u>Verbal Memory</u>							
VSRT-Recall[1]	17	18.048	23.493	12.542	-26.440	68.130	-13.17***
VSRT-LTS	36	17.784	23.784	19.446	-56.760	60.730	-19.33***
VSRT-CLTR	36	32.331	13.353	29.016	14.250	72.680	-10.60***
Sentence Memory	36	41.913	11.650	45.652	16.170	63.040	-4.85***
<u>Nonverbal Memory</u>							
NVSRT-Recall	36	32.196	11.282	34.520	9.000	50.790	-10.68***
NVSRT-LTS	36	31.818	11.516	29.950	15.270	56.950	-10.91***
NVSRT-CLTR	36	32.618	6.603	31.378	23.520	48.420	-10.43***
Rey Figure - Recall	36	28.486	11.231	25.099	11.730	55.290	-12.91***
Rey Figure - Reorgan-ization	36	33.518	5.895	32.439	25.800	47.480	-9.89***

[1]VSRT - Verbal Selective Reminding Test
NVSRT - Nonverbal Selective Reminding Test
LTS - Long-term Storage
CLTR - Consistent Retrieval

** $p<.01$ one-tailed *** $p<.001$ one-tailed

TABLE 14

Construction and Problem-Solving Abilities:
Descriptive Statistics (in T-scores) and Z-Test Results

	N	Mean	Stdev	Median	Min	Max	Z-value
<u>Construction</u>							
DTVMI[1]	36	33.333	10.983	36.667	20.000	56.670	-10.000***
Rey Figure - Copy	36	46.486	8.805	47.864	23.560	58.980	-2.11*
Rey Figure - Organization	36	34.762	8.882	33.480	21.100	52.440	-9.14***
<u>Problem-Solving</u>							
Halstead Category	36	34.432	14.645	33.073	5.330	68.670	-9.34***

[1]DTVMI = Developmental Test of Visuomotor Integration

<u>Note</u>: All values represent one-tailed tests
** $p<.01$ *** $p<.001$

TABLE 15

Attention: Descriptive Statistics (in T-scores) and Z-Test Results

	N	Mean	Stdev	Median	Min	Max	Z-value
CPT (omission error)[1]	34	28.982	41.463	41.135	-160.630	64.000	-12.26***
CPT (commission errors)	34	26.140	39.332	39.584	-71.850	65.330	-13.91***
Underlining Subtest 1	34	30.529	10.940	31.477	9.590	59.440	-11.35***
Underlining Subtest 2	33	26.291	13.581	29.284	-.470	49.550	-13.62***
Underlining Subtest 4	33	42.057	8.310	41.915	27.950	59.450	-4.56***
Underlining Subtest 5	33	34.850	9.278	34.038	12.110	64.930	-8.70***

[1]CPT = Continuous Peformance Test

*** p,.001 one-tailed

TABLE 16

Motor Ability: Descriptive Statistics (in T-scores) and Z-Test Results

	N	Mean	Stdev	Median	Min	Max	Z-value
Finger-tapping (dominant)	36	50.635	17.654	53.510	13.760	80.420	.38
Finger-tapping (nondominant)	36	49.675	13.962	51.928	22.960	74.790	-.20
Pegs (dominant)	36	7.441	45.963	19.333	-178.00	58.750	-25.54***
Pegs (nondominant)	35	-6.555	70.693	15.356	-336.80	63.640	-33.46***
Trails A (time)	35	31.945	22.188	34.000	-59.960	63.640	-10.68***
Trails A (error)	35	51.495	19.344	53.000	-13.670	76.670	.88
Trails B (time)	35	32.101	22.415	35.625	-52.790	72.500	-10.59***
Trails B (error)	35	51.532	14.472	46.250	44.170	106.870	.91

<u>Note</u>: All values represent one-tailed tests
** *p*<.01 *** *p*<.001

TABLE 17

Academic Ability: Descriptive Statistics (in T-scores) and Z-Test Results

	N	Mean	Stdev	Median	Min	Max	Z-value
WRAT-R Spelling	36	43.593	11.513	46.667	20.000	64.670	-3.84***
WRAT-R Arithmetic	36	34.204	9.952	34.000	14.000	51.330	-9.48***
PIAT-Reading Recognition	35	52.381	12.874	53.333	19.330	70.670	1.41
PIAT-Reading Comprehension	36	44.426	11.965	45.333	12.670	65.330	-3.34***

Note: All values represent one-tailed tests
** $p<.01$ *** $p<.001$

TABLE 18

Tactile-Perceptual Ability: Descriptive Statistics (in T-scores) and Z-Test Results

	N	Mean	Stdev	Median	Min	Max	Z-value
Agnosia (dominant)	36	35.792	46.419	54.000	-190.000	70.000	-8.52***
Agnosia (nondominant)	36	47.278	18.869	56.000	-24.00	60.000	-1.63
Dysgraphethesia (dominant)	36	13.524	57.761	25.446	-268.180	62.500	-21.89***
Dysgraphethesia (nondominant)	36	2.597	70.370	24.745	-295.610	70.240	-28.44***
Astereognosis (dominant)	36	58.599	8.439	60.769	13.810	62.000	5.16
Astereognosis (nondominant)	36	55.689	14.732	62.381	-3.330	65.000	3.41

Note: All values represent one-tailed tests
** $p<.01$ *** $p<.001$

In summary, of the 55 neuropsychological tests administered the mean t-score obtained by the myelomeningocele sample on nine of the variables did not differ significantly from the norms (16.36% of the tests administered). It was hypothesized that the myelomeningocele children would perform as well as the normative sample on two of the nine measures (1) verbal comprehension (Token Test) and (2) single-word reading (PIAT-Reading Recognition subtest).

Of the 46 tests that were significant, as anticipated, the myelomeningocele sample as a group performed below the level expected for their age (83.63% of the tests administered).

As mentioned in the Method section, 4 children were excluded from the analyses on the basis of a low FSIQ WISC-R score. It was thought that in order to obtain a more accurate picture of the heterogeneity of the cognitive abilities of this clinical population, that the WISC-R test results of these children be examined in conjunction with the thirty-six children who met the criteria for participation in the study.

The mean VIQ T-score for the entire sample (n = 40) fell within the lower end of the Low Average range (see Tables 19 & 20). When the four children were excluded from the analyses (n = 36), the mean VIQ score improved to the upper end of the low Average range (see Table 19). The mean PIQ T-score for the entire sample (n = 40) fell within the upper end of the Borderline range. When the four children were excluded from the analyses (n = 36), the mean PIQ score improved to the lower end of the Low Average range. With regard to the FSIQ, when the four children were included in the analyses (n = 40), although the mean score was lower, their scores did not change the range within which the score fell (i.e., lower end of the Low Average range).

Inspection of the WISC-R subtests, found that when the four children were included in the analysis (n = 40), the following subtest scores fell one standard deviation below the mean: Information, Vocabulary, Block Design, and Object Assembly. These subtest scores were in the average range when the four children were excluded from the analysis (see Tables 19 & 20).

Examination of the entire set of neuropsychological variables (n = 36 subjects) revealed considerable variation within measures as indicated by the wide range of abilities. In particular, the standard deviations indicate marked variation within many of the measures, indicating that while this is a homogenous sample in terms of etiology, there is much heterogeneity in terms of cognitive abilities. This issue of heterogeneity will be addresses more extensively in Section 3.4.

TABLE 19

Intellectual Domain: Descriptive Statistics
in T-Score Units (in Standardized WISC-R Form)

	N = 36		N = 40	
	Mean	Stdev	Mean	Stdev
VIQ	41.611 (87.417)	9.275 (13.913)	39.400 (84.10)	11.138 (16.707)
PIQ	38.907 (83.361)	11.542 (17.313)	36.583 (79.875)	13.027 (19.540)
FSIQ	39.370 (84.056)	9.463 (14.194)	36.867 (80.3)	11.793 (17.690)
Verbal Subtests				
Information	41.944 (7.583)	10.761 (3.228)	40.333 (7.100)	11.468 (3.440)
Similarities	46.111 (8.833)	8.067 (2.420)	43.833 (8.150)	10.393 (3.118)
Arithmetic	42.870 (7.861)	7.608 (2.282)	41.167 (7.350)	8.885 (2.666)
Vocabulary	42.222 (7.667)	10.690 (3.207)	40.667 (7.200)	11.403 (3.421)

TABLE 20

Intellectual Domain: Descriptive Statistics in T-Score Units (in Standardized WISC-R Form)

	N = 36		N = 40	
	Mean	Stdev	Mean	Stdev
<u>Verbal Subtests</u>				
Comprehension	43.611 (8.083)	8.669 (2.601)	41.750 (7.525)	10.042 (3.013)
Digit Span	44.167 (8.250)	9.607 (2.882)	42.833 (7.850)	10.227 (3.068)
<u>Performance Subtests</u>				
Picture Completion	45.185 (8.556)	11.140 (3.342)	43.583 (8.075)	11.679 (3.504)
Picture Arrangements	43.333 (8.000)	10.631 (3.189)	41.250 (7.375)	11.975 (3.593)
Block Design	41.759 (7.528)	10.910 (3.273)	40.083 (7.025)	11.633 (3.490)
Object Assembly	41.204 (7.361)	14.078 (4.223)	39.250 (6.775)	14.627 (4.388)
Coding	36.111 (5.833)	10.063 (3.019)	34.583 (5.375)	10.613 (3.184)

3.3 SECTION 2 - BEHAVIOURAL SEQUELAE

This section contains a summary of the performance of the myelomeningocele sample on a selection of behavioural measures. The measures were divided into two domains; 1) Self-Concept; and 2) Behavioural and Social Competence. Table 21 rank orders the various behavioural means in terms of the degree to which they deviate from the normative mean (i.e., 1 or more standard deviations from the normative mean). It should be kept in mind that in the case of the Personality Inventory for Children (PIC), as well as the Achenbach Child Behaviour Checklists, a score greater than the normative mean is in the deviant direction. Graphic display of this data is presented in Figures 2 to 4.

More detailed descriptive statistics of the behavioural measures for the myelomeningocele children are presented in Tables 22 through 36. As was found with the neuropsychological measures, marked variation was evident within each measure.

Hypothesis 2 predicted that children with myelomeningocele will have low self-esteem, exhibit an external locus of control, and obtain high scores on the internalizing scales of the Achenbach scales (Parent and Teacher's versions of the Child Behaviour Checklist). This hypothesis was partially supported. A series of Z-tests were performed comparing the clinical sample with the normative data (see Tables 22-36).

TABLE 21

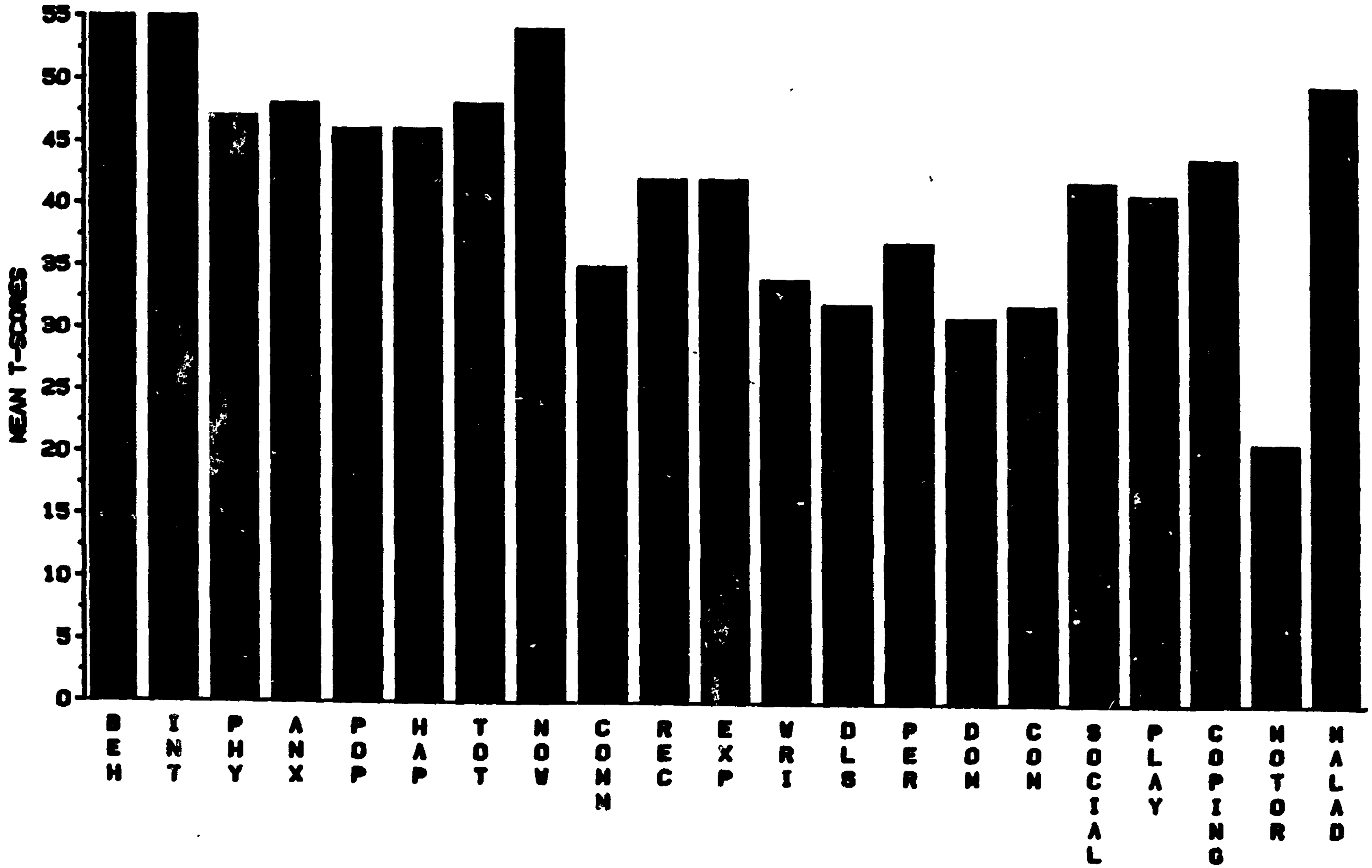
Behavioural Measures: Summary of T-Score Deviations From Mean

1 SD	**2 SD**	**3 SD**
PIC[1] Scales	PIC Scales	PIC Scales
- F-S Scale	- Cognitive	Intellectual Status
- Depression Scale	- Adjustment	
- Withdrawal Scale	- Delinquency	
- Hyperactivity Scale	- Psychosis	
Parent Achenbach		
- Social Competence Scale		
- Subdomains - Activities		
- Social		
- School		
Vineland Adaptive Scale	Vineland Adaptive Scale	
- Communication Domain	- Estimated Motor Domain	
- Daily Living Domain		
Subdomains		
- Written		
- Personal		
- Domestic		
- Community		

[1]Personality Inventory for Children

FIGURE 2

Mean T-Scores for Piers-Harris Self-Concept Scale and the Vineland Adaptive Behaviour Scale



See legend on next page.

Legend for Figure 2

ANX = Piers-Harris Anxiety Subscale

BEH = Vineland Behaviour Subscale

COM = Vineland Community Subdomain

COMM = Vineland Communication Domain

COPING = Vineland Coping Subdomain

DLS = Vineland Daily Living Skills Domain

DOM = Vineland Domestic Subdomain

EXP = Piers-Harris Expressive Subdomain

HAP = Piers-Harris Happiness and Satisfaction

INT = Vineland Intellectual and School Status

MALAD = Vineland Maladaptive Domain

MOTOR = Vineland Motor Domain

NOW = Nowicki-Strickland Locus of Control

PER = Piers-Harris Personal Subdomain

PHY = Vineland Physical Appearance and Attributes

PLAY = Piers-Harris Play and Leisure Subdomain

POP = Vineland Popularity

REC = Vineland Receptive Subdomain

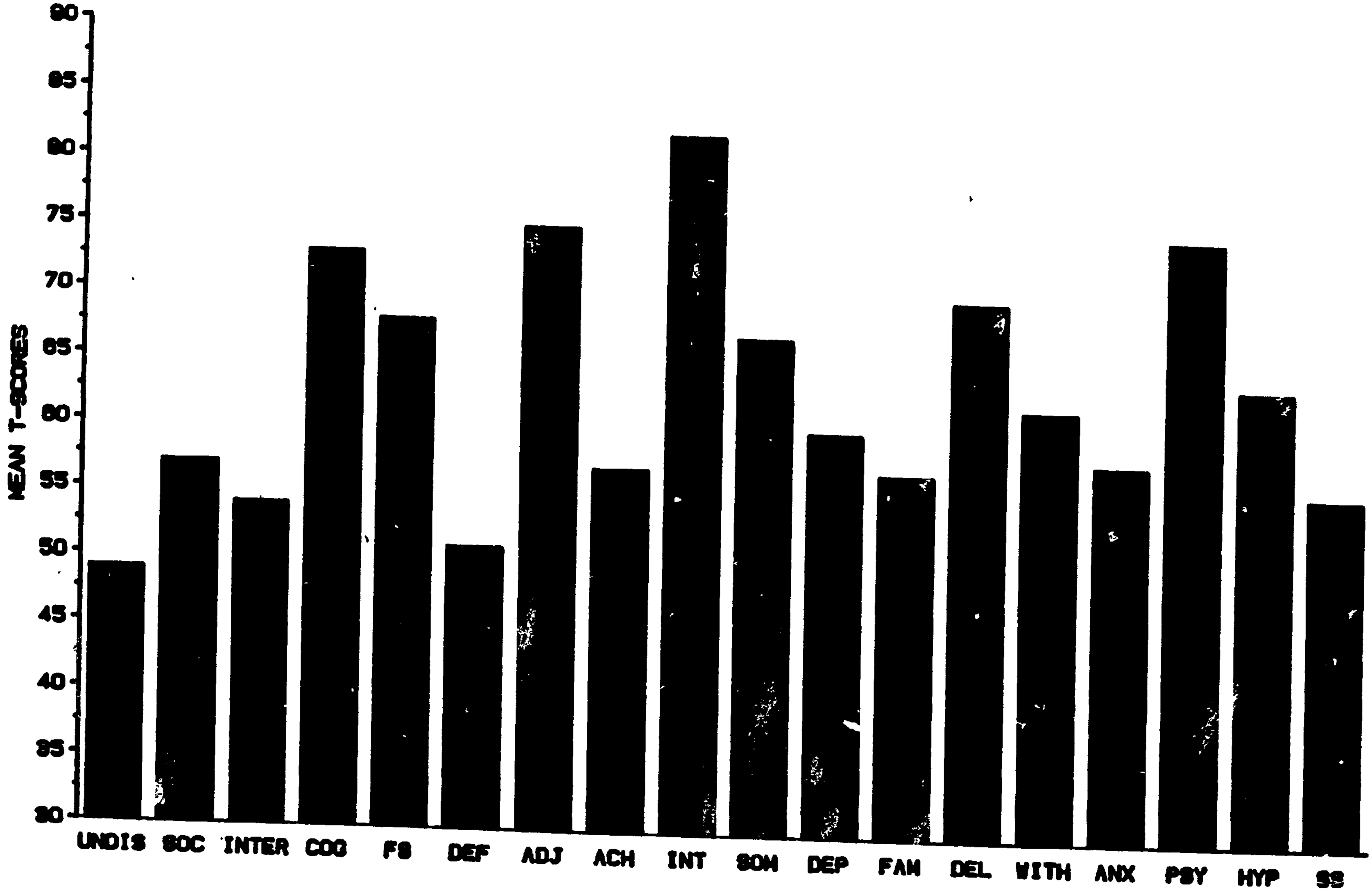
SOCIAL = Piers-Harris Socialization domain

TOT = Vineland Total Score

WRI = Vineland Written Subdomain

FIGURE 3

Mean T-Scores for Personality Inventory for Children



See legend on next page.

Legend for Figure 3

Personality Inventory for Children

ACH = Achievement

ADJ = Adjustment

ANX = Anxiety

COG = Cognitive Development

DEF = Defensiveness

DEL = Delinquency

DEP = Depression

FAM = Family Relations

FS = F-Scale

HYP = Hyperactivity

INT = Intellectual Screening

INTER = Internalization/Somatic Symptoms

PSY = Psychosis

SOC = Social Incompetence

SOM = Somatic Concern

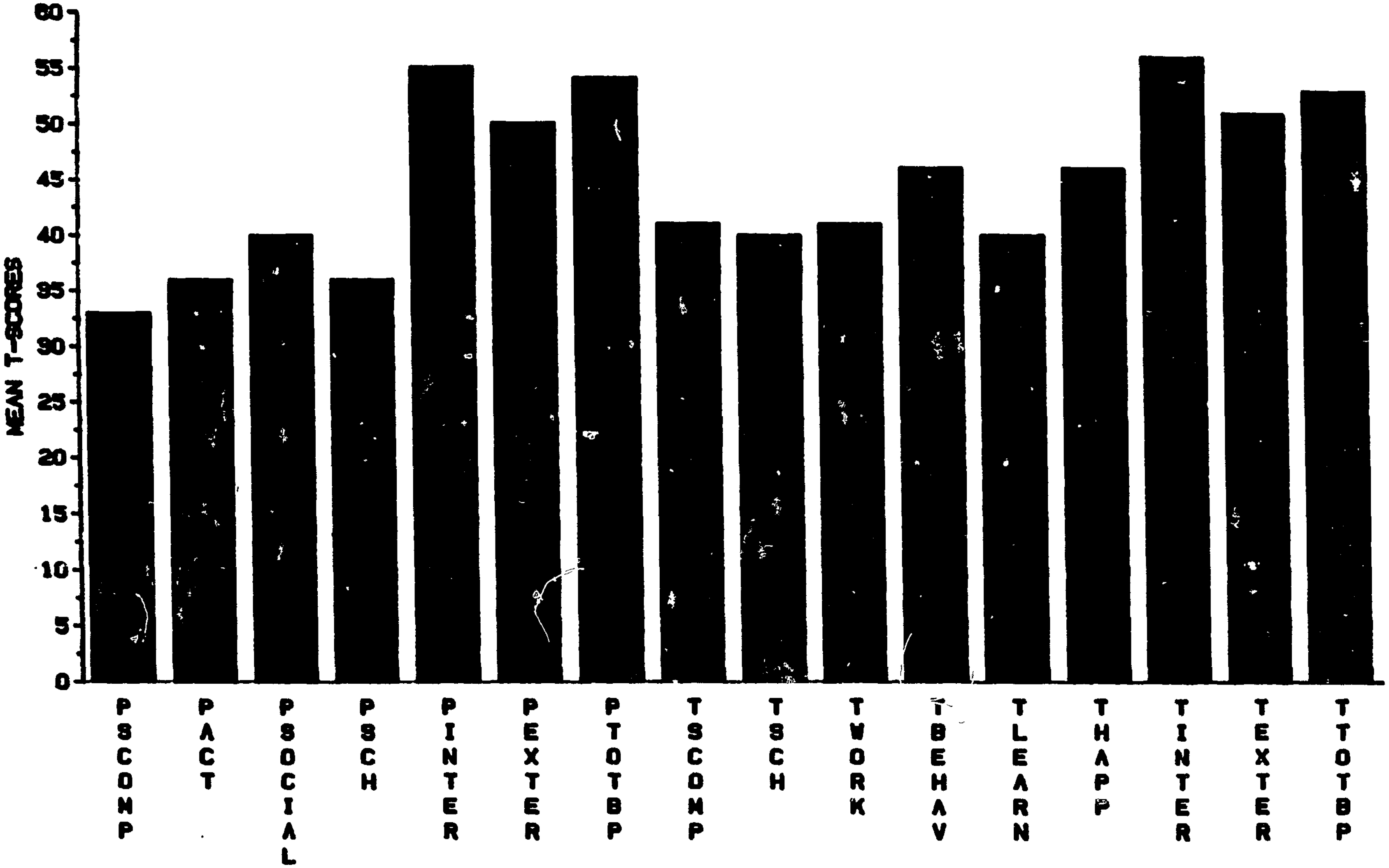
SS = Social Skills

UNDIS = Undisciplined Scale

WITH = Withdrawal

FIGURE 4

Mean T-Scores for Parent and Teacher
Achenbach Summary Scales



See legend on next page.

Legend for Figure 4

Parent Achenbach

PACT = Activities Subscale

PEXTER = Externalizing

PINTER = Internalization

PSCH = School Subscale

PSCOMP = Social Competence Scale

PSOCIAL = Social Subscale

PTOTBP = Total Problems

Teacher Achenbach

TBEHAV = Behaving

TEXTER = Externalizing

THAPP = Happy

TINTER = Internalization

TLEARN = Learning

TSCH = School Performance

TSCOMP = Social Competence

TTOTBP = Total Problems

TWORK = Working

Self-Concept was assessed using the Nowicki-Strickland Locus-of Control measure and the Piers-Harris Self- Concept scale. Of the 7 scales in the Piers-Harris Self-Concept scale, only the Popularity ($z = -2.31$, $p<.05$); and Happiness and Satisfaction ($z = -2.04$, $p<.05$) scales were significantly different from the norm (see Table 22). A significant difference emerged on the Nowicki-Strickland Locus of Control scale ($z = 2.84$, $p<.01$ see Table 22) in the predicted direction.

Inspection of the Behaviour-and Social Competence area showed that significant group differences emerged for all measures within the Vineland Adaptive Behaviour Scale (see Tables 23 & 24), except the Maladaptive scale ($z = .14$, $p>.05$).

The hypothesis that the myelomeningocele sample would exhibit personality problems was partly supported. Examination of the individual scales of the Personality Inventory Scale for Children (PIC) revealed that the myelomeningocele sample differed significantly from the normative data on all but one of the PIC scales; Undisciplined ($z = -.28$, $p>.05$) scale (see Table 25).

Tables 27 to 36 provide information on the Achenbach Child Behaviour Checklists (Parent and Teacher versions). The hypothesis that myelomeningocele children would receive higher ratings on the Internalizing dimension of the Child Behaviour Checklist was supported ($z = 3.00$, $p<.01$). They were also found to differ on the Total Behaviour Problem Composite Score ($z = 2.91$, $p<.01$), as well as the Social Competence Composite score ($z = -8.27$, $p<.001$ see Table 27). Examination of the individual behaviour scales revealed that for boys 9-11 years of age, the myelomeningocele sample was rated significantly higher on the Schizoid-Anxious ($z = 3.03$, $p<.01$); Obsessive-Compulsive ($z = 1.68$, $p<.05$); Somatic ($z = 1.72$, $p<.05$) and Hyperactive ($z = 2.00$, $p<.05$) scales (see Table 28). For boys 12 to 16 years of age, the myelomeningocele sample was rated significantly higher on the Somatic scale ($z = 2.07$, $p<.05$ see Table 29). Inspection of the female behaviour scales, reveals that for girls 9 to 11 years of age, the myelomeningocele sample had significantly higher ratings on the Social Withdrawal ($z = 2.72$, $p<.01$) and Hyperactive ($z = 2.13$, $p<.05$) scales (see Table 30). For girls 12 to 16 years of age, the myelomeningocele sample rated significantly higher on the Somatic ($z = 2.58$, $p<.01$); Depressed-Withdrawn ($z = 2.26$, $p<.05$); Immature-Hyperactive ($z = 3.10$, $p<.001$) and Cruel ($z = 1.78$, $p<.05$) scales (see Table 31).

Inspection of the Teacher's Behaviour Checklist reveals that similar to the Parent CBCL, significant differences emerged on the Internalizing dimension ($z = 3.32$, $p<.001$); Total behaviour ($z = 1.90$, $p<.05$) and Social Competence ($z = -4.40$, $p<.001$) summary scales (see Table 32).

Examination of the individual behaviour scales reveals that for Boys 9 to 11 years of age, the myelomeningocele group was rated significantly higher on the Social Withdrawal ($z = 1.72$, $p<.05$) and Inattentive ($z = 2.61$, $p<.01$) scales (see Table 33). For boys 12 to 16 years of age, statistical significant differences did not emerge on any of the behaviour scales (see Table 34). For girls 9 to 11 years, the myelomeningocele group was rated significantly higher on the Social Withdrawal ($z = 3.01$, $p<.01$); Self-Destructive ($z = 1.84$, $p<.05$) and Inattentive ($z = 2.33$, p<.01) scales (see Table 35). For girls 12 to 16 years of age, the myelomeningocele sample was rated significantly higher on the Anxious ($z = 2.51$, $p<.01$); Depressed ($z = 3.48$, $p<.001$); Immature ($z = 3.65$, $p<.001$); Self-destructive (3.79, $p<.001$); Inattentive ($z = 2.06$, $p<.05$) and Unpopular ($z = 2.57$, $p<.05$) scales (see Table 36).

TABLE 22

Self-Concept Ability: Descriptive Statistics
(in T-scores) and Z-Test Results

	N	Mean	Stdev	Median	Min	Max	Z-value
Nowicki-Strickland (Locus of Control)	36	54.740	11.071	54.013	31.270	79.920	2.84**
<u>Piers-Harris</u>							
Behaviour	36	55.876	9.075	56.849	29.450	65.030	3.53
Intellectual and School Status	36	48.911	9.174	49.608	25.220	62.900	-.65
Physical Appear-ance & Attributes	36	47.706	9.411	49.439	24.880	63.470	-1.38
Anxiety	36	48.899	10.943	49.336	28.350	72.120	-.66
Popularity	36	46.147	10.144	45.764	24.880	66.010	-2.31*
Happiness and Satisfaction	36	46.605	13.056	49.617	4.510	60.550	-2.04*
Total Behaviour	36	48.665	9.372	49.127	28.390	62.960	-.78

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE 23

Behaviour and Social Competence Ability:
Descriptive Statistics (in T-scores) and Z-Test Results

	N	Mean	Stdev	Median	Min	Max	Z-value
<u>Vineland Adaptive Domains</u>							
Communication	36	35.222	10.385	35.000	16.000	56.670	-8.87***
Daily Living Skills	36	32.630	13.677	35.333	-2.670	51.330	-10.42***
Socialization	36	42.407	9.759	42.667	22.000	63.330	-4.56***
Motor (estimated)	36	21.815	14.534	16.333	3.330	55.330	-16.91***
Maladaptive	36	50.231	6.762	47.941	41.480	68.870	.14
<u>Vineland Subdomain Communication</u>							
Receptive	36	42.444	28.889	52.500	-72.500	55.000	-4.53***
Expressive	36	42.730	10.269	41.818	23.640	60.590	-4.36***
Written	36	34.415	13.081	35.477	-5.260	56.030	-9.35***

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE 24

Behaviour and Social Competence Ability:
Descriptive Statistics (in T-scores) and Z-Test Results

	N	Mean	Stdev	Median	Min	Max	Z-value
Vineland Subdomains							
<u>Daily Living Skills</u>							
Personal	36	37.951	26.536	44.934	-52.400	69.600	-7.23***
Domestic	36	31.780	10.318	35.759	1.220	46.150	-10.93***
Community	36	32.563	15.342	37.474	-20.210	52.140	-10.46***
<u>Socialization</u>							
Interest	36	46.165	17.088	47.050	-35.650	73.040	-2.30*
Play	36	41.367	11.638	41.795	4.120	62.310	-5.18***
Coping Skills	36	44.323	11.096	45.174	9.430	62.040	-3.41***

<u>Note</u>: All values represent one-tailed tests
* p<.05 ** p<.01 *** p<.001

TABLE 25

Behaviour and Social Competence:
Descriptive Statistics (in T-scores) and Z-Test Results

	N	Mean	Stdev	Median	Min	Max	Z-value
PIC[1] - Factor Scales							
Undisciplined	34	49.512	10.599	47.411	40.100	82.140	-.28
Social Incompetence	34	57.934	11.007	55.943	39.490	81.250	4.63***
Internalization/ Somatic Symptoms	34	54.635	11.376	53.709	39.160	89.340	2.70**
Cognitive Development	34	73.194	16.378	72.894	46.220	113.580	13.52***
F-Scale	34	68.958	15.096	64.063	47.800	101.560	11.05***
Defensiveness	34	51.703	13.040	52.958	17.750	74.430	.99
Adjustment	34	75.895	11.012	73.549	60.630	108.980	15.10***

[1]PIC - Personality Inventory for Children

Note: All values represent one-tailed tests
** $p<.01$ *** $p<.001$

TABLE 26

Behaviour and Social Competence:
Descriptive Statistics (in T-scores) and Z-Test Results

	N	Mean	Stdev	Median	Min	Max	Z-value
<u>PIC - Clinical Scales</u>							
Achievement	34	57.266	9.222	57.288	40.430	75.220	4.24***
Intellectual Screening	34	82.857	23.833	77.534	41.430	151.550	19.16***
Somatic Concern	34	67.407	11.163	66.955	46.120	100.610	10.15***
Depression	34	60.274	13.087	58.761	41.300	89.200	5.99***
Family Relations	34	57.133	11.933	55.438	41.610	94.610	4.16***
Delinquency	34	70.275	10.542	68.025	49.510	96.650	11.82***
Withdrawal	34	62.605	9.991	63.472	43.230	79.520	7.35***
Anxiety	34	58.571	11.731	56.594	41.800	92.520	5.00***
Psychosis	34	75.245	17.677	72.114	47.740	128.390	14.72***
Hyperactivity	34	64.959	9.712	64.104	45.000	87.740	8.72***
Social Skills	34	56.195	12.783	54.524	34.330	90.310	3.61***

*** $p<.001$ one-tailed

TABLE 27

Behaviour and Social Competence:
Descriptive Statistics (in T-scores) and Z-Test Results

	N	Mean	Stdev	Median	Min	Max	Z-value
<u>Parent Achenbach</u>							
Social Competence	26	33.777	12.465	32.173	7.500	63.750	-8.27***
Internalization	34	55.147	11.067	51.963	40.000	82.240	3.00**
Externalizing	34	50.756	9.210	47.716	40.000	83.820	.44
Total Problems	34	54.984	10.796	52.327	38.780	90.710	2.91**
<u>Social Competence</u>							
Activities	34	36.662	13.929	34.474	13.680	66.320	-7.78***
Social	32	40.698	9.838	40.526	16.470	60.000	-5.26***
School	27	36.185	10.570	40.000	15.000	52.500	-7.18***

<u>Note</u>: All values represent one-tailed tests
** $p<.01$ *** $p<.001$

TABLE 28

Behaviour and Social Competence:
Descriptive Statistics (in T-scores) and Z-Test Results

Behaviour Scales Boys 9 - 11 Parent Scale	N	Mean	Stdev	Median	Min	Max	Z-value
Schizoid-Anxious	5	63.571	19.821	55.000	47.860	97.860	3.03**
Depressed	5	48.235	12.409	43.529	40.590	70.000	-.39
Uncommunicative	5	52.105	4.708	55.263	44.740	55.260	.47
Obsessive-Compulsive	5	57.500	17.313	53.929	39.640	86.070	1.68*
Somatic	5	57.692	12.640	51.538	43.850	74.620	1.72*
Social Withdrawal	5	52.778	7.244	51.667	46.110	62.780	.62
Hyperactive	5	58.966	6.168	59.655	52.760	66.550	2.00*
Aggressive	5	50.526	10.048	49.474	42.460	67.020	.12
Delinquent	5	51.176	6.444	50.000	44.120	61.760	.26

Note: All values represent one-tailed tests
** p<.01 *** p<.001

TABLE 29

Behaviour and Social Competence:
Descriptive Statistics (in T-scores) and Z-Test Results

Behaviour Scales Boys 12-16 Parent Scale	N	Mean	Stdev	Median	Min	Max	Z-value
Somatic	9	56.889	10.833	58.000	43.000	73.000	2.07*
Schizoid	9	49.333	5.774	49.333	42.670	56.000	-.20
Uncommunicative	9	55.309	12.301	52.222	41.110	80.000	1.59
Immature	9	53.333	12.163	50.769	43.080	73.850	1.00
Obsessive-Compulsive	9	46.316	4.558	46.316	41.050	51.580	-1.11
Hostile-Withdrawn	9	54.800	14.283	46.800	42.800	74.800	1.44
Delinquent	9	52.889	8.937	54.000	44.000	69.000	.87
Aggressive	9	46.177	4.876	45.424	40.340	55.590	-1.15
Hyperactive	9	51.533	8.466	50.000	39.660	67.240	.46

* p<.05 one-tailed

TABLE 30

Behaviour and Social Competence:
Descriptive Statistics (in T-scores) and Z-Results

Behaviour Scales Girls 9-11 Parent Scale	N	Mean	Stdev	Median	Min	Max	Z-value
Depressed	9	55.159	15.833	49.459	38.650	81.890	1.55
Social Withdrawal	9	59.057	13.325	51.053	45.790	82.630	2.72**
Somatic	9	52.386	13.636	46.500	39.470	81.500	.72
Schizoid-obsessive	9	49.794	9.348	43.636	43.640	71.790	-.06
Hyperactive	9	57.094	7.251	57.857	43.850	68.570	2.13*
Sex Problems	9	50.802	8.233	50.000	40.910	68.180	.24
Delinquent	9	52.060	6.243	56.667	45.560	59.660	.62
Aggressive	9	45.366	4.860	45.965	39.670	54.670	-1.39
Cruel	9	44.902	.294	45.000	44.120	45.000	-1.53

$p < .05$ one-tailed

TABLE 31

Behaviour and Social Competence:
Descriptive Statistics (in T-scores) and Z-Test Results

<u>Behaviour Scales</u> <u>Girls 12-16</u> <u>Parent Scale</u>	N	Mean	Stdev	Median	Min	Max	Z-value
Anxious-Obsessive	11	52.555	10.353	53.784	40.270	70.000	.85
Somatic	11	57.769	14.295	53.636	44.550	80.910	2.58**
Schizoid	11	53.131	12.975	51.111	40.000	84.440	1.04
Depressed-Withdrawn	11	56.818	13.118	53.571	42.860	75.000	2.26*
Immature-Hyperactive	11	59.345	23.136	56.800	40.800	124.800	3.10***
Delinquent	11	54.573	11.850	51.818	42.730	79.090	1.52
Aggressive	11	49.283	13.573	44.038	40.190	76.730	-.24
Cruel	11	55.372	21.687	45.455	45.450	118.180	1.78*

<u>Note</u>: All values represent one-tailed tests
** p<.05 **p<.01 *** p<.001

TABLE 32

Behaviour and Social Competence:
Descriptive Statistics (in T-scores) and Z-Test Results

Teacher Achenbach	N	Mean	Stdev	Median	Min	Max	Z-value
Social Competence	26	41.363	6.639	42.826	23.820	52.910	-4.40***
Internalization	28	56.277	13.436	52.054	40.000	104.230	3.32***
Externalizing	28	51.836	10.166	47.843	42.290	90.000	.97
Total Problems	28	53.590	12.893	48.425	41.040	103.210	1.90*
School Performance	27	40.683	6.476	41.429	27.000	51.430	-4.84***
Working	28	41.469	11.442	41.765	24.290	81.430	-4.51***
Behaving	28	46.183	5.551	45.000	26.250	57.500	-2.02*
Learning	28	40.727	11.442	40.625	24.290	82.860	-4.91***
Happy	28	46.248	10.296	45.000	23.570	84.620	-1.99*

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE 33

Behaviour and Social Competence:
Descriptive Statistics (in T-scores) and Z-Test Results

Behaviour Scales Boys 9-11 Teacher Scale	N	Mean	Stdev	Median	Min	Max	Z-value
Anxious	5	51.500	4.541	50.000	47.500	57.500	.34
Social Withdrawal	5	57.692	7.398	54.615	50.770	70.000	1.72*
Unpopular	5	55.217	7.778	56.087	47.390	64.780	1.17
Self-Destructive	5	55.238	7.529	55.238	45.710	64.760	1.17
Obsessive-Compulsive	5	52.105	13.105	47.895	42.630	74.210	.47
Inattentive	5	61.667	10.665	60.641	50.380	76.030	2.61**
Nervous Overactive	5	45.652	3.074	45.652	41.300	50.000	-.97
Aggressive	5	45.351	2.113	46.579	43.070	47.460	-1.04

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE 34

Behaviour and Social Competence:
Descriptive Statistics (in T-scores) and Z-Test Results

Behaviour Scales Boys 12-16 Teacher Scale	N	Mean	Stdev	Median	Min	Max	Z-value
Social Withdrawal	6	54.167	9.927	52.500	41.250	68.750	1.02
Anxious	6	51.569	9.049	49.118	41.760	65.290	.38
Unpopular	6	48.333	11.111	42.778	42.780	70.560	-.41
Obsessive-Compulsive	6	48.947	6.446	46.316	41.050	56.840	-.26
Immature	6	48.148	5.738	44.444	44.440	55.560	-.45
Self-Destructive	6	52.593	9.729	48.889	43.330	71.110	.64
Inattentive	6	54.762	7.647	51.948	47.400	65.580	1.17
Aggressive	6	44.236	2.149	43.609	42.110	48.120	-1.41

Note: No significant differences at .05 one-tailed level of significance

TABLE 35

Behaviour and Social Competence:
Descriptive Statistics (in T-scores) and Z-Test Results

Behaviour Scales Girls 9 - 11 Teacher Scale	N	Mean	Stdev	Median	Min	Max	Z-value
Anxious	7	52.718	8.762	53.415	41.220	63.170	.72
Social Withdrawal	7	61.374	10.279	61.923	46.540	77.310	3.01**
Depressed	7	53.631	6.299	55.417	42.920	59.580	.96
Unpopular	7	50.549	6.052	46.154	46.150	61.540	.15
Self-Destructive	7	56.964	18.298	46.250	46.250	96.250	1.84*
Inattentive	7	58.820	10.306	61.304	45.360	74.350	2.33**
Nervous Overactive	7	44.935	2.218	43.636	43.640	48.180	-1.34
Aggressive	7	45.633	2.091	45.429	44.000	49.710	-1.16

Note: All values represent one-tailed tests
** p<.01

TABLE 36

Behaviour and Social Competence:
Descriptive Statistics (in T-scores) and Z-Test Results

Behaviour Scales Girls 12 - 16 Teacher Scale	N	Mean	Stdev	Median	Min	Max	Z-value
Anxious	10	57.941	18.643	52.647	40.880	96.760	2.51**
Social Withdrawal	10	53.143	16.540	48.286	41.140	92.570	.99
Depressed	10	61.000	33.267	44.000	44.000	124.000	3.48***
Immature	10	61.538	30.078	48.462	44.620	136.920	3.65***
Self-Destructive	10	62.000	32.728	48.000	48.000	148.000	3.79***
Inattentive	10	56.508	16.469	52.381	42.060	91.270	2.06*
Unpopular	10	58.125	19.863	51.250	45.000	95.000	2.57**
Delinquent	10	46.250	4.414	43.333	43.330	55.830	-1.19
Aggressive	10	50.189	12.862	44.623	43.680	83.300	.06

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

3.4 SECTION 3 - INFLUENCE OF SOCIO-DEMOGRAPHIC VARIABLES

3.4.1 Preliminary Considerations of Socio-Demographic Variables

This section addresses the issue of whether or not there is a relationship between certain demographic variables and cognitive test performance. As mentioned previously, two socio-demographic variables were investigated; 1) socio-economic status; and 2) age.

Since the sample size was relatively small, it would be inappropriate to use multivariate techniques to analyze the medical data. As such, T-tests were employed in order to determine if a particular socio-demographic variable influenced the outcome on neuropsychological test performance (i.e., does the presence of a specific variable indicate more impairment on cognitive tests).

Although this strategy increases the risk of Type I error (i.e., claiming to find a statistical difference when none exists), it was considered important to minimize Type II error so that possible areas of significance for future research can be identified. In this study, the level of significance adopted for the analyses was .05 one-tailed. (However, if one wanted to adopt a more stringently set alpha-level, based on the bonferroni method (Dunn, 1961), for these analyses it would be at the .001 level of significance.)

The equality of sample variances in two groups was tested by means of an F-test. If variances were equal, they were pooled for T-tests of significance of the between group differences. If variances were unequal, the T-test for separate variance estimate (modifies T-test by adjusting degrees of freedom) was reported.

3.4.2 <u>Socio-economic Status</u>

In order to further examine socio-economic status, a median split was made dividing the sample into two groups. Those with a Hollingshead Socio-economic Index score below 32 were classified as low SES and families with a score of 33 and above were classified as a high SES group. A series of T-tests were performed to compare the test performance of those above the median with those below it. Graphic display of this data is presented in Figures 5 to 7.

With regard to Intellectual ability, children from the lower SES group obtained significantly lower scores on the VIQ ($t(34) = -2.69$, $p<.01$) and FSIQ ($t(34) = -1.79$, $p<.05$; see Table E-1). Of the 6 verbal subscales of the WISC-R, the low SES group obtained significantly lower scores on 5 of the subtests; the exception was performance on the Comprehension subtest ($t(34) = -1.23$, $p>.05$; see Table E-2). There was a trend albeit not significant for the children from the lower SES group to perform more poorly on the Performance subscales (see Table E-3).

Significant differences also emerged on the following measures: (1) Language ability--Peabody Picture Vocabulary Test ($t(34) = -1.73$, $p<.05$) and Expressive One Word Picture Test ($t(34) = -3.10$, $p<.01$; see Table E-4); (2) Tactile-Perceptual ability--Dysgraphesthesia for the nondominant hand ($t(21.53) = -1.77$, $p<.05$; see Table E-10); (3) Academic ability--all the measures were significantly different (see Table E-11).

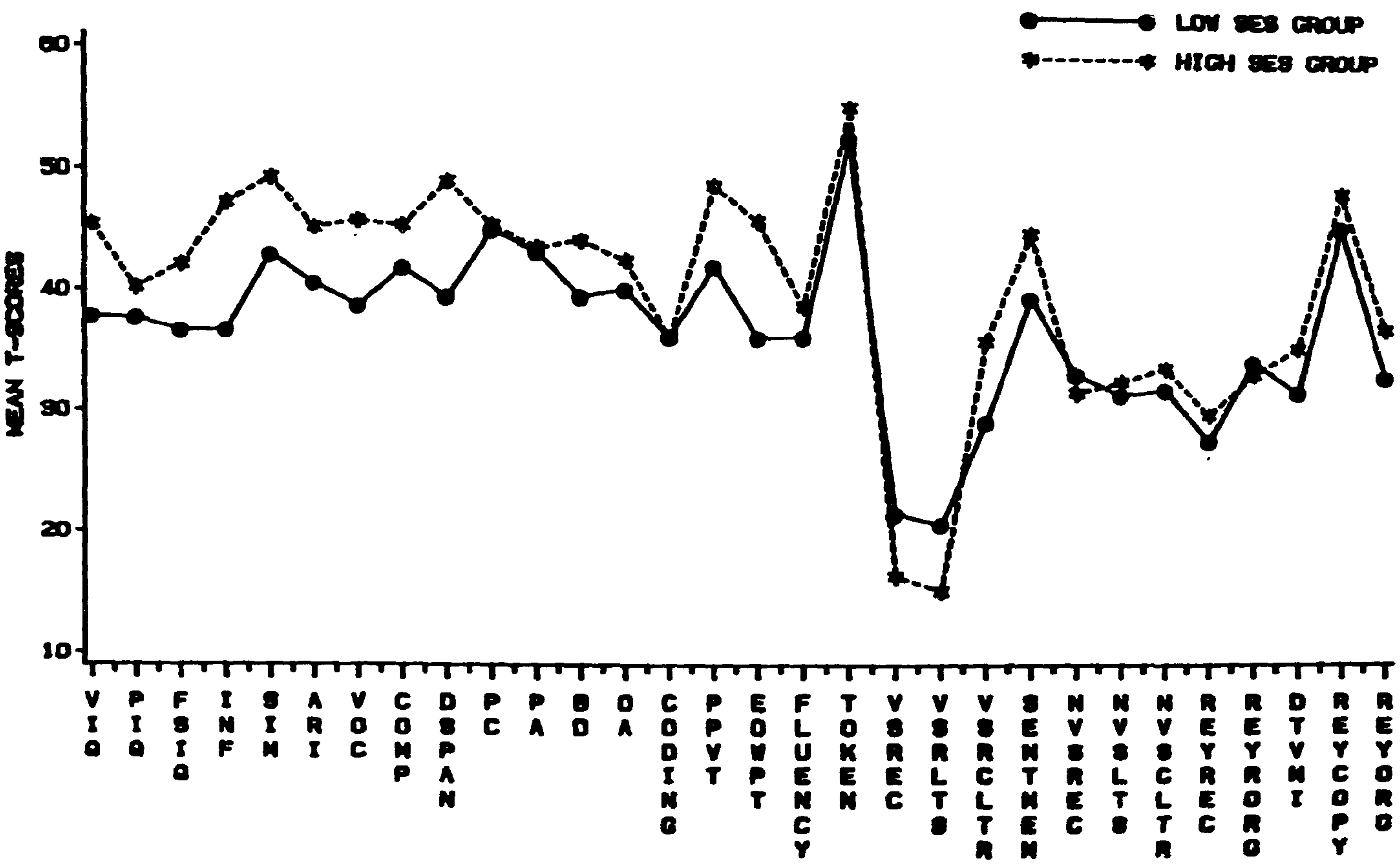
Within the Behaviour and Social Competence domain, significant differences emerged on the following scales of the Vineland Adaptive Behaviour Scale: Communication domain ($t(34) = -3.14$, $p<.01$); and Written ($t(34) = -3.30$, $p<.001$) and Coping ($t(34) = -2.48$, $p<.01$) subscales (see Table E-12).

For the remaining measures, there was a general trend for children from the lower SES group to perform more poorly when compared with children from the high SES group.

In summary, as anticipated, the performance of the low SES group on the 17 t-tests that reached significance was poorer than that of the high SES group (22.07% of the tests administered). In addition, on another 42 tests (54.54% of the tests administered), the level of performance albeit not reaching significance, was poorer for the children in the low SES group than that of the high SES group.

FIGURE 5

Mean T-Scores for Intellectual, Language, Memory and Construction Skill Areas for Low and High Socioeconomic Groups



See legend on next page.

Legend for Figure 5

ARI = Arithmetic

BD = Block Design

CODING = Coding subtest

COMP = Comprehension

DSPAN = Digit Span

DTVMI = Developmental Test of Visual-Motor Integration

EOWPT = Expressive One-Word Picture Test

FLUENCY = Fluency Test

FSIQ = Full Scale IQ

INF = Information

NVSCLTR = Nonverbal Selective Reminding Test - Consistent Long-Term Retrieval

NVSLTS = Nonverbal Selective Reminding Test - Long-Term Storage

NVSREC = Nonverbal Selective Reminding Test - Recall Condition

OA = Object Assembly

PA = Picture Arrangement

PC = Picture Completion

PIQ = Performance IQ

PPVT = Peabody Picture Vocabulary Test

REYCOPY = Rey Figure - Copy

REYORG = Rey Figure - Organizational Skill

REYREC = Rey Figure - Recall Condition

REYRORG = Rey Figure - Recall - Organizational Skill

SIM = Similarities

TOKEN = Token Test

VIQ = Verbal IQ

VOC = Vocabulary

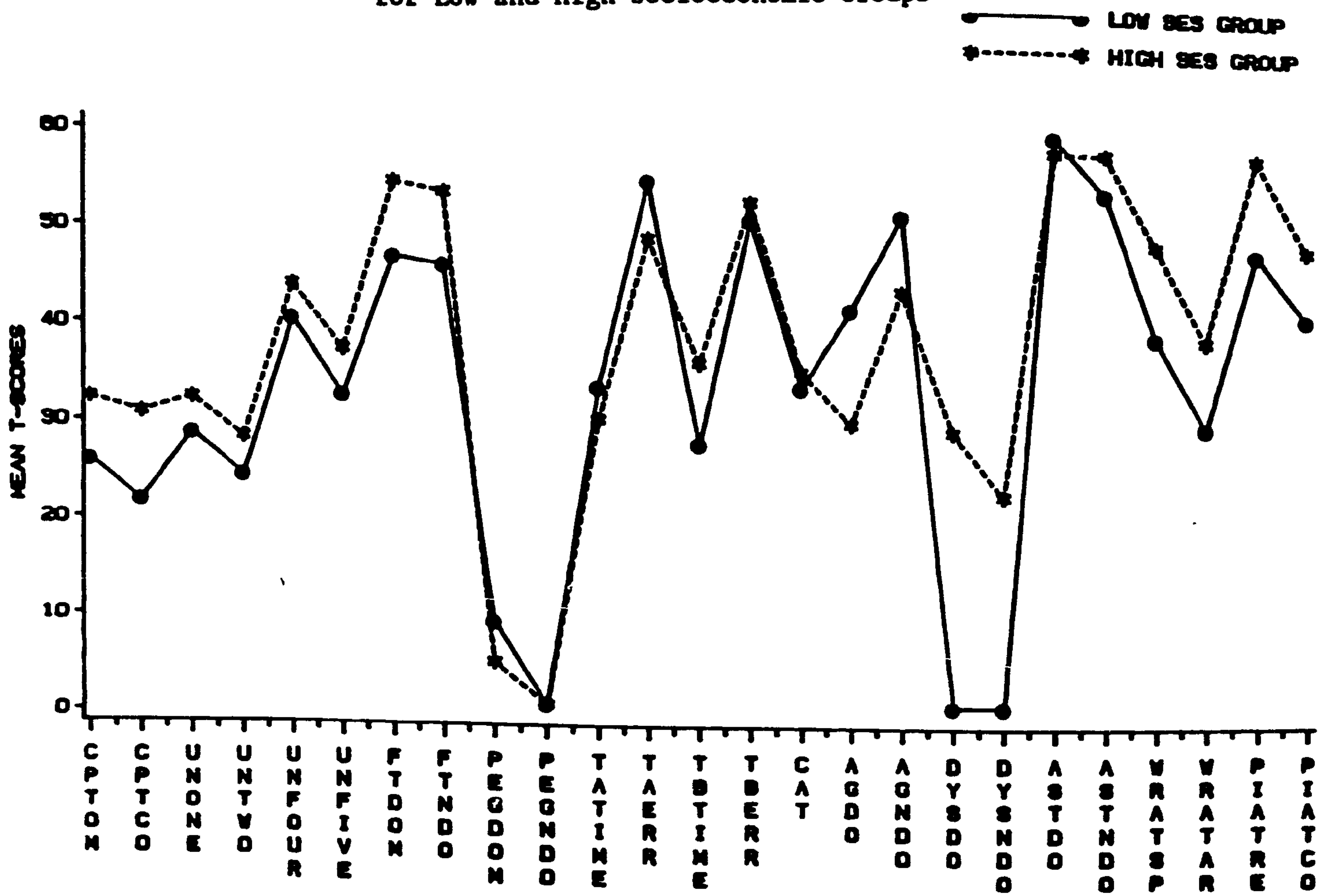
VSRCLTR = Verbal Selective Reminding Test - Consistent Long-Term Retrieval

VSREC = Verbal Selective Reminding Test - Recall Condition

VSRLTS = Verbal Selective Reminding Test - Long-Term Storage

FIGURE 6

Mean T-Scores for Attention, Motor, Problem-Solving, Tactile-Perceptual and Academic Skill Areas-- for Low and High Socioeconomic Groups



See legend on next page.

Legend for Figure 6

AGDOM = Agnosia: Dominant Hand

AGNDO = Agnosia: Nondominant Hand

ASTDO = Astereognosis: Dominant

ASTNDO = Astereognosis: Nondominant

CAT = Halstead Category

CPTCO = Continuous Performance Test - Commission Errors

CPTOM = Continuous Performance Test - Omission Errors

DYSDOM = Dysgraphesthesia: Dominant Hand

DYSNDO = Dysgraphesthesia: Nondominant Hand

FTDOM = Finger-Tapping Test - Dominant Hand

FTNDO = Finger-Tapping Test - Nondominant Hand

PEGDOM = Pegboard Test - Dominant Hand

PEGNDO = Pegboard Test - Nondominant Hand

PIATCO = Peabody Individual Achievement Test - Comprehension Subtest

PIATRE = Peabody Individual Achievement Test - Reading Recognition Subtest

TAERR = Trails A: Errors

TATIME = Trails A: Time

TBERR = Trails B: Errors

TBTIME = Trails B: Time

UNFIVE = Underlining Test: Subtest 5 (4 letter nonsense syllable)

UNFOUR = Underlining Test: Subtest 4 (Gestalt Figure)

UNONE = Underlining Test: Subtest 1 (Number)

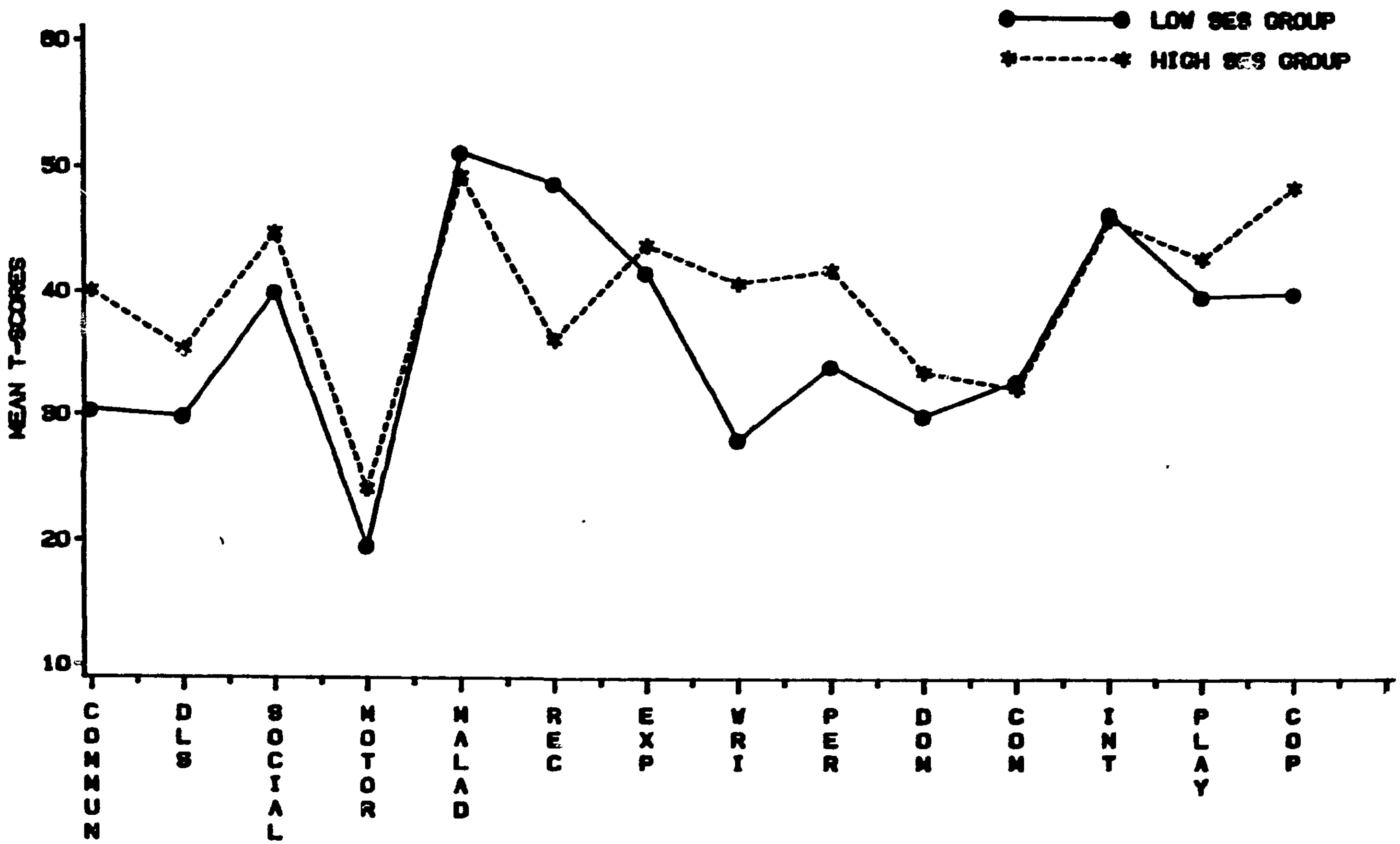
UNTWO = Underlining Test: Subtest 2 (Geometric Form)

WRATAR = Wide Range Achievement Test: Arithmetic Subtest

WRATSP = Wide Range Achievement Test: Spelling Subtest

FIGURE 7

Mean T-Scores for Vineland Adaptive Behaviour Scale for Low and High Socioeconomic Groups



See legend on next page.

Legend for Figure 7

Vineland Behaviour Adaptive Scale

COM = Community Subdomain

COMMUN = Communication Domain

DLS = Daily Living Scale Domain

DOM = Domestic Subdomain

EXP = Expressive Subdomain

INT = Interests Subdomain

LOP = Coping Subdomain

MALAD = Maladaptive Domain

MOTOR = Motor Domain

PER = Personal Subdomain

PLAY = Play and Leisure Subdomain

REC = Receptive Subdomain

SOCIAL = Socialization Domain

WRI = Written Subdomain

3.4.3 Median Age Analyses

The sample of myelomeningocele children were divided into two groups, on the basis of the median age of the sample (13.33 years). The test performance of those children above the median were compared with those below it. This was done in order to determine if children who were older than the median age at the time of testing would perform more poorly when compared with the children who were younger than the median age. A series of T-tests were performed. Graphic display of this data is presented in Figures 8 to 10.

Significant differences were found between the older and younger children in the following domains, with the younger children performing better. 1) Intellectual ability -Digit Span ($t(34) = 1.99$, $p<.05$; see Table F-2); 2) Language ability--Expressive One-Word Test ($t(34) = 2.55$, $p<.01$) Token Test ($t(33) = -2.93$, $p<.01$; see Table F-4); 3) Memory ability--Sentence Memory Test ($t(28.27) = 1.98$, $p<.05$) recall on the Nonverbal Selective Reminding Test ($t(24.06) = -2.61$, $p<.01$); see Table F-5); 4) Attention--Subtest 4 (gestalt figure) of the Underlining Test ($t(31) = 2.68$, $p<.01$; see Table F-8); 5) Motor ability--accuracy on Trails A ($t(25.45) = -2.71$, $p<.01$; see Table F-9; 6) Tactile-Perceptual ability-Dysgraphesthesia for both the dominant ($t(19.68) = 2.17$, $p<.05$) and non-dominant hand ($t(20.07) = 1.92$, $p<.05$; see Table F-11).

Within the Behavioural and Social Competence domain, significant differences in favour of the younger group emerged on the following scales of the Vineland Adaptive Behaviour: Communication domain ($t(34) = 2.64$,

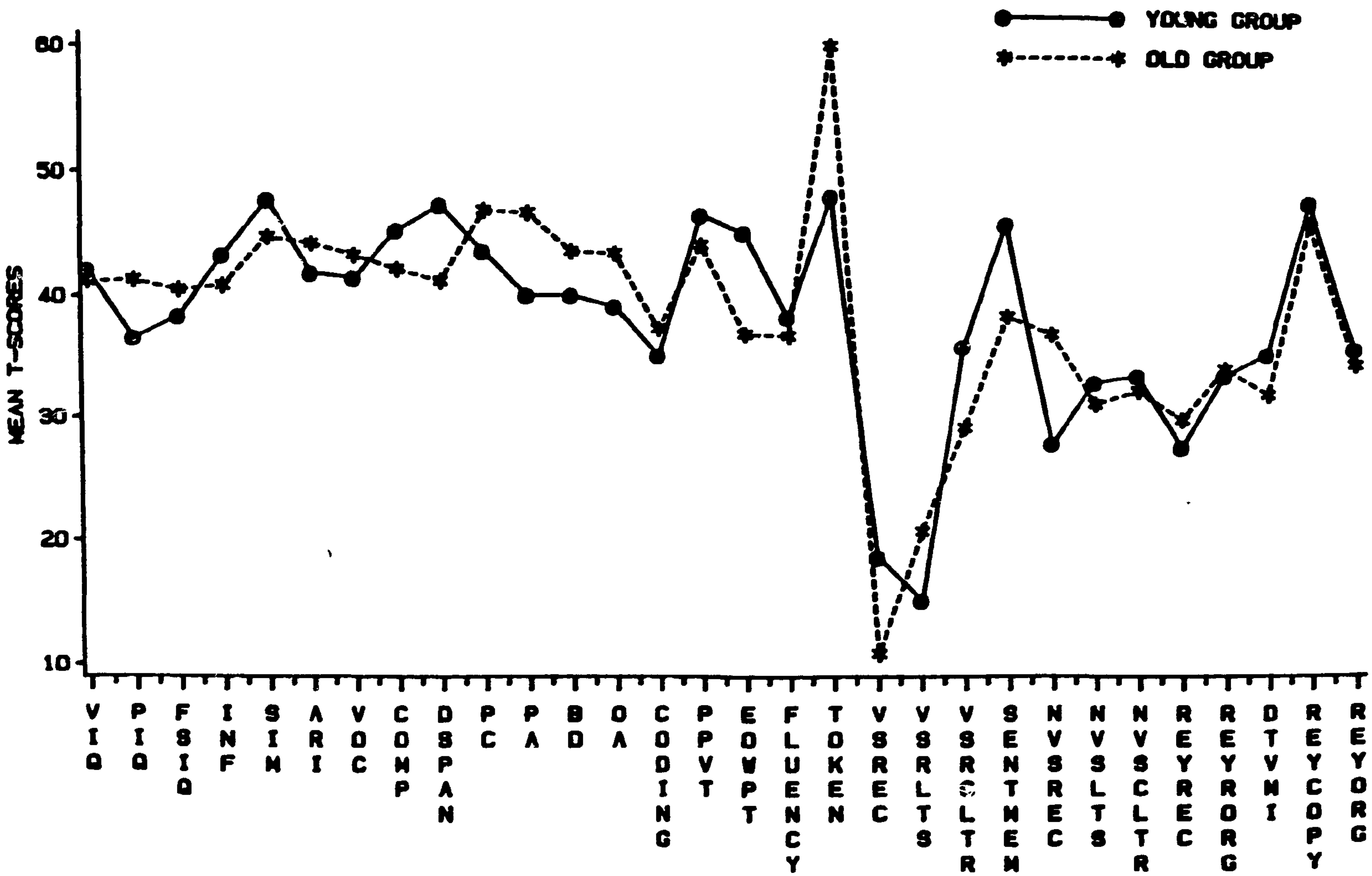
$p<.01$), written ($t(34) = 2.00$, $p<.05$), domestic ($t(34) = 1.84$, $p<.05$), and Coping skills ($t(26.81) = 2.27$, $p<.05$) scales (See Tables F-13 and F-15).

Significant differences emerged in favour of the older group on the following measures: 1) Intellectual ability--Picture Arrangement ($t(34) = -1.96$, $p<.05$) subtest; 2) Language ability--Token Test ($t(33) = -2.93$, $p<.01$); 3) Memory ability--recall condition of the Nonverbal Selective Reminding Test ($t(24.06) = -2.61$, $p<.01$) and (4) Motor ability--accuracy on Trails A ($t(25.45) = -2.71$, $p<.01$) (see Appendix F).

In summary, of the 14 t-tests that reached statistical significance, 10 were in the predicted direction (18.18% of the tests administered). That is, the children in the older group experienced more difficulty in these areas. In addition, on another 31 variables (40.25% of the tests administered), the level of performance, albeit not reaching statistical significance, was poorer for the children in the older group.

FIGURE 8

Mean T-Scores for Intellectual, Language, Memory and Construction Skill Areas for Median Age Variable



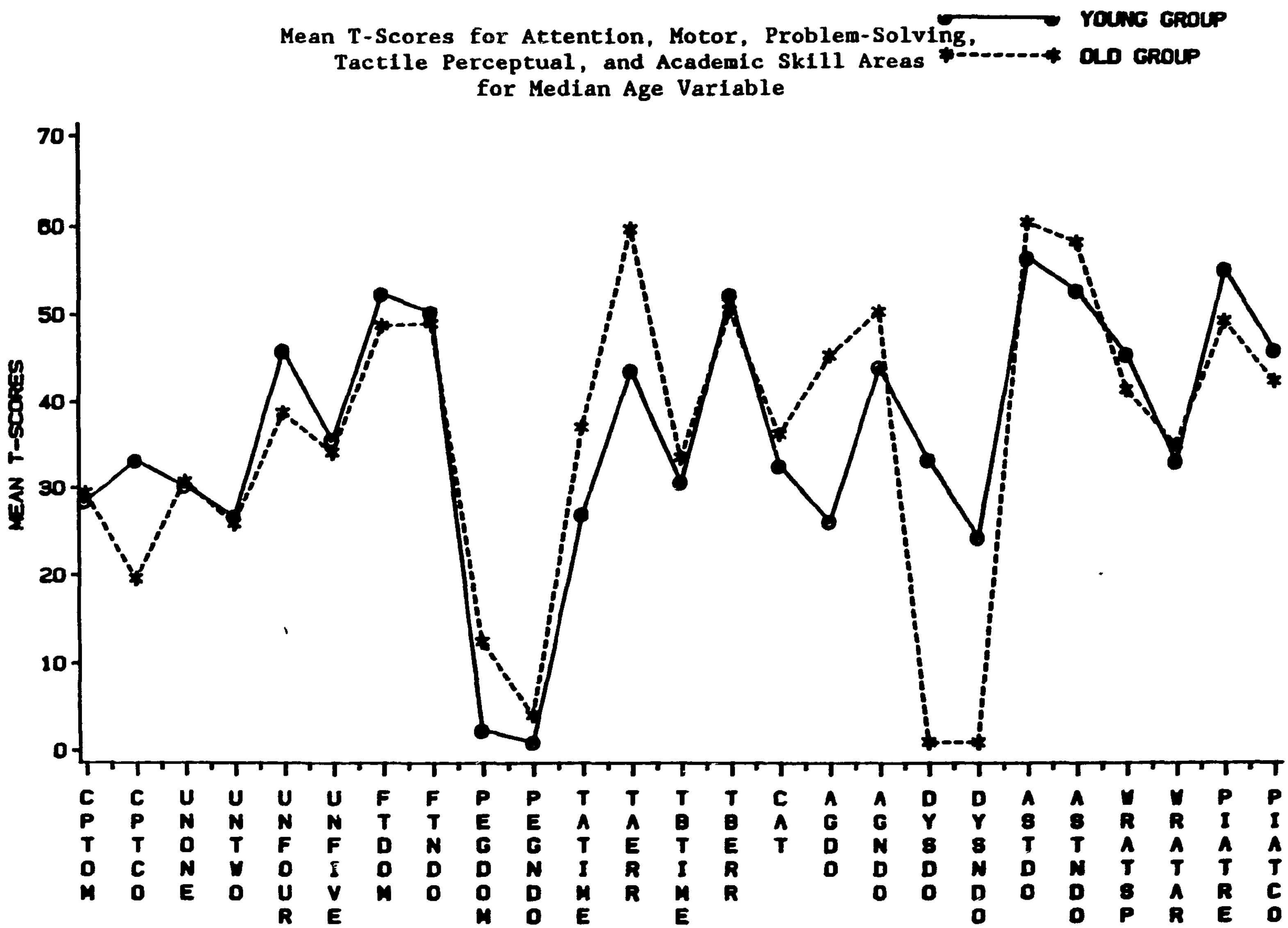
See legend on next page.

Legend for Figure 8

ARI	=	Arithmetic
BD	=	Block Design
CODING	=	Coding subtest
COMP	=	Comprehension
DSPAN	=	Digit Span
DTVMI	=	Developmental Test of Visual-Motor Integration
EOWPT	=	Expressive One-Word Picture Test
FLUENCY	=	Fluency Test
FSIQ	=	Full Scale IQ
INF	=	Information
NVSCLTR	=	Nonverbal Selective Reminding Test - Consistent Long-Term Retrieval
NVSLTS	=	Nonverbal Selective Reminding Test - Long-Term Storage
NVSREC	=	Nonverbal Selective Reminding Test - Recall Condition
OA	=	Object Assembly
PA	=	Picture Arrangement
PC	=	Picture Completion
PIQ	=	Performance IQ
PPVT	=	Peabody Picture Vocabulary Test
REYCOPY	=	Rey Figure - Copy
REYORG	=	Rey Figure - Organizational Skill
REYREC	=	Rey Figure - Recall Condition
REYRORG	=	Rey Figure - Recall - Organizational Skill
SENTMEM	=	Sentence Memory
SIM	=	Similarities
TOKEN	=	Token Test
VIQ	=	Verbal IQ
VOC	=	Vocabulary
VSRCLTR	=	Verbal Selective Reminding Test - Consistent Long-Term Retrieval
VSREC	=	Verbal Selective Reminding Test - Recall Condition
VSRLTS	=	Verbal Selective Reminding Test - Long-Term Storage

FIGURE 9

Mean T-Scores for Attention, Motor, Problem-Solving, Tactile Perceptual, and Academic Skill Areas for Median Age Variable



See legend on next page.

Legend for Figure 9

AGDOM = Agnosia: Dominant Hand

AGNDO = Agnosia: Nondominant Hand

ASTDO = Astereognosis: Dominant

ASTNDO = Astereognosis: Nondominant

CAT = Halstead Category

CPTCO = Continuous Performance Test - Commission Errors

CPTOM = Continuous Performance Test - Omission Errors

DYSDOM = Dysgraphesthesia: Dominant Hand

DYSNDO = Dysgraphesthesia: Nondominant Hand

FTDOM = Finger-Tapping Test - Dominant Hand

FTNDO = Finger-Tapping Test - Nondominant Hand

PEGDOM = Pegboard Test - Dominant Hand

PEGNDO = Pegboard Test - Nondominant Hand

PIATCO = Peabody Individual Achievement Test - Comprehension Subtest

PIATRE = Peabody Individual Achievement Test - Reading Recognition Subtest

TAERR = Trails A: Errors

TATIME = Trails A: Time

TBERR = Trails B: Errors

TBTIME = Trails B: Time

UNFIVE = Underlining Test: Subtest 5 (4 letter nonsense syllable)

UNFOUR = Underlining Test: Subtest 4 (Gestalt Figure)

UNONE = Underlining Test: Subtest 1 (Number)

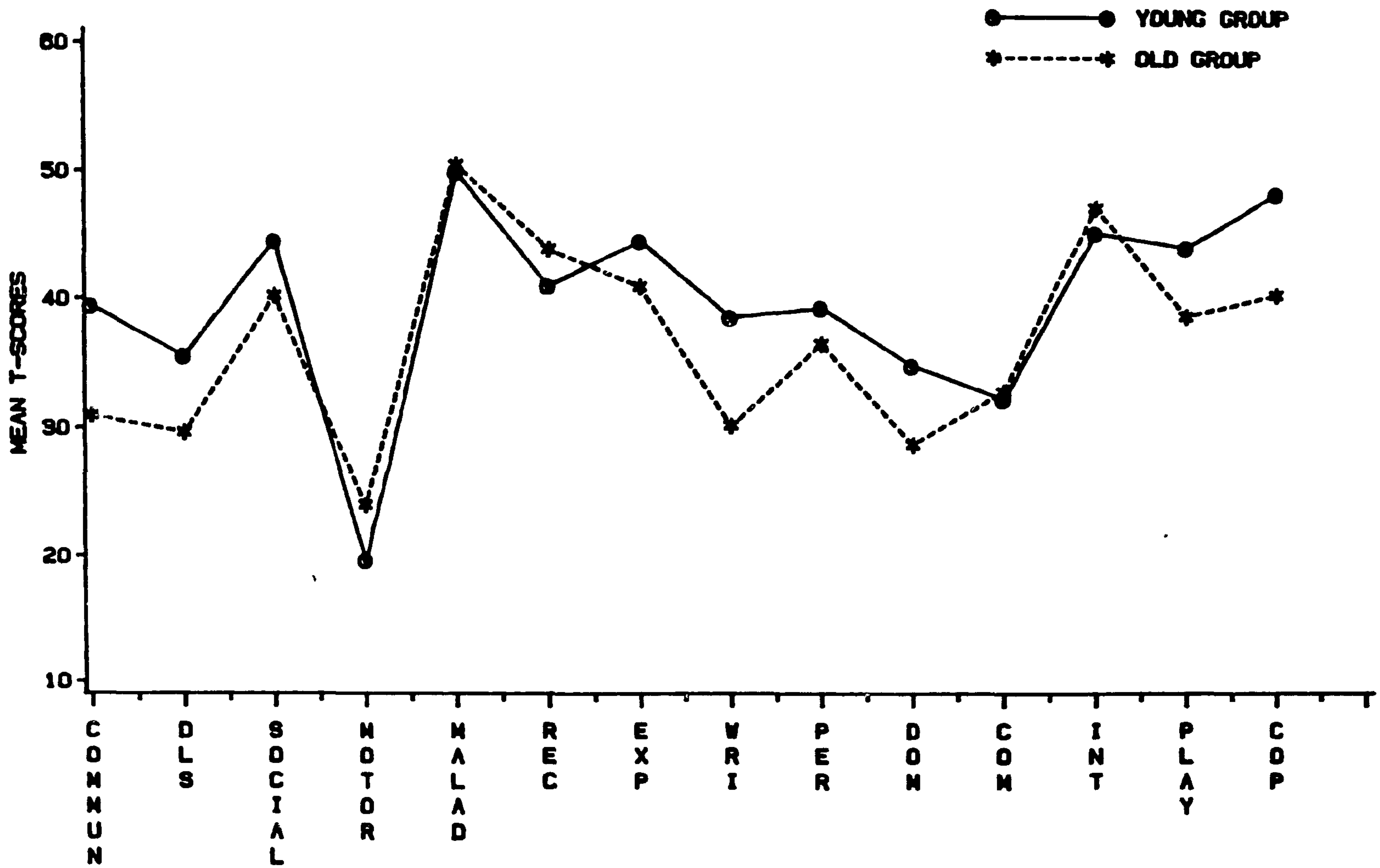
UNTWO = Underlining Test: Subtest 2 (Geometric Form)

WRATAR = Wide Range Achievement Test: Arithmetic Subtest

WRATSP = Wide Range Achievement Test: Spelling Subtest

FIGURE 10

Mean T-Scores for Vineland Adaptive Behaviour Scale for Median Age Variable



See legend on next page.

Legend for Figure 10

Vineland Behaviour Adaptive Scale

COM = Community Subdomain

COMMUN = Communication Domain

DLS = Daily Living Scale Domain

DOM = Domestic Subdomain

EXP = Expressive Subdomain

INT = Interests Subdomain

LOP = Coping Subdomain

MALAD = Maladaptive Domain

MOTOR = Motor Domain

PER = Personal Subdomain

PLAY = Play and Leisure Subdomain

REC = Receptive Subdomain

SOCIAL = Socialization Domain

WRI = Written Subdomain

3.5 SECTION 4 - INFLUENCE OF MEDICAL VARIABLES

3.5.1 Preliminary Considerations of Medical Variables

This section addresses the issue of whether or not there is a relationship between certain medical variables and cognitive test performance. As outlined earlier, four medical variables were investigated; 1) history of complications; 2) ocular abnormalities; 3) level of lesion; and 4) onset of hydrocephalus (Intrauterine Hydrocephalus).

3.5.2 History of Complications

The myelomeningocele sample was divided into children with and without a history of complications. As mentioned previously, complications are defined as evidence of infections and/or seizures associated with a shunt.

It was found that 50% (n = 18) of the myelomeningocele sample had a history of complications. Of these 18 children, it was noted that 12 (66.66%) had a history of seizures. Analysis of the type of seizures revealed that 5 children had focal seizures; 2 had generalized seizures; and 5 had generalized seizures with focal onset.

Of these 18 children, it was noted that 13 (72.22%), had a history of shunt infection. A frequency analysis of the type of organisms causing the shunt infection found that the most frequently incurred organism was Staphylococcus Albus (7 cases). Finally, of these 18 cases, 39% (n = 7), had a history of seizures and shunt infection.

To determine if a history of complications was associated with poorer cognitive test performance and behavioural problems relative to those children without a history of complications, a series of T-tests were performed (see Appendix G). Graphic display of this data is presented in Figures 11, 12 and 13.

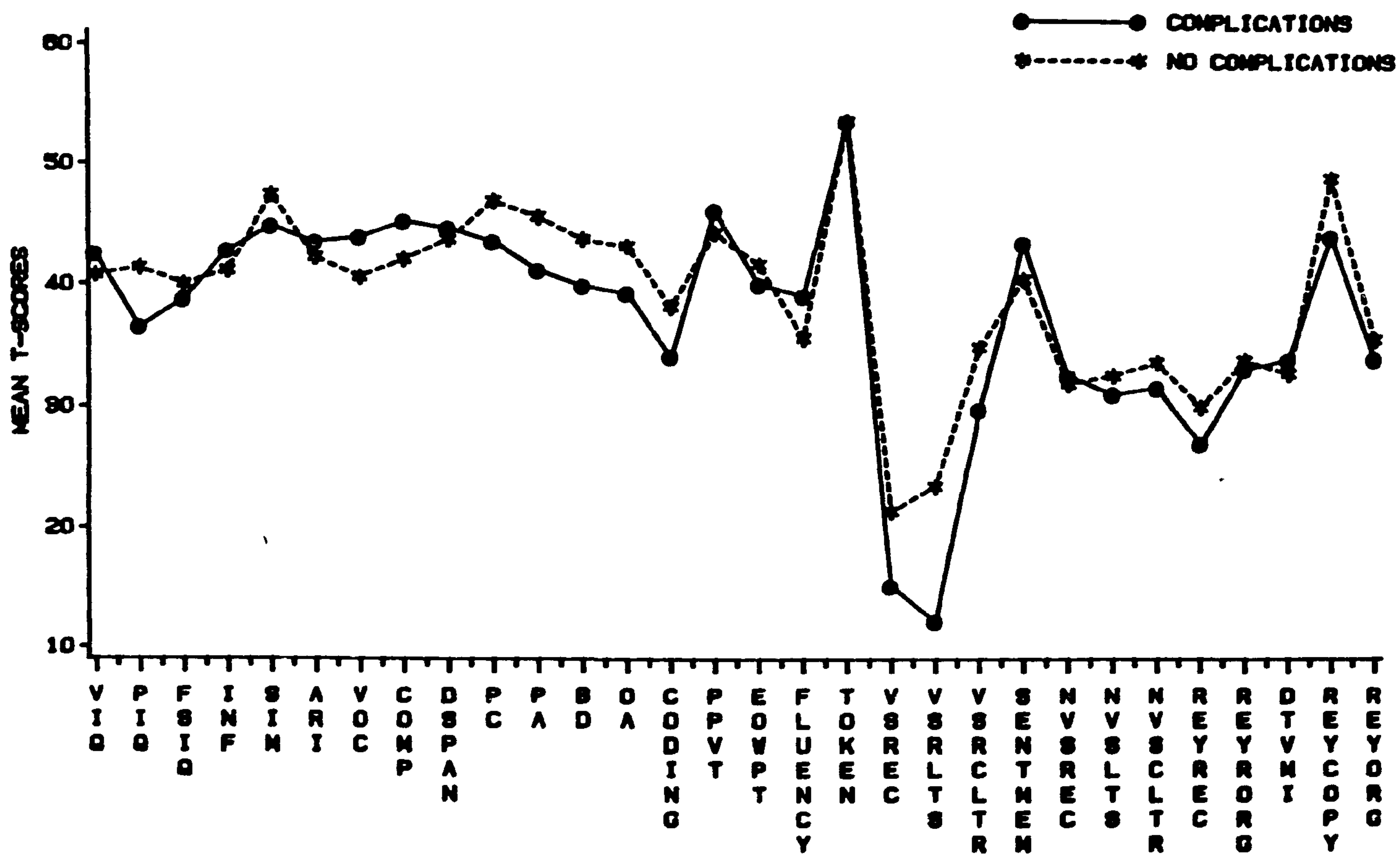
Significant group differences favouring the group without complications were found in the following skill areas: 1) Attention--Subtest 1 ($t(32) = -1.77$, $p<.05$) and Subtest 2 - geometric form ($t(31) = -2.08$, $p<.05$) of the Underlining test (see Table G-8); 2) Motor ability-Finger-Tapping for the nondominant hand ($t(34)= -2.40$, $p<.01$), the Grooved Pegboard Test for dominant ($t(22.49) = -1.85$, $p<.05$) hand; see Table G-9; 3) Tactile-Perceptual ability--Astereognosis for the dominant hand ($t(17.16) = -1.93$, $p<.05$; see Table G-10).

Examination of the Behaviour and Social Competence domain revealed that a significant difference between the groups favouring the group without complications emerged for the Receptive scale of the Vineland Adaptive Behaviour scale ($t(17.26) = -1.93$, $p<.05$; see Table G-13).

In summary, of the 8 t-tests that reached significance (10.38% of the tests administered), only one was not in the predicted direction (result obtained from the DVTMI accuracy on Trails B; see Table G-9). That is, in general, the children with a history of complications experienced more difficulty in these areas. In addition, on another 54 variables (70.13% of the tests administered), the level of performance albeit not reaching statistical significance, was poorer for the children with a history of complications.

FIGURE 11

Mean T-Scores for Intellectual, Language, Memory and Construction Skill Areas for Complication Variable



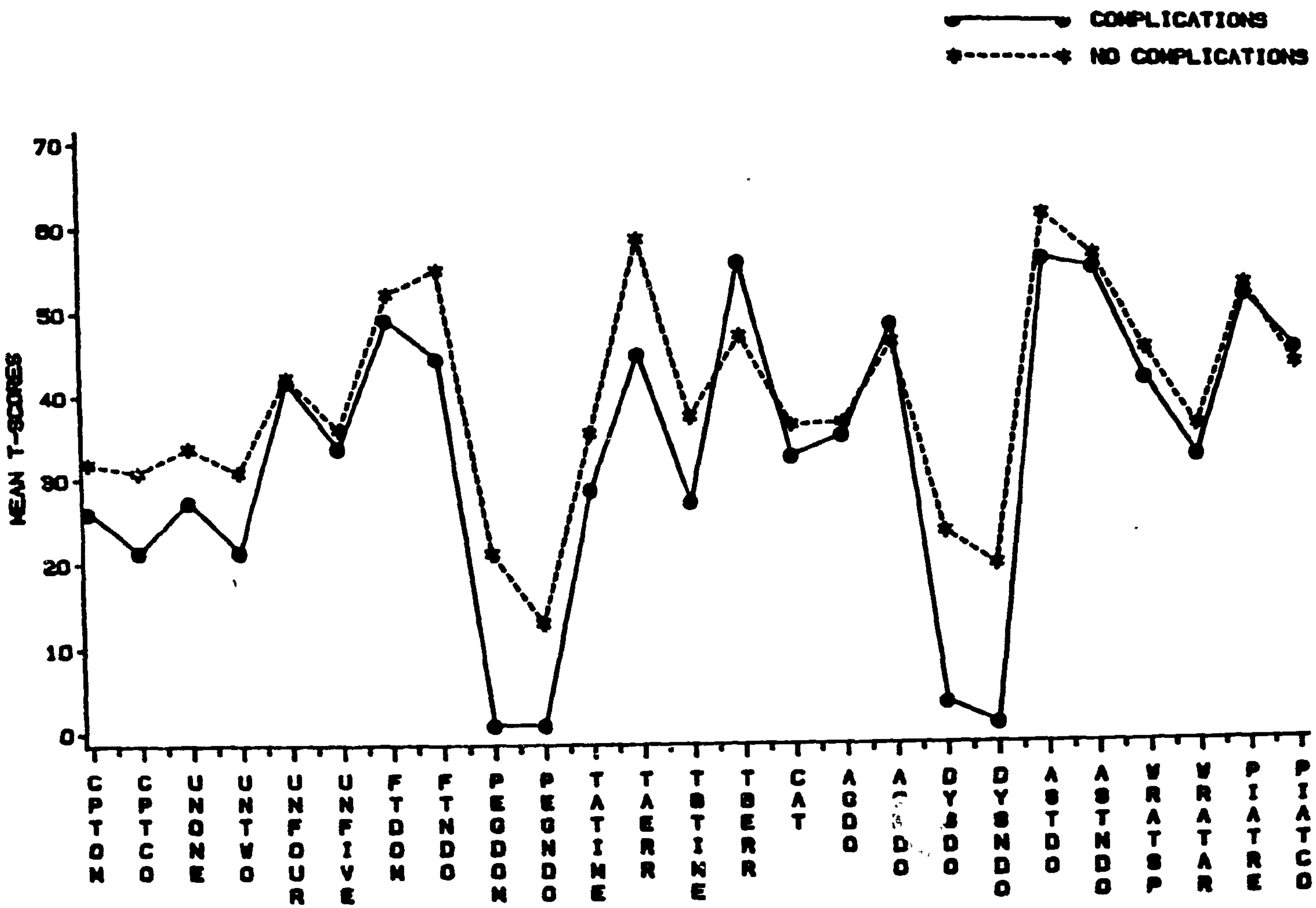
See legend on next page.

Legend for Figure 11

ARI	=	Arithmetic
BD	=	Block Design
CODING	=	Coding subtest
COMP	=	Comprehension
DSPAN	=	Digit Span
DTVMI	=	Developmental Test of Visual-Motor Integration
EOWPT	=	Expressive One-Word Picture Test
FLUENCY	=	Fluency Test
FSIQ	=	Full Scale IQ
INF	=	Information
NVSCLTR	=	Nonverbal Selective Reminding Test - Consistent Long-Term Retrieval
NVSLTS	=	Nonverbal Selective Reminding Test - Long-Term Storage
NVSREC	=	Nonverbal Selective Reminding Test - Recall Condition
OA	=	Object Assembly
PA	=	Picture Arrangement
PC	=	Picture Completion
PIQ	=	Performance IQ
PPVT	=	Peabody Picture Vocabulary Test
REYCOPY	=	Rey Figure - Copy
REYORG	=	Rey Figure - Organizational Skill
REYREC	=	Rey Figure - Recall Condition
REYRORG	=	Rey Figure - Recall - Organizational Skill
SENTMEM	=	Sentence Memory
SIM	=	Similarities
TOKEN	=	Token Test
VIQ	=	Verbal IQ
VOC	=	Vocabulary
VSRCLTR	=	Verbal Selective Reminding Test - Consistent Long-Term Retrieval
VSREC	=	Verbal Selective Reminding Test - Recall Condition
VSRLTS	=	Verbal Selective Reminding Test - Long-Term Storage

FIGURE 12

Mean T-Scores for Attention, Motor, Problem-Solving, Tactile-Perceptual and Academic Skill Areas for Complication Variable



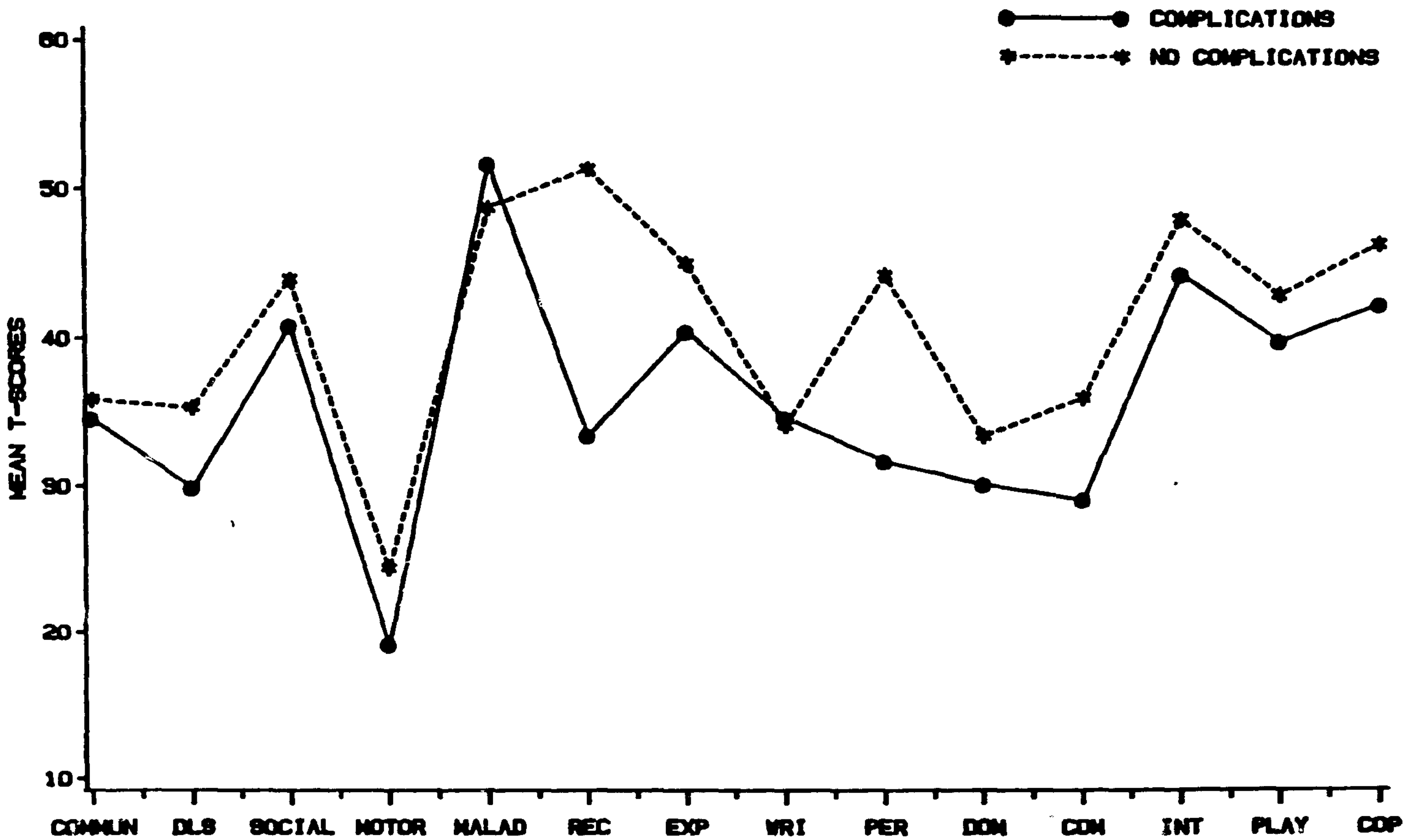
See legend on next page.

Legend for Figure 12

AGDOM	=	Agnosia: Dominant Hand
AGNDO	=	Agnosia: Nondominant Hand
ASTDO	=	Astereognosis: Dominant
ASTNDO	=	Astereognosis: Nondominant
CAT	=	Halstead Category
CPTCO	=	Continuous Performance Test - Commission Errors
CPTOM	=	Continuous Performance Test - Omission Errors
DYSDOM	=	Dysgraphesthesia: Dominant Hand
DYSNDO	=	Dysgraphesthesia: Nondominant Hand
FTDOM	=	Finger-Tapping Test - Dominant Hand
FTNDO	=	Finger-Tapping Test - Nondominant Hand
PEGDOM	=	Pegboard Test - Dominant Hand
PEGNDO	=	Pegboard Test - Nondominant Hand
PIATCO	=	Peabody Individual Achievement Test - Comprehension Subtest
PIATRE	=	Peabody Individual Achievement Test - Reading Recognition Subtest
TAERR	=	Trails A: Errors
TATIME	=	Trails A: Time
TBERR	=	Trails B: Errors
TBTIME	=	Trails B: Time
UNFIVE	=	Underlining Test: Subtest 5 (4 letter nonsense syllable)
UNFOUR	=	Underlining Test: Subtest 4 (Gestalt Figure)
UNONE	=	Underlining Test: Subtest 1 (Number)
UNTWO	=	Underlining Test: Subtest 2 (Geometric Form)
WRATAR	=	Wide Range Achievement Test: Arithmetic Subtest
WRATSP	=	Wide Range Achievement Test: Spelling Subtest

FIGURE 13

Mean T-Scores for Vineland Adaptive Behaviour Scale
for Complication Variable



See legend on next page.

Legend for Figure 13

Vineland Behaviour Adaptive Scale

COM	=	Community Subdomain
COMMUN	=	Communication Domain
DLS	=	Daily Living Scale Domain
DOM	=	Domestic Subdomain
EXP	=	Expressive Subdomain
INT	=	Interests Subdomain
LOP	=	Coping Subdomain
MALAD	=	Maladaptive Domain
MOTOR	=	Motor Domain
PER	=	Personal Subdomain
PLAY	=	Play and Leisure Subdomain
REC	=	Receptive Subdomain
SOCIAL	=	Socialization Domain
WRI	=	Written Subdomain

3.5.3 Ocular Abnormalities

Of the 36 myelomeningocele children, 25 (69.4%) had a history of ocular abnormalities. Inspection of the frequency analysis revealed that of the 25 children with ocular difficulties, 84% (n = 21) had a history of strabismus (squint); and that 30% (n = 9) of these cases also had a history of nystagmus (see Table 37). Strabismus was further broken down into specific types and it was found that esotropia (n = 10) was most frequently noted (see Table 38).

To determine if a history of ocular abnormalities was associated with poorer cognitive test performance and behavioural problems as compared to those without ocular abnormalities, a series of T-tests were conducted (see Appendix H). Graphic display of this data is presented in Figures 14 to 16.

With regard to Intellectual ability, although the myelomeningocele children with a history of ocular abnormalities performed lower than children without such a history on the WISC-R composite scores (i.e., VIQ, PIQ, FSIQ), only the score on the PIQ reached statistical significance ($t(34) = -1.84$, $p<.05$). Focusing on the WISC-R subtests, a significant group difference emerged for the Picture Arrangement subtest ($t(34) = -2.14$, $p<.05$; see Table H-2). Furthermore, although the difference did not reach significance for 7 of the 11 subtests, the values presented in Tables H-1 and H-2 showed a poorer level of performance for the children with a history of ocular abnormalities.

Significant differences also emerged for the following skill areas: 1) Language ability--the Expressive One-Word Test (EOWPT) ($t(34) = -2.49$,

$p<.01$; see Table H-3); 2) Memory ability--the Long-Term Storage ($t(34) = -2.14$, $p<.05$) and Consistent Retrieval ($t(34) = -2.45$, $p<.01$) measures of the Verbal Selective Reminding Test (VSRT); and the recall condition of the Rey-Osterrieth Figure ($t(34) = -2.19$, $p<.05$; see Tables H-4 & H-5). On the remaining memory measures, although there were no significant differences, children with ocular difficulties performed less well than those without ocular difficulties on 5 of the 9 memory measures; 3) Constructional ability--copy of the Rey Figure ($t(34) = -2.11$, $p<.05$; see Table H-6); 4) Attention--the amount of omission errors on the Continuous Performance Test (CPT) ($t(31.77) = -2.06$, $p<.05$; see Table H-7); 5) Motor ability--the Grooved Pegboard Test for both the dominant ($t(33.47) = -2.49$, $p<.01$) and nondominant hand ($t(29.54) = -2.40$, $p<.05$); amount of time on Trails A ($t(29.91) = -1.78$, $p<.05$) and errors ($t(33) = -1.70$, $p<.05$) on Trails A (see Table H-8); 6) Tactile-Perceptual ability--Agnosia for both the dominant ($t(30.98) = -2.39$, $p<.05$) and nondominant hand ($t(31.67) = -2.32$, $p<.05$; and Astereognosis for both the dominant ($t(24.99) = -1.81$, $p<.05$) and nondominant hand ($t(26.21) = -3.05$, $p<.01$; see Table H-9).

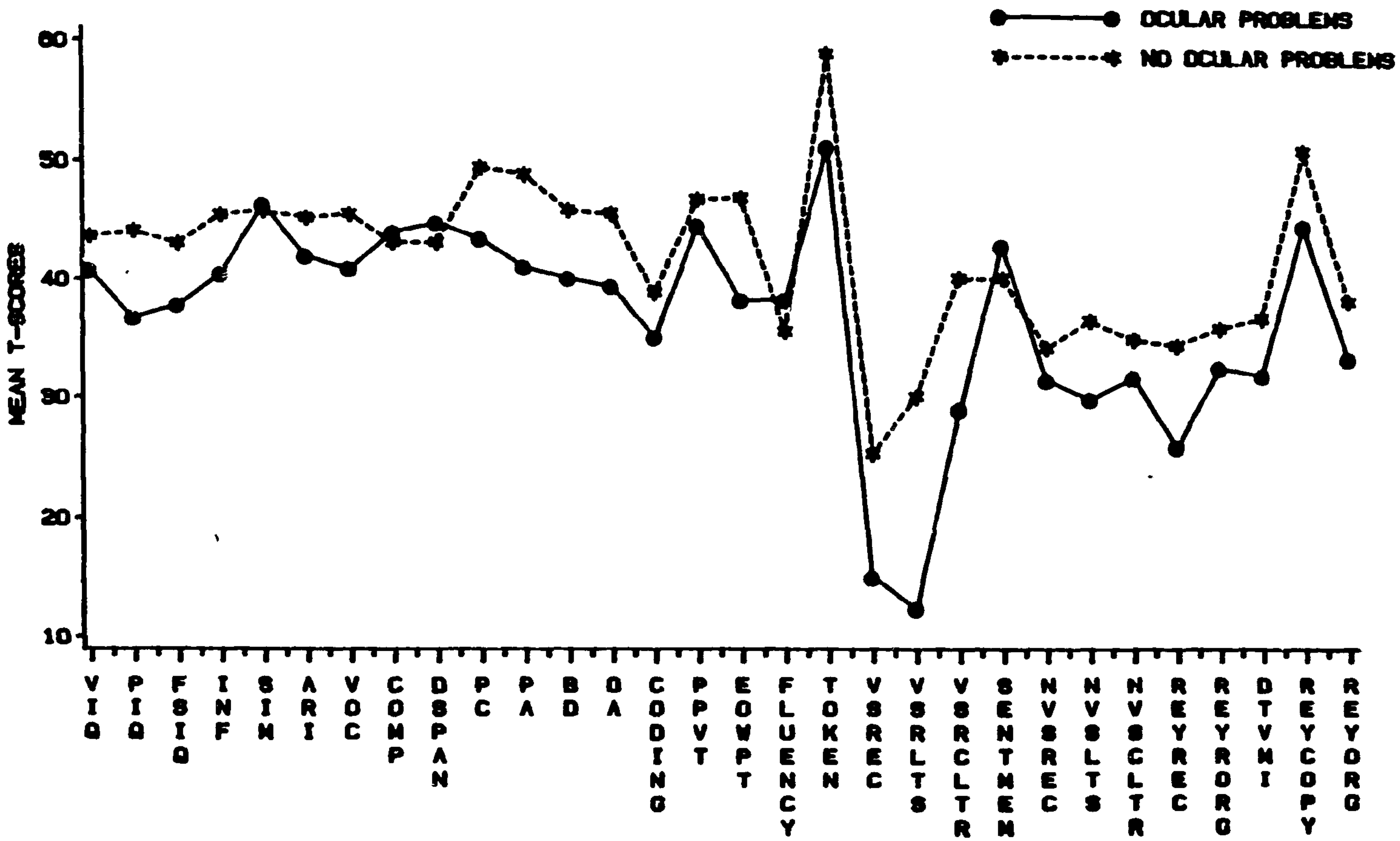
Within the Behavioural and Social Competence skill area, significant differences emerged on the following scales of the Vineland Adaptive Behaviour Scale: Motor ($t(13.15) = -3.10$, $p<.01$); (see Table H-11). In addition, the children with ocular difficulties were rated lower on the Social Competence scale, for both the Parent and Teacher Achenbach scales ($t(24) = -2.14$, $p<.05$) and $t(24) = -1.90$, $p<.05$, respectively; see Tables H-14 & H-15).

In summary, of the 19 t-tests that reached statistical significance, all were in the predicted direction (24.67% of the tests administered). That is, the children with a history of ocular abnormalities experienced more difficulty in these areas. In addition, on another 45 variables (58.44% of the tests administered), the level of performance, albeit not reaching statistical significance was poorer for the children with a history of ocular abnormalities.

Finally, to investigate the relationship between ocular abnormalities and history of complications, a frequency analysis was conducted. This distribution was nonsignificant (Chi-sq (1) = 3.2723, p>.05). However, there was a trend towards a higher proportion of children with ocular abnormalities (n = 15) in the complication group (see Table 39).

FIGURE 14

Mean T-Scores for Intellectual, Language, Memory and Construction Skill Areas for Ocular Variable



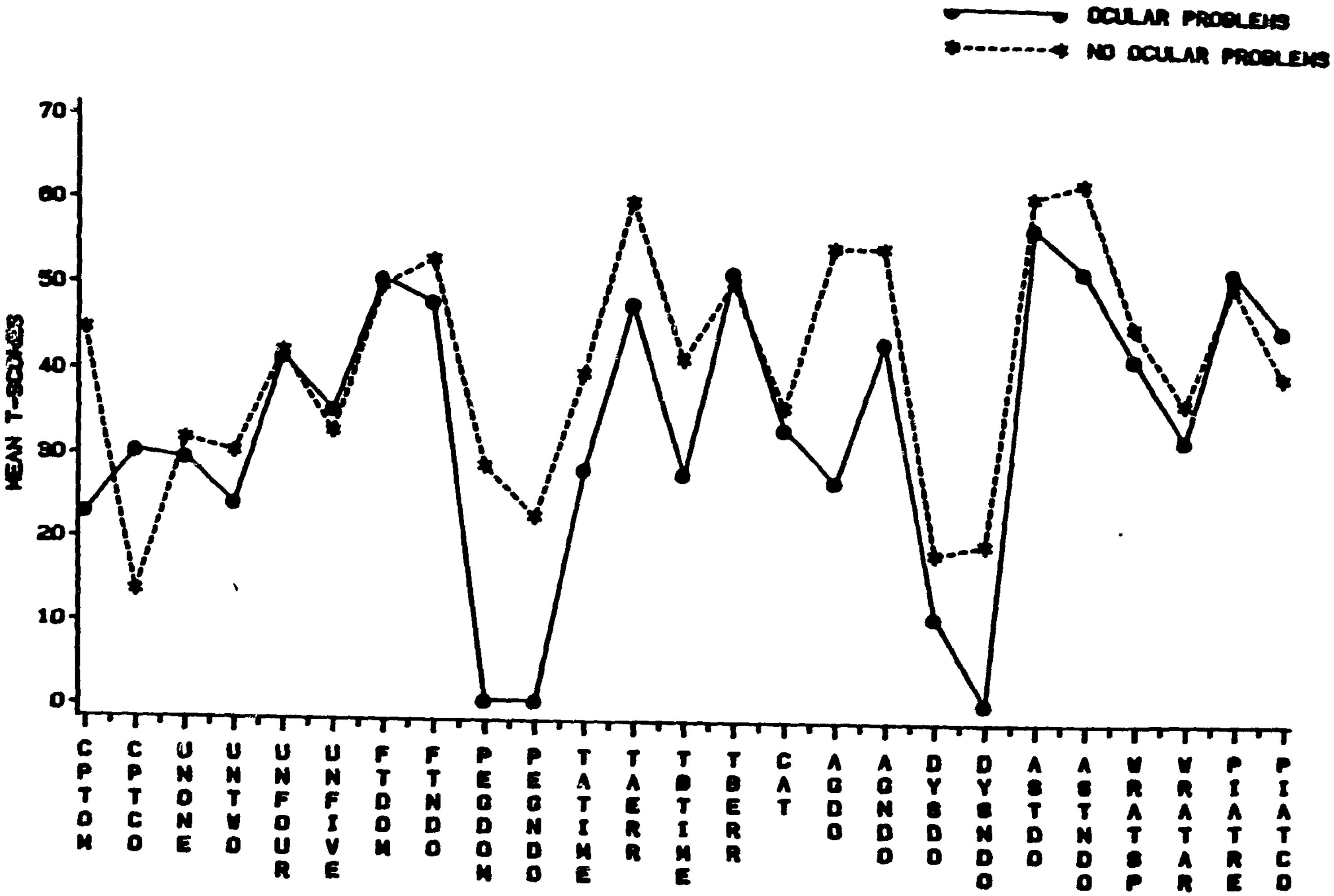
See legend on next page.

Legend for Figure 14

ARI	=	Arithmetic
BD	=	Block Design
CODING	=	Coding subtest
COMP	=	Comprehension
DSPAN	=	Digit Span
DTVMI	=	Developmental Test of Visual-Motor Integration
EOWPT	=	Expressive One-Word Picture Test
FLUENCY	=	Fluency Test
FSIQ	=	Full Scale IQ
INF	=	Information
NVSCLTR	=	Nonverbal Selective Reminding Test - Consistent Long-Term Retrieval
NVSLTS	=	Nonverbal Selective Reminding Test - Long-Term Storage
NVSREC	=	Nonverbal Selective Reminding Test - Recall Condition
OA	=	Object Assembly
PA	=	Picture Arrangement
PC	=	Picture Completion
PIQ	=	Performance IQ
PPVT	=	Peabody Picture Vocabulary Test
REYCOPY	=	Rey Figure - Copy
REYORG	=	Rey Figure - Organizational Skill
REYREC	=	Rey Figure - Recall Condition
REYRORG	=	Rey Figure - Recall - Organizational Skill
SENTMEM	=	Sentence Memory
SIM	=	Similarities
TOKEN	=	Token Test
VIQ	=	Verbal IQ
VOC	=	Vocabulary
VSRCLTR	=	Verbal Selective Reminding Test - Consistent Long-Term Retrieval
VSREC	=	Verbal Selective Reminding Test - Recall Condition
VSRLTS	=	Verbal Selective Reminding Test - Long-Term Storage

FIGURE 15

Mean T-Scores for Attention, Motor, Problem-Solving, Tactile-Perceptual and Academic Skill Areas for Ocular Variable



See legend on next page.

Legend for Figure 15

AGDOM = Agnosia: Dominant Hand

AGNDO = Agnosia: Nondominant Hand

ASTDO = Astereognosis: Dominant

ASTNDO = Astereognosis: Nondominant

CAT = Halstead Category

CPTCO = Continuous Performance Test - Commission Errors

CPTOM = Continuous Performance Test - Omission Errors

DYSDOM = Dysgraphesthesia: Dominant Hand

DYSNDO = Dysgraphesthesia: Nondominant Hand

FTDOM = Finger-Tapping Test - Dominant Hand

FTNDO = Finger-Tapping Test - Nondominant Hand

PEGDOM = Pegboard Test - Dominant Hand

PEGNDO = Pegboard Test - Nondominant Hand

PIATCO = Peabody Individual Achievement Test - Comprehension Subtest

PIATRE = Peabody Individual Achievement Test - Reading Recognition Subtest

TAERR = Trails A: Errors

TATIME = Trails A: Time

TBERR = Trails B: Errors

TBTIME = Trails B: Time

UNFIVE = Underlining Test: Subtest 5 (4 letter nonsense syllable)

UNFOUR = Underlining Test: Subtest 4 (Gestalt Figure)

UNONE = Underlining Test: Subtest 1 (Number)

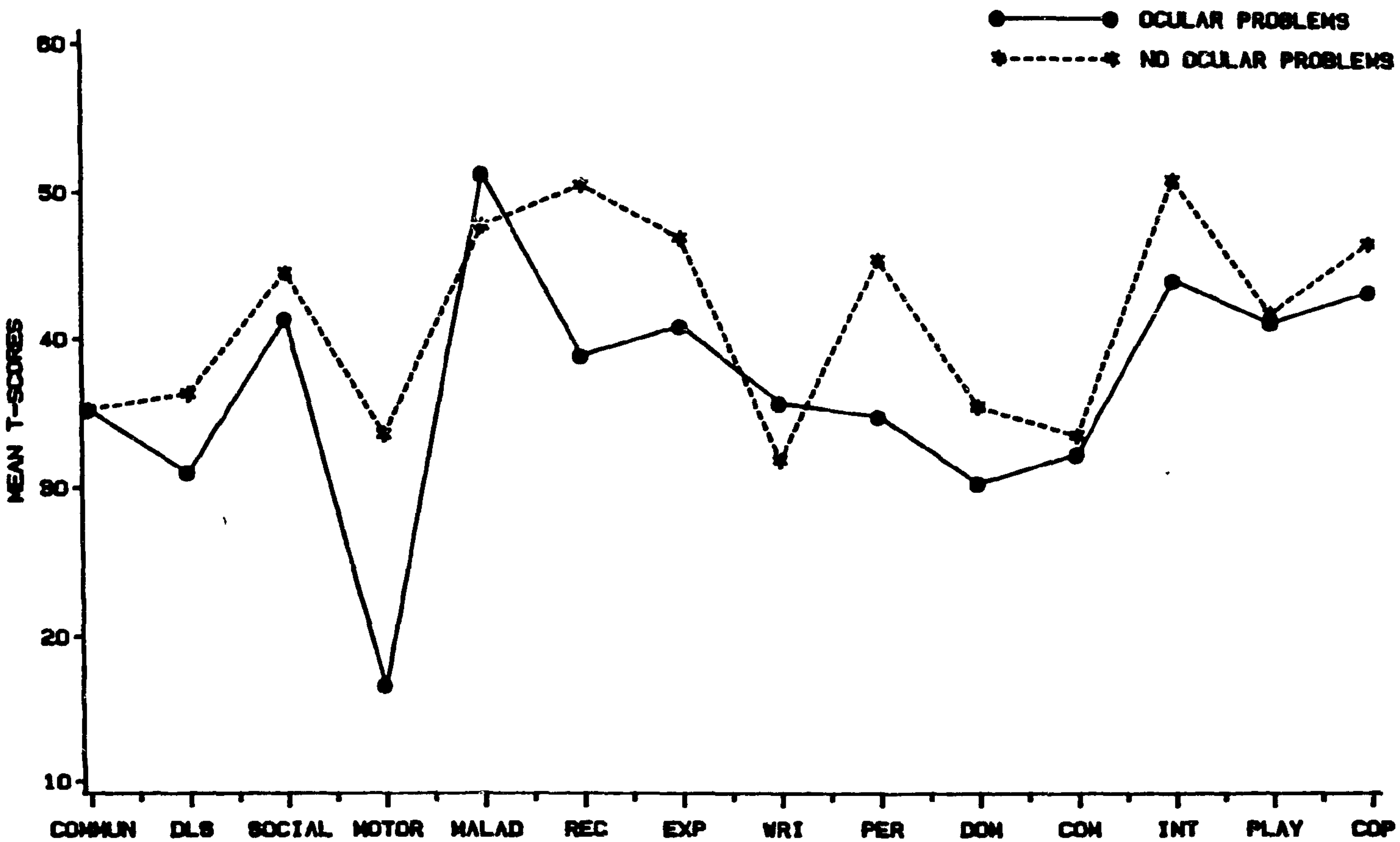
UNTWO = Underlining Test: Subtest 2 (Geometric Form)

WRATAR = Wide Range Achievement Test: Arithmetic Subtest

WRATSP = Wide Range Achievement Test: Spelling Subtest

FIGURE 16

Mean T-Scores for Vineland Adaptive Behaviour Scale for Ocular Variable



See legend on next page.

Legend for Figure 16

Vineland Behaviour Adaptive Scale

COM = Community Subdomain

COMMUN = Communication Domain

DLS = Daily Living Scale Domain

DOM = Domestic Subdomain

EXP = Expressive Subdomain

INT = Interests Subdomain

LOP = Coping Subdomain

MALAD = Maladaptive Domain

MOTOR = Motor Domain

PER = Personal Subdomain

PLAY = Play and Leisure Subdomain

REC = Receptive Subdomain

SOCIAL = Socialization Domain

WRI = Written Subdomain

TABLE 37

Frequency Analysis of Ocular Abnormalities (n = 25)

		Absolute Frequency	Relative Frequency
(1)	Gaze and Movement Disorder:		
	Strabismus	12	48
	Nystagmus Only	3	12
	Strabismus and Nystagmus	9	36
(2)	Refraction Error		
	Astigmatism	1	4

TABLE 38

Frequency of Types of Strabismus (n = 21)

				Frequency
(1)	Heterotropia	(a)	Esotropria	10
		(b)	Exotropia	8
(2)	Heterophoria	(a)	Esophoria	5
		(b)	Exophoria	1

TABLE 39

Frequency Analysis of Complications by
Ocular Abnormalities

	Ocular Abnormalities	No Ocular Abnormalities
Complications	15 (41.7%)	3 (8.3%)
No Complications	10 (27.8%)	8 (22.2%)

(Chi-sq (2) = 3.2723, p>.05)

3.5.4 Level of Lesion

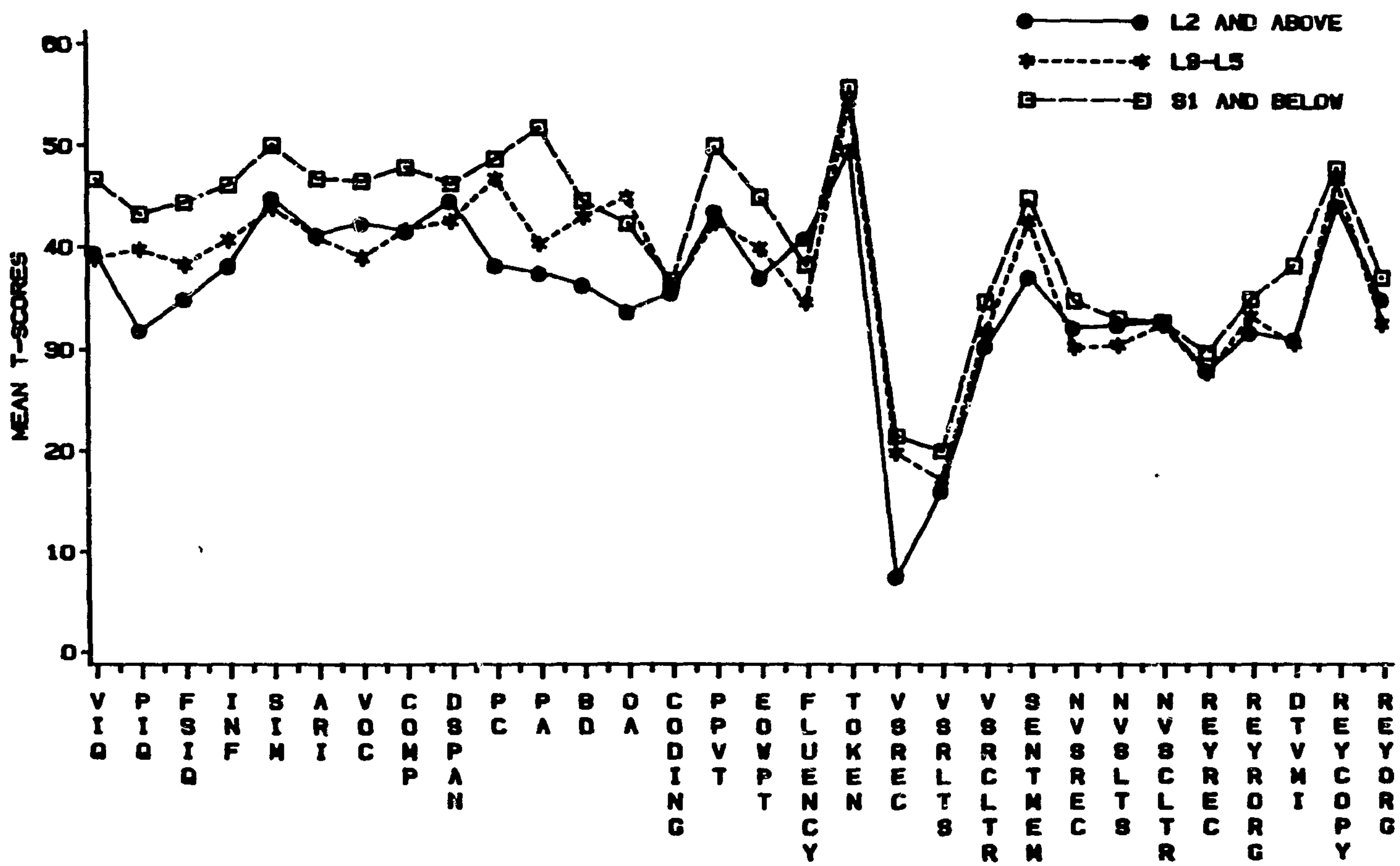
The 36 myelomeningocele children were divided into three groups according to the level of their lesion. The patients were distributed as follows: 1) 9 (25%) of the cases were classified as belonging to the group with lesions L2 or above; 2) 15 (41.7%) in the L3-L5 lesion group; and 3) 12 (33.3%) were classified as belonging to the S1 or below.

A series of frequency analyses were conducted to investigate the relationship between level of lesion and certain medical variables. Although not significant, a trend was found indicating that a high proportion of myelomeningocele children who had lesions above S1 also had ocular abnormalities (Chi-sq (2) = 3.?203, $p>.05$; see Table 40). When level of lesion was compared with children who had a history of complications, again a trend, albeit nonsignificant, was noted (Chi-sq (2) = 1.6000, $p>.05$; see Table 41). Comparing the level of lesion with a history of intrauterine hydrocephalus, a higher proportion of children with such a history were found in the groups above S1. This distribution was nonsignificant (Chi-sq (2) = 5.42338, $p>.05$; see Table 42). It is noteworthy that the four children that were excluded from the study all had lesions at L2 or above and a history of intrauterine hydrocephalus.

To determine if level of the myelomeningocele lesion was associated with poorer cognitive test performance and behavioural problems, a series of t-tests were conducted (See Appendix I). Graphic display of this data is presented in Figures 17 to 19.

FIGURE 17

Mean T-Scores for Intellectual, Language, Memory and Construction Skill Areas for Lesion Levels



See legend on next page.

Legend for Figure 17

ARI = Arithmetic

BD = Block Design

CODING = Coding subtest

COMP = Comprehension

DSPAN = Digit Span

DTVMI = Developmental Test of Visual-Motor Integration

EOWPT = Expressive One-Word Picture Test

FLUENCY = Fluency Test

FSIQ = Full Scale IQ

INF = Information

NVSCLTR = Nonverbal Selective Reminding Test - Consistent Long-Term Retrieval

NVSLTS = Nonverbal Selective Reminding Test - Long-Term Storage

NVSREC = Nonverbal Selective Reminding Test - Recall Condition

OA = Object Assembly

PA = Picture Arrangement

PC = Picture Completion

PIQ = Performance IQ

PPVT = Peabody Picture Vocabulary Test

REYCOPY = Rey Figure - Copy

REYORG = Rey Figure - Organizational Skill

REYREC = Rey Figure - Recall Condition

REYRORG = Rey Figure - Recall - Organizational Skill

SENTMEM = Sentence Memory

SIM = Similarities

TOKEN = Token Test

VIQ = Verbal IQ

VOC = Vocabulary

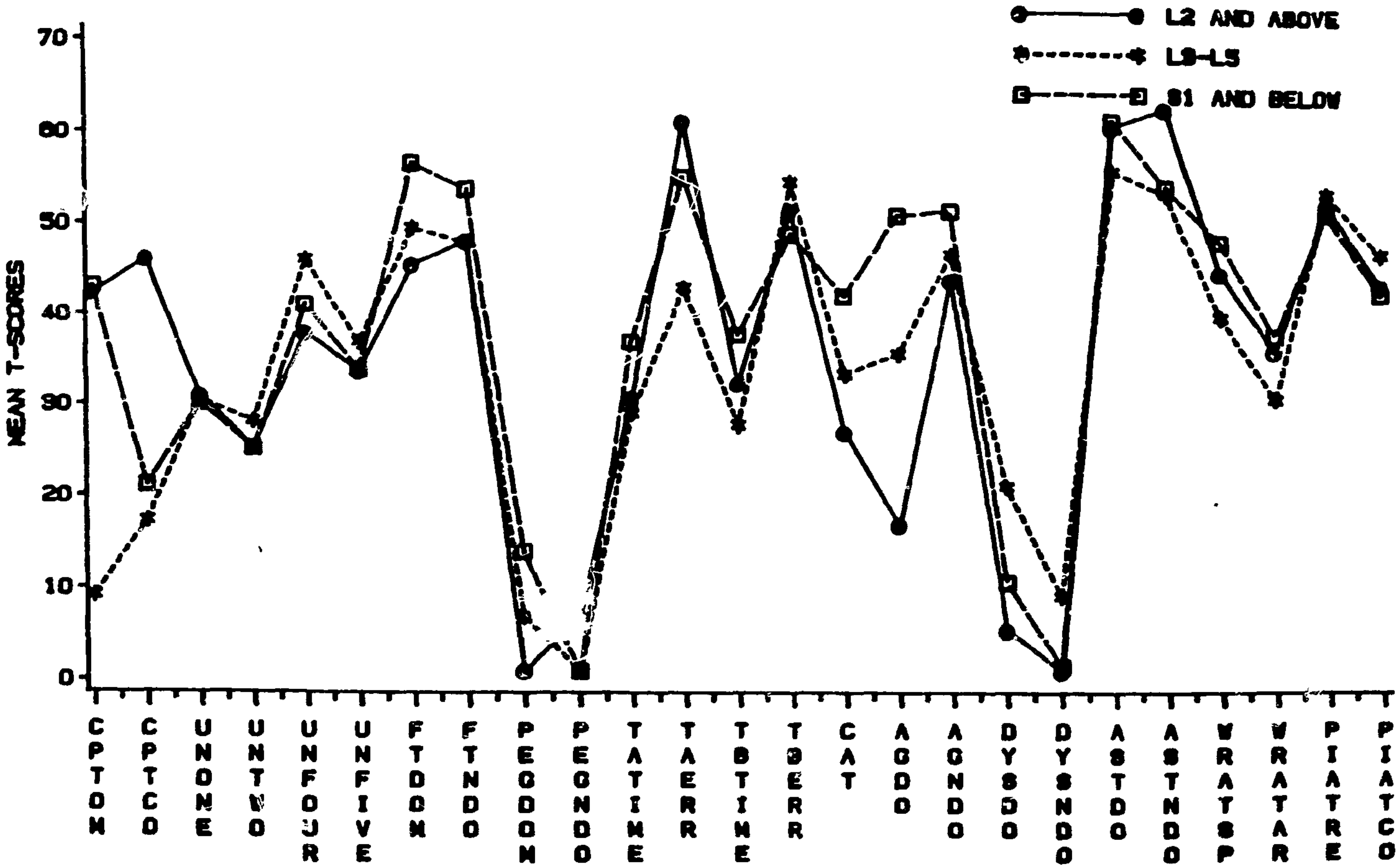
VSRCLTR = Verbal Selective Reminding Test - Consistent Long-Term Retrieval

VSREC = Verbal Selective Reminding Test - Recall Condition

VSRLTS = Verbal Selective Reminding Test - Long-Term Storage

FIGURE 18

Mean T-Scores for Attention, Motor, Problem-Solving, Tactile-Perceptual and Academic Skill Areas for Lesion Levels



See legend on next page.

Legend for Figure 18

AGDOM = Agnosia: Dominant Hand

AGNDO = Agnosia: Nondominant Hand

ASTDO = Astereognosis: Dominant

ASTNDO = Astereognosis: Nondominant

CAT = Halstead Category

CPTCO = Continuous Performance Test - Commission Errors

CPTOM = Continuous Performance Test - Omission Errors

DYSDOM = Dysgraphesthesia: Dominant Hand

DYSNDO = Dysgraphesthesia: Nondominant Hand

FTDOM = Finger-Tapping Test - Dominant Hand

FTNDO = Finger-Tapping Test - Nondominant Hand

PEGDOM = Pegboard Test - Dominant Hand

PEGNDO = Pegboard Test - Nondominant Hand

PIATCO = Peabody Individual Achievement Test - Comprehension Subtest

PIATRE = Peabody Individual Achievement Test - Reading Recognition Subtest

TAERR = Trails A: Errors

TATIME = Trails A: Time

TBERR = Trails B: Errors

TBTIME = Trails B: Time

UNFIVE = Underlining Test: Subtest 5 (4 letter nonsense syllable)

UNFOUR = Underlining Test: Subtest 4 (Gestalt Figure)

UNONE = Underlining Test: Subtest 1 (Number)

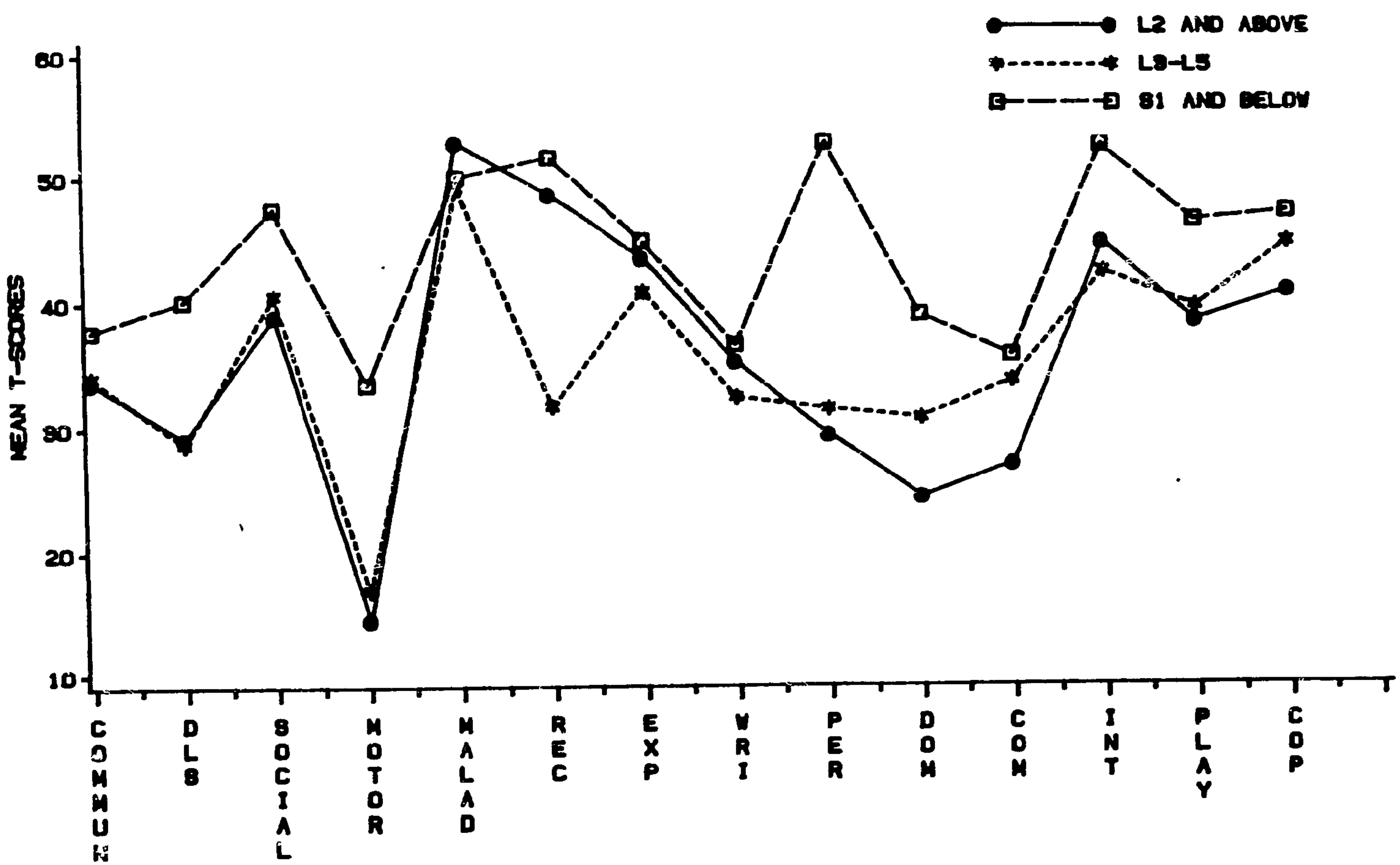
UNTWO = Underlining Test: Subtest 2 (Geometric Form)

WRATAR = Wide Range Achievement Test: Arithmetic Subtest

WRATSP = Wide Range Achievement Test: Spelling Subtest

FIGURE 19

Mean T-scores for Vineland Adaptive Behaviour Scale
for Lesion Levels



See legend on next page.

Legend for Figure 19

Vineland Behaviour Adaptive Scale

COM = Community Subdomain

COMMUN = Communication Domain

DLS = Daily Living Scale Domain

DOM = Domestic Subdomain

EXP = Expressive Subdomain

INT = Interests Subdomain

LOP = Coping Subdomain

MALAD = Maladaptive Domain

MOTOR = Motor Domain

PER = Personal Subdomain

PLAY = Play and Leisure Subdomain

REC = Receptive Subdomain

SOCIAL = Socialization Domain

WRI = Written Subdomain

The first set of t-tests compared the children with lesions at or above L2 with those children whose lesion was at or below S1. Significant differences were found in the following skill areas: 1) Intellectual ability--PIQ ($t(19) = -3.48$, $p<.01$); FSIQ ($t(19) = -2.66$, $p<.001$); and all the Performance subtest scales except the Coding scale (see Table I-1 to I-3); 2) Problem Solving ability--Category Test ($t(19) = -2.67$, $p<.01$; see Table I-7); 3) Attention--commission errors (i.e., impulsive errors) on the Continuous Performance Test (CPT) ($t(10.57) = 1.83$, $p<.05$; see Table I-8).

Within the Behavioural and Social Competence domain, significant differences were found for the following scales of the Vineland Adaptive Behaviour scale: the Daily Living Skills ($t(19) = -1.79$, $p<.05$); Socialization ($t(19) = -2.22$, $p<.05$) and Motor ($t(14.88) = -3.67$, $p<.01$) domains; and the Personal ($t(8.69) = -2.07$, $p<.05$); Domestic ($t(10.22) = -3.36$, $p<.01$); Interests ($t(19) = -1.76$, $p<.05$); and Play ($t(19) = -1.97$, $p<.05$) subscales (see Table I-13 to I-15). In terms of the Achenbach scales, a significant difference was found for Social Competence score ($t(8.21) = -3.82$, $p<.01$; see Table I-16).

In summary, of the 16 t-tests (20.77% of the tests administered) that reached statistical significance, with the exception of one variable (CPT - Commission Errors), the results were in the predicted direction. That is, the children with the higher level lesions (L2 or above) experienced more difficulty in these areas. In addition, on another 45 variables (58.44% of the tests administered), the level of performance, albeit not reaching statistical significance was poorer for the children with the higher level lesion.

The next set of analyses compared children with lesions between L3-L5 relative to the children with lesions S1 or below. It was hypothesized that children with lesion between L3-L5 would perform more poorly than children with lesion S1 or below. Significant differences emerged on measures within the following skill areas: 1) Intellectual ability--VIQ ($t(25) = -2.19$, $p<.05$); Similarities ($t(25) = -2.26$, $p<.05$); Arithmetic ($t(25) = -1.96$, $p<.05$); Comprehension ($t(15.58) = -1.79$, $p<.05$); and Picture Arrangement ($t(25) = -3.07$, $p<.01$) subtests; see Tables J-1 to J-3); 2) Language ability--Peabody Picture Vocabulary Test ($t(25) = -1.77$, $p<.05$; see Table J-4); 3) Construction ability--Developmental Test of Visuomotor Integration ($t(25) = -1.80$, $p<.05$; see Table J-7); 4) Attention--omission errors on the Continuous Performance Test ($t(15.65) = -2.12$, $p<.05$; see Table J-8); 5) Tactile-Perceptual ability--Agnosia for the dominant hand ($t(25) = -1.71$, $p<.05$); (see Table J-11); and 6) Academic ability--Spelling ($t(25) = -1.96$, $p<.05$) and Arithmetic ($t(25) = -1.77$, $p<.05$) subtests of the Wide Range Achievement Test (see Table J-12).

Within the Behaviour and Social Competence domain, significant differences were found for the following scales of the Vineland Adaptive scale: the Daily Living Skills ($t(25) = -2.66$, $p<.01$); Socialization ($t(25) = -1.82$, $p<.05$); and Motor ($t(25) = -3.15$, $p<.01$) domains; and the Receptive ($t(14.31) = -1.81$, $p<.05$); Personal ($t(16.63) = -2.76$, $p<.01$); and Domestic ($t(25) = -2.79$, $p<.01$) subscales (see Tables J-13 to J-15).

In terms of the Achenbach Scales, a significant difference was found for Social Competence score ($t(17) = -4.18$, $p<.001$; see Table J-16).

In summary, all of the 18 t-tests that reached statistical significance (23.37% of the tests administered), were in the predicted direction. That is, the children with the higher level lesion (L3-L5) experienced more difficulty in these areas relative to the children with the lower level lesion (S1 or below). In addition, on another 43 variables (55.84% of the tests administered), the level of performance, albeit not reaching statistical significance was poorer for the children with the higher level lesion (L3-L5).

The final set of analyses compared the children with lesions at or above L2 with children whose lesion were between L3-L5. It was hypothesized that these children would perform significantly worse than the children whose lesions were between L3-L5. Significant differences in the expected direction were found for the measures within the following skill areas: 1) Intellectual ability--PIQ ($t(20.26) = -1.85$, $p<.05$); Object Assembly ($t(22) = -1.83$, $p<.05$) subtest ;see Tables K-1 to K-3); 2) Attention--omission ($t(16.54) = 2.03$, $p<.05$) and commission ($t(13.93) = 2.38$, $p<.05$) errors on the Continuous Performance Test; subtest 4 of the Underlining Test ($t(20) = -2.77$, $p<.01$); see Table K-8); 3) Motor ability-accuracy on Trails A ($t(19.38) = 2.23$, $p<.05$; see Table K-10); 4) Tactile-Perceptual ability--Astereognosis for the nondominant ($t(17.07) = 2.44$, $p<.01$; see Table K-11). No significant differences emerged on any of the measures within the Behaviour and Social Competence domain (See Tables K-13 to K-17).

In summary, of the 7 t-tests (9.09% of the tests administered) that reached statistical significance, three were in the predicted direction (PIQ, Object Assembly and subtest four of the Underlining Test). That is, the children with the higher level lesion (L2 or above) experienced more difficulty in these areas relative to the children with the lower level lesion (L3-L5). In addition, on another 39 variables (50.64% of the tests administered), the level of performance, albeit not reaching statistical significance, was poorer for the children with the higher level lesion (L2 or above).

TABLE 40

Frequency Analysis of Level of Lesion by
History of Ocular Abnormalities

Lesion Level	History of Ocular Abnormalities	No History of Ocular Abnormalities
L2 or Above	7 (19.4%)	2 (5.69%)
L3-L5	12 (33.3%)	3 (8.3%)
S1 or Below	6 (16.7%)	6 (16.7%)

(Chi-sq (2) = 3.22036, p > .05)

TABLE 41

Frequency Analysis of Level of Lesion
by Complications

	Complications	No Complications
L2 or Above	3 (8.3%)	6 (16.7%)
L3-L5	9 (25.0%)	6 (16.7%)
S1 or Below	6 (16.7%)	6 (16.7%)

(Chi-sq (2) = 1.6000, p > .05)

TABLE 42

Frequency Analysis of Level of Lesion
by Intrauterine Hydrocephalus (Total Percent)

Lesion Level	Intrauterine Hydrocephalus	Hydrocephalus Developed after Birth
L2 or Above	3 (8.3%)	6 (16.7%)
L3-L5	9 (25.0%)	6 (16.7%)
S1 or Below	2 (5.6%)	10 (27.8%)

(Chi-sq (2) = 5.42338, $p > .05$)

3.5.5 Intrauterine Hydrocephalus

Fourteen (38.9%) of the myelomeningocele sample were classified as having intrauterine hydrocephalus (i.e., a history of hydrocephalus at birth). Of these, 13 (93%) cases also had a history of ocular abnormalities.

To determine if a history of intrauterine hydrocephalus was associated with poorer cognitive test performance and behaviour problems relative to myelomeningocele children without such a history, a series of t-tests were performed (see Appendix L). Graphic display of this data is presented in Figures 20 to 22.

In terms of Intellectual ability, inspection of the results revealed that children with a history of Intrauterine Hydrocephalus obtained significantly lower scores on the VIQ ($t(34) = -1.96$, $p<.05$), PIQ ($t(34) = -2.23$, $p<.05$) and FSIQ ($t(34) = -2.47$. $p<.01$) scales. Of the 11 subscales of the WISC-R, 5 were significant. Although the other 6 did not achieve the level of significance, it is noteworthy that 100% of the subscale scores for the children with a history of intrauterine hydrocephalus were lower than those for individuals who developed hydrocephalus after birth.

Significant differences also emerged on the following measures: 1) Language ability--Expressive One Word Test ($t(34) = -1.91$, $p<.05$; see Table L-4); 2) Memory ability--Four of the 9 measures (see Tables L-5 to L-6); 3) Construction ability--all the measures were significantly different (see Table L-7); 4) Attention--omission errors on the Continuous Performance Test ($t(12.76) = -2.60$, $p<.05$); Underlining test-subtest 2

($t(31) = -2.50$, $p<.01$) and subtest 5 ($t(30.86) = -1.78$, $p<.05$; see Table L-8); 5) Motor domain--Finger Tapping for the nondominant hand ($t(34) = -2.37$, $p<.01$); amount of time on Trails A ($t(16.18) = -2.09$; $p<.05$) and Trails B ($t(18.46) = -2.71$, $p<.01$); and amount of errors on Trials A ($t(15.30) = -2.01$, $p<.05$; see Table L-9); 6) Academic ability--Spelling ($t(34) = -2.08$, $p<.05$) and Arithmetic ($t(34) = -1.96$, $p<.05$; see Table L-10); and (7) Tactile-Perceptual ability--Dysgraphesthesia for the nondominant hand ($t(14.38) = -2.32$, $p<.05$) and Astereognosis for the nondominant hand ($t(14.48) = -2.14$, $p<.05$ see Table L-11).

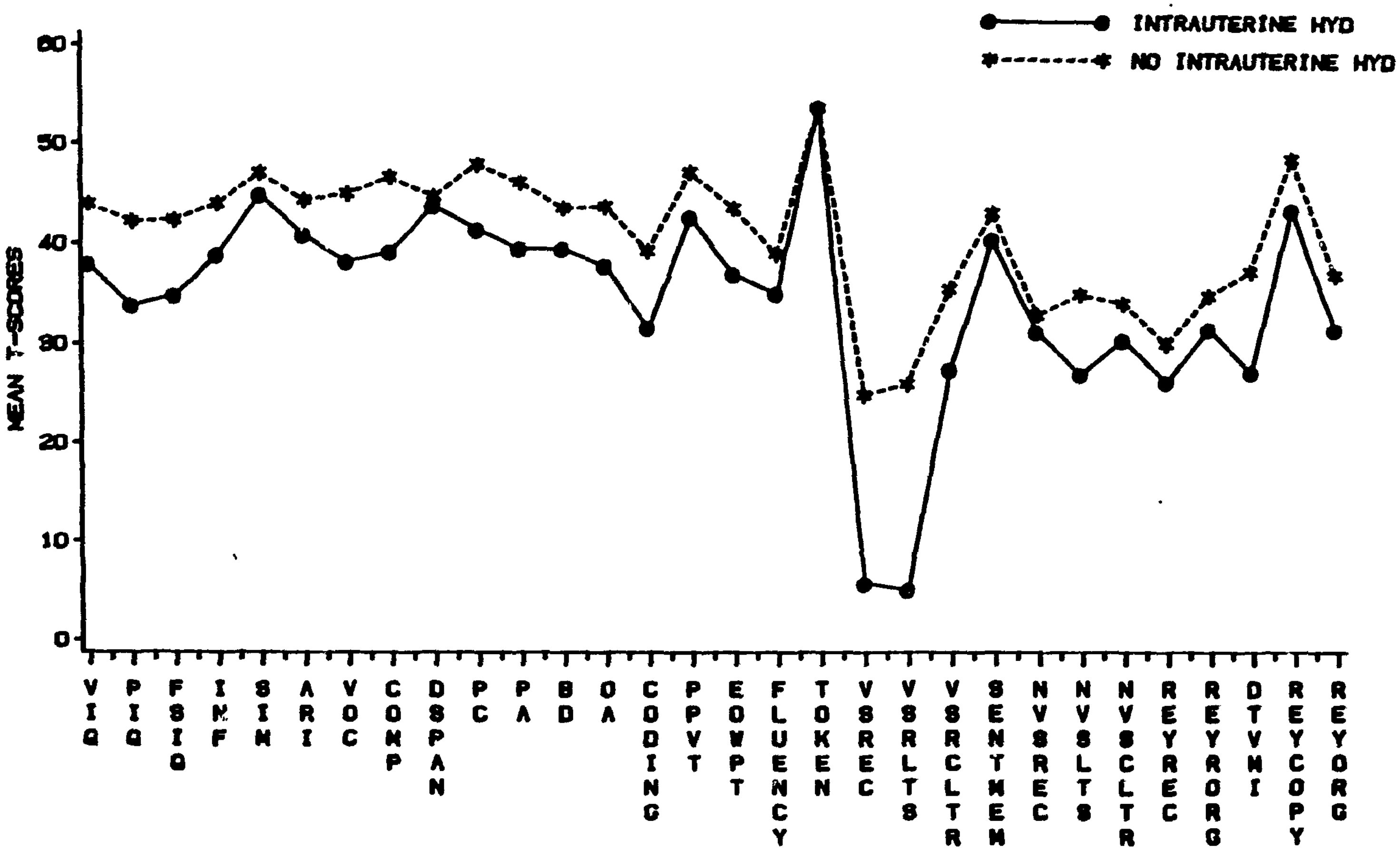
Within the Behaviour and Social Competence domain, significant differences were found for the following scales of the Vineland Adaptive scale: the Daily Living skills ($t(34) = -2.38$, $p<.05$) and Motor ($t(25.10) = -4.56$, $p<.001$) domains and; the expressive ($t(34) = -2.60$, $p<.01$); personal ($t(17.33) = -1.74$, $p<.05$); domestic ($t(17.87) = -2.49$, $p<.05$) and community ($t(34) = -1.71$, $p<.05$) subdomains; see Tables L-12 to L-14.

For the remaining measures, there was a trend for the children with a history of Intrauterine Hydrocephalus to perform more poorly when compared with children without such a history.

In summary, of the 33 t-tests (42.85% of the tests adminisitered) that reached statistical significance, all were in the predicted direction. That is, the children with a history of Intrauterine Hydrocephalus experienced more difficulty in these areas. In addition, on another 33 variables (42.85% of the tests administered), the level of performance, albeit not reaching statistical significance, was poorer for the children with a history of Intrauterine Hydrocephalus.

FIGURE 20

Mean T-Scores for Intellectual, Language, Memory and Construction Skill Areas for Intrauterine Hydrocephalus Variable



See legend on next page.

Legend for Figure 20

ARI = Arithmetic

BD = Block Design

CODING = Coding subtest

COMP = Comprehension

DSPAN = Digit Span

DTVMI = Developmental Test of Visual-Motor Integration

EOWPT = Expressive One-Word Picture Test

FLUENCY = Fluency Test

FSIQ = Full Scale IQ

INF = Information

NVSCLTR = Nonverbal Selective Reminding Test - Consistent Long-Term Retrieval

NVSLTS = Nonverbal Selective Reminding Test - Long-Term Storage

NVSREC = Nonverbal Selective Reminding Test - Recall Condition

OA = Object Assembly

PA = Picture Arrangement

PC = Picture Completion

PIQ = Performance IQ

PPVT = Peabody Picture Vocabulary Test

REYCOPY = Rey Figure - Copy

REYORG = Rey Figure - Organizational Skill

REYREC = Rey Figure - Recall Condition

REYRORG = Rey Figure - Recall - Organizational Skill

SENTMEM = Sentence Memory

SIM = Similarities

TOKEN = Token Test

VIQ = Verbal IQ

VOC = Vocabulary

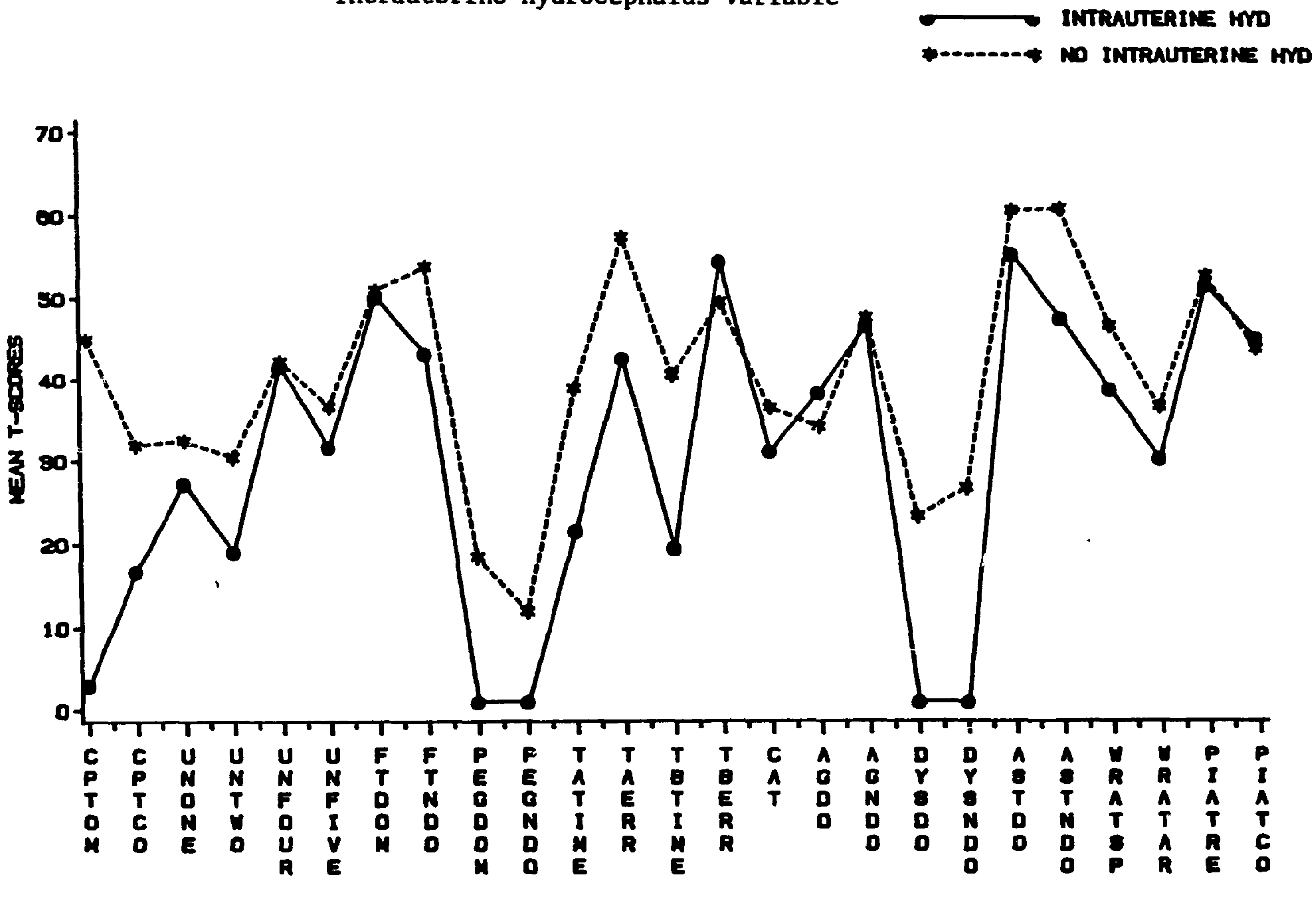
VSRCLTR = Verbal Selective Reminding Test - Consistent Long-Term Retrieval

VSREC = Verbal Selective Reminding Test - Recall Condition

VSRLTS = Verbal Selective Reminding Test - Long-Term Storage

FIGURE 21

Mean T-Scores for Attention, Motor, Problem-Solving, Tactile-Perceptual and Academic Skill Areas for Intrauterine Hydrocephalus Variable



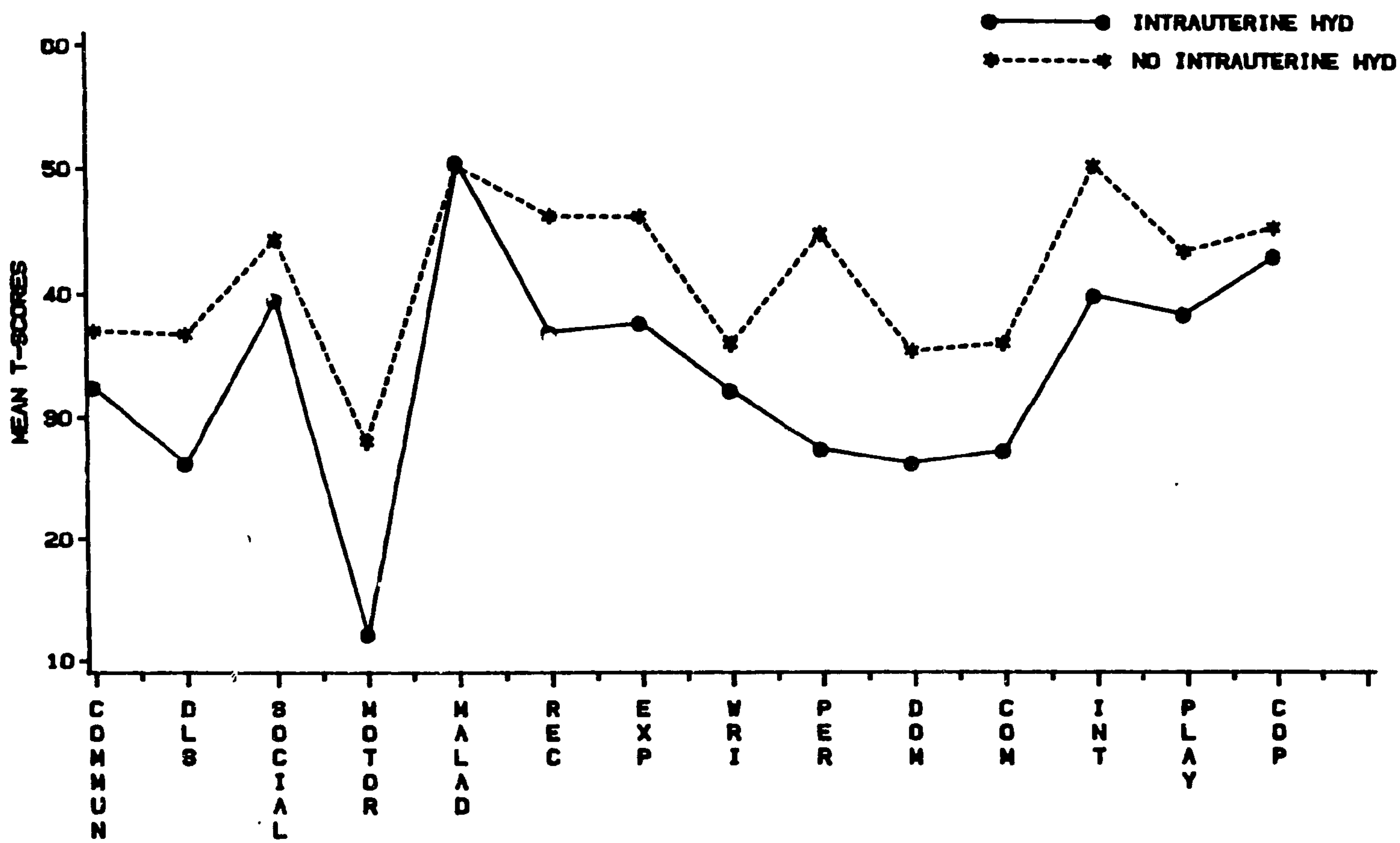
See legend on next page.

Legend for Figure 21

AGDOM	=	Agnosia: Dominant Hand
AGNDO	=	Agnosia: Nondominant Hand
ASTDO	=	Astereognosis: Dominant
ASTNDO	=	Astereognosis: Nondominant
CAT	=	Halstead Category
CPTCO	=	Continuous Performance Test - Commission Errors
CPTOM	=	Continuous Performance Test - Omission Errors
DYSDOM	=	Dysgraphesthesia: Dominant Hand
DYSNDO	=	Dysgraphesthesia: Nondominant Hand
FTDOM	=	Finger-Tapping Test - Dominant Hand
FTNDO	=	Finger-Tapping Test - Nondominant Hand
PEGDOM	=	Pegboard Test - Dominant Hand
PEGNDO	=	Pegboard Test - Nondominant Hand
PIATCO	=	Peabody Individual Achievement Test - Comprehension Subtest
PIATRE	=	Peabody Individual Achievement Test - Reading Recognition Subtest
TAERR	=	Trails A: Errors
TATIME	=	Trails A: Time
TBERR	=	Trails B: Errors
TBTIME	=	Trails B: Time
UNFIVE	=	Underlining Test: Subtest 5 (4 letter nonsense syllable)
UNFOUR	=	Underlining Test: Subtest 4 (Gestalt Figure)
UNONE	=	Underlining Test: Subtest 1 (Number)
UNTWO	=	Underlining Test: Subtest 2 (Geometric Form)
WRATAR	=	Wide Range Achievement Test: Arithmetic Subtest
WRATSP	=	Wide Range Achievement Test: Spelling Subtest

FIGURE 22

Mean T-Scores for Vineland Adaptive Behaviour Scale for Intrauterine Hydrocephalus Variable



See legend on next page.

Legend for Figure 22

Vineland Behaviour Adaptive Scale

COM = Community Subdomain

COMMUN = Communication Domain

DLS = Daily Living Scale Domain

DOM = Domestic Subdomain

EXP = Expressive Subdomain

INT = Interests Subdomain

LOP = Coping Subdomain

MALAD = Maladaptive Domain

MOTOR = Motor Domain

PER = Personal Subdomain

PLAY = Play and Leisure Subdomain

REC = Receptive Subdomain

SOCIAL = Socialization Domain

WRI = Written Subdomain

CHAPTER 4
DISCUSSION

This study investigates four main objectives. The subsequent discussion evaluates this goal and presents implications for future research.

4.1 NATURE OF ABILITY STRUCTURE

The first objective of this study addresses the question: Do children with myelomeningocele and hydrocephalus show a characteristic pattern of cognitive abilities as determined by neuropsychological testing?

As described in the Methods Section, 9 skill areas were assessed. These have been labelled as follows: 1) Psychometric Intelligence; 2) Language; 3) Memory and Learning; 4) Visual-Spatial/Constructional; 5) Attention and Psychomotor Efficiency; 6) Problem Solving and Reasoning; 7) Tactile-Perceptual; 8) Motor; and 9) Academic Achievement.

The presence of a neuropsychological deficit was inferred from a score that fell two or more standard deviations below the mean for normal children of the same age (X = 50; SD = 10). A mild degree of impairment was defined as at least one standard deviation below the mean. For each measure used in this study, the percentage of myelomeningocele children falling within the significantly impaired range was determined.

4.1.1 Psychometric Intelligence

The results of this investigation support previous research which suggests that myelomeningocele children with hydrocephalus yield lower scores on psychometric intelligence tests when compared to the normative data (Shaffer et al., 1985; Soare & Raimondi, 1977).

In this study the Wechsler Intelligence Scale for Children - Revised (WISC-R) was administered to the entire sample. In order to facilitate comparison with other studies, the results of the WISC-R will be discussed in terms of the WISC-R standard scores (i.e., for composite scores $\bar{X}$ = 100; SD = 15; for subtests $\bar{X}$ = 10; SD = 3). On this scale, an IQ below 70 falls within the mentally retarded range of ability; an IQ between 70 and 79 reflects borderline range of ability; an IQ of 80-89 falls within the low average range; an IQ 90-109 falls within the average range and; an IQ above 110 reflects high average intelligence or better.

Current results indicated that as a group, the mean full scale (FSIQ = 84.058; SD = 14.194); verbal IQ (VIQ = 87.417; SD = 13.993) and, performance IQ (PIQ = 83.361; SD = 17.313) of the myelomeningocele children fell within the low average range of psychometric intelligence.

Although there are too many sampling and other methodological differences among other investigations of myelomeningocele children to permit precise comparison, it seems reasonable to conclude that this sample is similar to those in other studies in terms of general intellectual functioning (Diller et al., 1969; Glasscock, 1978; Hayden et al., 1979; Spain, 1974).

These findings are consistent with the view that early brain damage is usually associated with a lowering of general intelligence (Fletcher & Levin, 1989). Neuroanatomically, investigators such as Isaacson (1975) contend that this may be due in part to the disruption of the development and differentiation of the cells of origin for the cortical mantle.

With regard to the FSIQ, significant intellectual impairment which is defined as a deficit in IQ in the mentally retarded range, was obtained in 17% of this sample; 20% of the sample obtained scores that fell within the borderline range of ability; 30% within the low average range; 28% within the Average range and; 6% fell above the average range of psychometric intelligence.

With regard to the VIQ scale, 5% of the scores fell within the mentally retarded range; 25% in the low average range; 33% in the Average range and 5.5% fell above the average range.

In terms of the PIQ scale, 25% of the sample obtained scores that fell within the mentally retarded range; 11% of the sample obtained scores in the borderline range; 30% obtained scores in the low average range, 31% exhibited an average level of performance and; 5% of the sample obtained scores which fell above the average range.

In the literature it has been reported frequently that shunted spina bifida children obtain significantly lower PIQ than VIQ scores (e.g., Badell-Ribera et al., 1966; Dennis et al., 1981). This observation has been interpreted to reflect greater impairment of visual spatial ability than verbal intellectual abilities among these children. Although this verbal-performance difference seems to be consistently reported in the literature, the magnitude of the difference varies between studies. For example, Dennis and her colleagues (1981) noted for their entire sample the mean VIQ-PIQ difference was 13.75, whereas Glasscock (1978) found the verbal-performance difference to be 10 for her shunted-spina bifida group of children. In this investigation, the finding of a lower mean PIQ relative to the VIQ score is in agreement with the clinical literature; the mean difference was found to be 13.75. However, this finding was true only for the high socio-economic group and will be discussed in Section 3.4.

The work by Dennis and her colleagues (1981) noted that a tendency for lower IQ scores, especially lower performance IQ scores was related to a selective loss of cortical mantle in the posterior regions of the brain. In this study, 58% of the sample exhibited a difference greater than or equal to 12 points between the verbal and performance scores. In 14 cases (39%), the PIQ score exceeded the VIQ, whereas 7 cases had a significantly higher verbal IQ than performance IQ.

A significant decline in intellectual abilities is also a prominent finding in follow-up studies of pediatric head trauma (Klonoff, Low & Clark, 1977). PIQ deficits are usually more severe and persistent than declines in VIQ (Chadwick, Rutter & Brown, 1981; Winogron, Knights & Bawden, 1984). A second disease relevant to the present discussion is acute lymphocytic leukemia (ALL). Copeland and her associates (Copeland et al., 1984) found that the CNS irradiated group obtained significantly lower scores than a non-irradiated group on the WISC-R FSIQ, PIQ and VIQ scores. Similarly, Taylor and his colleagues (Taylor et al., 1987) noted that higher doses of brain irradiation for treatment of leukemia in children was associated with lower IQ scores.

4.1.2 Language

In this study various components of language functioning were assessed. As mentioned previously, for this skill area and all subsequent cognitive areas, the criterion for significant impairment on a test was a T-score of at least two standard deviations below the mean T-score ($\bar{X}$ = 50; SD = 10). A mild degree of impairment was defined as at least one standard deviation below the mean.

The results of the language measures revealed the following findings. First, on a measure of receptive understanding of vocabulary knowledge (PPVT-R), the performance of the myelomeningocele sample as a group, fell within the average range. A mild degree of impairment was exhibited by 30% of the sample; 5.5% exhibited significant impairment.

On a measure of expressive single word naming ability (EOWPT), as a group, their performance fell in the mild range of impairment. Significant impairments were noted for 17% of the sample.

Contrary to what was predicted, the results were surprising considering that it is generally reported in the literature that myelomeningocele children do not as a rule exhibit expressive or receptive language impairments. Horn and her associates (1985) postulated that distractibility is responsible, at least partially for deficits on measures of language functioning. These investigators noted that when irrelevant information was intermittently introduced during the administration of a verbal comprehension task (Boehm Concept Test), myelomeningocele children with hydrocephalus exhibited vocabulary deficits. In this study, perhaps the stimuli of the PPVT (i.e., four pictures) were too distracting. In terms of the EOWPT, perhaps the children with perceptual difficulties have trouble interpreting the line drawings. These are intriguing hypotheses and warrant further investigation.

On a fluency test sensitive to word production and retrieval, 33% of the sample obtained scores in the mildly impaired range. In addition, 28% exhibited scores in the significantly impaired range. These results support the findings of Dennis and her colleagues (Dennis et al., 1981). These investigators hypothesized that there may be a common pathological basis to verbal fluency and motor deficits commonly seen in myelomeningocele children with hydrocephalus. It has also been proposed that poor performance on this task suggests that rapid fluent ordering of lexical access is adversely affected in spina bifida.

On part 5 of the Token Test for children which primarily involves short-term memory for auditory sequences and which is sensitive to disruption of syntax and semantics, the mean T-score fell within the average range. This is one of the few neuropsychological tests which failed to show a significant difference when the performance of the myelomeningocele sample was compared with the normative sample. This finding is consistent with the view that in general language skills are relatively spared in spina bifida.

However, on this test, 4 children (11%) obtained scores in the significantly impaired range. These particular children also obtained a Full Scale IQ which fell within the lower end of the borderline range of ability. Also characteristic of these children was the use of cliches and inappropriate, repetitive flow of well-structured sentences during the testing situation. This type of speech is characteristic of the Cocktail Party syndrome (CPS). The examiner also noted characteristics of this speech when she was administering the WISC-R to the 4 children whose FSIQ fell within the mild mentally retarded range of psychometric intelligence. This observation supports the findings of Tew (1979) who found that many children with CPS function in the mentally retarded range of intelligence. Emery and Svitok (1968) hypothesized that disruption of the association fibers of the cerebral cortex following ventricular dilation may be responsible for CPS. In contrast, Hagberg and Sjorgen (1966) speculated that CPS was related to the frontal lobe syndrome, where damage results in behavioural disinhibition, overtalkativeness, and redundant speech. Specific information from CT and MRI scans would be necessary to test this theory.

4.1.3 Visual-Spatial/Constructional

Visual-motor and visual-perceptual problems are commonly reported in this clinical population. In this study, two measures of perceptual-constructional ability were administered.

First, on the Developmental Test of Visuomotor Integration, a design copying task, significant impairment was noted for 42% of the sample. A mild degree of impairment was noted for 33% of the sample. This finding is in accord with Soare and Raimondi (1977) who administered this particular test, albeit to a group of hydrocephalic children with differing etiologies.

Polubinskin and his colleagues (Polubinskin, Melamed & Prinzo, 1986) with the use of factor analysis found that the Beery Test of Visual-Motor Integration does not measure a unitary dimension of perceptual-motor development; four factors emerged: 1) simple horizontal and vertical lines; 2) open geometric designs; 3) closed geometric designs; and 4) three-dimensional designs. Over the course of administering this test to myelomeningocele children it became apparent to the examiner that while many children missed items because they responded impulsively, failing to copy the figures completely, only a very small number of children (approximately 20%) were able to even attempt to copy the three-dimensional figures such as the necker square. It may be that myelomeningocele children have more difficulty with three-dimensional designs. Benton (1969) distinguished two different kinds of constructional impairments, that often but not always occur together one, having to do with difficulties in making two-dimensional constructions and the other concerned with three-dimensional building tasks. Another possibility may be that because the three-dimensional designs appear to be the most difficult designs on the DTVMI, the findings may be a function of age and mental age. Current findings indicate that more research is needed in this area.

Another construction task used in this study involved copying the complex Rey-Osterrieth Figure. The results indicated a level of performance similar to the normative sample. That is, as a group, the myelomeningocele children performed within the average range when required to copy the figure. This finding is somewhat surprising, given the incidence of visual-motor integration deficits reported in these children (Brunt, 1980; Soare & Raimondi, 1977; Spain, 1974). However, while they were able to reproduce a reasonably accurate copy of the figure, their approach to the task reflected poor planning and organizational skills. In general, normal children focus on the main features of the drawing (e.g., large rectangle) and organize their drawing around these features (Waber & Holmes, 1985). In contrast, myelomeningocele children tended to deal with smaller units, building the figure by accretion. That is, they tended to take a piecemeal, fragmented approach, losing the overall gestalt of the figure. Visser (1973) suggests that this approach reflects their inability to process as much information at a time as do normals. This pattern of performance has frequently been associated with right-hemispheric damage (Heilman, Bowers, Valenstein & Watson, 1986).

It is perplexing as to why the children performed within the normal range on the Rey Osterrieth Figure and exhibited considerable difficulty on the Developmental Test of Visuomotor Integration (DTVMI). There are a few plausible explanations. First, the scoring system of the DTVMI is very different than that of the Rey Osterrieth Figure. A drawing of the DTVMI is scored as correct only if it is completely accurate whereas for the Rey Figure, the accuracy score is based on a unit scoring system, so that a child may have a section of the figure drawn in the wrong place, but still receive some credit (i.e., 1 point). This explanation is consistent with the qualitative descriptions by Land (1977). This investigator noted that children could reproduce the designs on a draw to copy test (indicating accurate visual interpretation) but that they frequently lost points due to imprecision.

Second, as mentioned earlier (Section 2.2), the psychometric properties of many neuropsychological measures are lacking. With regard to the Rey Osterrieth figure, the normative data is derived from Kolb and Whishaw (1985). However, the authors do not adequately describe their norm group, and little is known about the reliability and validity of the test. Similarly, in terms of the DTVMI (Beery, 1982), limited information is provided about the norm group. Although reliability is satisfactory, more information is needed about the validity of the revised norms. Thus, the results especially those obtained on the Rey Figure may well be over estimates of normal performance.

Another explanation revolves around an examination of the differences in the demands and output of the two tasks. As aforementioned, the DTVMI test has been found to measure four types of perceptual motor skills, one of which involves the ability to copy a representational drawing of a three-dimensional figure. The Rey Figure is a two dimensional design. Future research could more clearly delineate what constructs are measured and assessed by each of these copying form instruments. In addition, future studies should examine more systematically the performance of myelomeningocele children on perceptual tasks that do not require a motor response (e.g., Recognition Discrimination Test, Satz & Fletcher, 1982). Thompson and her colleagues (Thompson, Chapieski & Fletcher, 1988), demonstrated that preschoolers with myelomeningocele performed at least within the average range on this measure.

In summary, current results suggest that myelomeningocele children experience considerable difficulty on visuospatial and visuomotor integration tasks. These results are not surprising considering the vulnerability of the white matter tracts to the pressure occurring in hydrocephalus. These long fiber tracts running posterior to anterior are thought to be essential in accomplishing the spatial and organizational demands of visuospatial/constructional tasks (Benton, 1985). These fibers serve to integrate the sensory and perceptual areas in the posterior cortex with the motor production areas of the anterior cortex.

However, it has also been hypothesized that difficulties in this area may be related to the decreased stimulation associated with prolonged hospital stay and reduced opportunities for exploration (Raimondi and Soare, 1977). For example, Shepherd (1969) noted that normally intelligent children with a history of chronic illness, performed below expected levels on visual-motor perception tests. Further research is warranted in this area.

4.1.4 Memory and Learning

Despite the frequency of memory difficulties following brain damage, few studies have investigated this area with a myelomeningocele population. Some investigators purport to show memory deficiency (e.g., Glasscock, 1978), while other studies fail to find such an association (Parsons, 1969).

In this study, various aspects of memory were assessed. First, in terms of short term memory (i.e., retention of material up to one minute), it was noted that the performance of myelomeningocele children as a group on a verbal short-term memory task did not differ from the normative sample. That is, the ability to immediately recall spoken sentences increasing in length and complexity was within the average range. This result is consistent with their average performance on the Digit Span subtest of the WISC-R. Both of these findings are consistent with those observed by Glasscock (1978) and Cull and Wyke (1984).

However, as a group, the myelomeningocele children were deficient on a task requiring immediate recall of a list of words (VSRT - Recall). Although the results obtained on immediate recall are based on a reduced sample (n = 17) (due to the fact that some children did not fall in the age range for which norms are available), 70% of the children exhibited a significant degree of impairment. However, these two short-term memory tasks are quite different in the sense that one involves recall of connected meaningful material, the other involves recall of unrelated material. Cull and Wyke (1984) noted a similar discrepancy in their investigation of memory functioning in a group of myelomeningocele children. Although the myelomeningocele children performed as well as normal children in learning and recalling a short story, significant differences were noted when the myelomeningocele children were required to recall a list of unrelated words. This finding will be discussed more fully below.

Examination of the results for a visual short-term memory task (the Rey-Complex Figure) indicated significant deficits for 72% of the sample. In terms of organization and planning skills, 33% of the children obtained scores in the mildly impaired range of ability. However, it is important to recall that when asked just to copy the design, the majority of myelomeningocele children showed significant impairments in terms of planning and organization. Torgesen (1977) noted that problems organizing visual designs can be expected to interfere with encoding, retention, and recall of the designs.

In terms of long-term memory, the majority of myelomeningocele children experienced considerable difficulty on the Verbal Selective Reminding Test, a measure which permits separation of storage and retrieval components of memory. Long-term storage (LTS) of a word is considered to have taken place when the child correctly recalls the items on two consecutive trials. Significant difficulties on this measure were exhibited by 75% of the sample, indicating that these children experienced difficulties storing information in long-term memory.

Similarly, in terms of consistent long-term retrieval (CLTR) significant impairment was exhibited by 55% of the sample; a mild degree of impairment was shown by 19% of the sample. These results are consistent with those observed by Cull and Wyke (1984). These investigators administered a list of 10 concrete nouns with three acquisition trials. They also found that relative to age-and-IQ matched controls, the spina bifida-hydrocephalic group exhibited significant impairments in learning and recalling the list. These findings suggest that myelomeningocele children experience considerable difficulty both storing and consistently retrieving verbal information from long-term memory.

To assess learning and long-term spatial memory, the visual analogue of the Verbal Selective Reminding test was administered. Significant impairment was noted for 33% of the sample when required to immediately recall the spatial patterns; a mild degree of impairment was evident for 44% of the sample. In terms of long-term storage, significant deficits were shown by 55% of the sample; 25% obtained scores which fell within the mildly impaired range of impairment. The results of consistent long-term storage subscore revealed that 44% of the sample experienced significant difficulty; a further 33% exhibited a mild degree of impairment. These findings suggest that myelomeningocele children also experienced considerable difficulty storing and consistently retrieving spatial nonverbal information from long-term memory.

The exact cause of this performance deficit on long-term memory tasks cannot presently be answered. First in terms of neuropathology, memory difficulties are particularly likely to be impaired given the vulnerable location of the thalamic and limbic structures involved in memory. The mesial structures of the temporal lobes play an especially important role in retention of recently learned information in the face of distraction. Thus the topography of the ventricular system in relation to the temporal lobes may place memory function at special risk for impairment from hydrocephalus. Significant expansion of the temporal horns of the lateral ventricles together with third ventricular expansion may compress mesial temporal structures, producing impairment of delayed recall of newly learned information. This may account for both verbal and visual spatial memory function.

Several other explanations are also feasible. It appears reasonable to suspect that poor long-term memory may interact with other existing problems such as attentional difficulties, thus culminating in poor performance (Nissen, 1980). However, if the poor performance was purely related specifically to attentional difficulties, one would not expect the children to do as well on the sentence memory test.

Cull and Wyke (1984) offered another explanation. These investigators proposed that the deficit may reflect an inability to use appropriate semantic strategies at the level of encoding. Partial support for this hypothesis was noted in this study with the finding that many of the children appeared to have difficulty retrieving semantic words on a verbal fluency measure.

Torgesen and Kail (1980) found that learning disabled students, who also have difficulty on long-term memory measures, do not spontaneously use efficient and organized strategies which would make memorization and rapid recall easier. Thus, it may be that myelomeningocele children are less prone to employ the active, planful memorization strategies (e.g., verbal rehearsal, imagery elaboration, planning and organization) that have been shown to facilitate memory performance. This lack of rehearsal can be inferred from failure to show serial position effects such as primary effects (i.e., elevated recall of items presented early in the word list) on a list learning task.

If such problems exist for myelomeningocele children, it will be important in terms of treatment and effective planning to determine if lack of strategy results from a skill or mediational deficiency (metamemory) as opposed to a performance or production deficit.

Metamemory is used to refer to memory knowledge, or what an individual consciously knows about strategies and their use, as distinct from executive processes or procedural implementation of strategies. Voelker and her associates (Voelker, Carter, Sprague, Gadowski & Lachar, 1988) found that on a metamemory questionnaire, Attention-Deficit Disorder (ADD) children and normal children demonstrated a similar level of knowledge about a broad range of efficient strategies and their application in many common learning situations. However, significant differences emerged between the two groups when the investigators administered free recall word list differing in category composition (acoustics vs. semantic categories) and list organization (clustered by category vs. unclustered). On this task the ADD-children performed more poorly than a control group in terms of recall of semantically related words on an unclustered list, which involved low strategy salience and more effortful strategy implementation than the clustered list.

It is strongly suspected that an examination of this area will lead to insights into why myelomeningocele children appear to have difficulty on measures of long-term memory. The likelihood that this research will be fruitful is bolstered by findings that improved learning does occur when cognitive style is matched to the informational qualities of the environment (Hallahan & Reeve, 1980).

Finally, several studies have shown residual difficulties in acquiring and retrieving information following cessation of post-traumatic amnesia in children and adults (Levin & Eisenberg, 1979; 1982; Levin & Grossman, 1976). These problems persisted even after many of the specific signs of neurological injury (e.g., hemiparesis or aphasia) had diminished. Children treated for leukemia also exhibit difficulties in learning and retrieving information from long-term memory (Copeland et al., 1985).

4.1.5 Attention and Psychomotor Efficiency

Attention permeates all aspects of behaviour. It is critical to new learning. An individual must be able to selectively attend to and be able to flexibly manipulate stimuli in order to store new information (Posner, 1980). Selective attention thus implies a withdrawal of attention from some things in order to deal more effectively with others. Disorders of attention may arise from lesions involving any point in the perceptual system (Worden, 1966).

Classroom observations have suggested that myelomeningocele children with hydrocephalus are markedly distractible, and that they have difficulty concentrating and focusing attention (Anderson, 1979). The current results support this observation.

In this study, the myelomeningocele children, as a group, exhibited a significant degree of difficulty sustaining attention (38% of the sample) and inhibiting impulsive responses (38%) on a computerized vigilance test (Continuous Performance Test). For both these measures a mild degree of difficulty was obtained by 6% and 14% of the sample, respectively. It would appear from the review of the literature, that this is the first more precise measure of selective attention used with myelomeningocele children, and therefore cannot be compared with current research. This measure has been used frequently with children with attention-deficit disorder (Barkley, 1981), who also exhibit significant impairment on this task.

On a measure assessing speed and accuracy of visual discrimination, as a group, significant impairments were noted on Subtest 1 which required underlining a single number (number four) and Subtest 2 underlining a geometric form (Greek cross). A mild degree of impairment was noted on Subtest 4 with required underlining a Gestalt figure. Finally, the mean T-score for Subtest 5 which involved underlining four letters, fell within the average range. However, as noted on the other neuropsychological tests, there was much variability in terms of level of performance on this measure. Significant impairments were noted on all subtests for this group of myelomeningocele children; Subtest 1 (50%); Subtest 2 (55%); Subtest 3 (39%); and Subtest 4 (24%).

As a group, the myelomeningocele children performed poorly on subtests involving simple stimuli (a simple number), while exhibiting adequate levels of performance on subtests which involved relatively more complex stimuli (gestalt figure). One possible explanation may be that the children needed some time to get used to the task (i.e., needed a "warm-up" period). Another possible explanation may be related to a particular aspect of attention, namely effortful attention (Posner & Boies, 1971). In order to regulate our attention, frequently we need to make a conscious effort to attend and maintain attention. Perhaps, the children perceived the first two subtests as quite simple and gave them even less attention than they normally give to tasks.

In the learning disablities literature, attentional susceptibility has been reported as possibly related to development of neural substrates that govern the transfer of verbal information across the corpus callosum (Obzrut, Hynd & Pirozzolo, 1981). It has been shown that myelination of the corpus callosum is delayed in children with hydrocephalus either from direct interference with myelinogenesis or as secondary destructive effects after myelination has begun (Gadsdon et al., 1979). Further research is needed to test this hypothesis with myelomeningocele children. Finally, because attention is such a basic and very important cognitive ability, more research is warranted in this area. The multi-level and hierarchically organized model of attention processing by Sohlberg and Mateer (1986) would be a useful model to employ in order to systematically investigate this area with myelomeningocele children.

4.1.6 Problem Solving and Reasoning

Significant deficits were exhibited by 33% of the sample on a nonverbal problem-solving test requiring abstract reasoning and hypothesis formation. A mild degree of impairment was noted for 30% of the sample.

These results support the findings of Hurley and her associates (Hurley et al., 1983).

It is possible that attentional and inhibitory difficulties may prevent myelomeningocele children from developing and mastering the strategies needed for effective complex problem solving. Lack of organizational skills also hinders performance on complex problem-solving tasks; as noted earlier, organizational ability appears to be an area of relative weakness for myelomeningocele children.

In terms of neuropathology, hydrocephalic pressure may have resulted in stretching and delaying myelination of reciprocal subcortical-frontal projections.

Damage to the brain that occurs early in development may not only disrupt the neural systems that are functional at that time, but may also be the cause of deficits that are not seen until much later in development, at the time at which the damaged structures or connections would normally become functional (Goldman, 1978). Investigators have found that frontal lobe functions do not become fully available in normal children until later in childhood, and as such manifestations of frontal dysfunction may change over time. Younger children may manifest deficit in this area as problems with attention, memory, impulsivity and hyperactivity. In older children problems appear as deficits in problem solving and executive functions. This area needs to be investigated more extensively with a sample of myelomeningocele children from a broad age-range.

4.1.7 Tactile-Perceptual

On a sensory-perceptual examination of tactile abilities, few children exhibited significant impairment on a measure of astereognosis (2.7% of the dominant hand and 8.33% of the nondominant hand; the remaining scores fell at least within the average range).

In terms of finger localization, 25% of the sample exhibited a significant degree of difficulty of the dominant hand whereas 14% exhibited difficulty of the nondominant hand. A mild degree of impairment was noted by 5.5% and 11% respectively. Finally, with regard to finger-tip writing, 55% and 58% of the sample exhibited significant difficult of the dominant and nondominant hand respectively. Finger-tip writing requires considerably more general intelligence than finger localization (Fitzhugh, Fitzhugh & Reitan, 1962).

According to Geschwind (1965), tactile-perceptual abilities, particularly stereognosis and finger-tip writing are critically dependent on the normal maturation of the CNS.

Tactile-perceptual abilities have been rarely studied in this clinical population. A notable exception was the work of Hurley and her associates (Hurley et al., 1983). These investigators administered simple and complex tactile perceptual tasks to a group of spina bifida adolescents as well as age-matched control. These investigators noted no difficulty for either group on the simple tactile tasks (i.e., double simultaneous stimulation for each hand as well face and opposite hand conditions). However, as this study found, poor scores were noted on the complex fingertip number writing task. These investigators also contended that this task may be too difficult for children with below normal intelligence. Land (1977) and Brunt (1980) both reported that myelomeningocele children exhibited significant deficits on the Manual Form Perception test, also suggesting an impairment of somatosensory integration.

Myelomeningocele children with hydrocephalus suffer generalized disturbances of motor and frequently oculomotor functioning that severely limit environmental exploration. In addition, when damage occurs early and is diffusely distributed throughout the brain, not only are the damaged neural structures themselves impaired (including the parietal lobe which is especially important for processing tactile-perceptual information), but the normal ontogenetic process, which requires interaction with the environment, is also disrupted (O'Leary & Boll, 1984). Hence it is not surprising that myelomeningocele children exhibit difficulties interpreting tactile-perceptual information. Deficits in this area have far-reaching effects. In Piaget's developmental framework, concept formation and the establishment of cause-and-effect relationships are the "building blocks" of more advanced levels of nonverbal reasoning and judgement, and the formation of this foundation depends on adequate sensorimotor experiences obtained during the first few years of life.

4.1.8 Motor

Many studies have described the motor functioning of children with spina bifida. Contrary to predictions, the myelomeningocele children, as a group, obtained scores within the average range bilaterally on a motor test of finger-tapping speed. These results were inconsistent with the findings of Hurley and her associates (1983) who found that myelomeningocele children performed slowly on this task. Why the two studies got different results is unclear. Perhaps, differences in sample composition may account for the incongruities. Another explanation may be linked to the findings of Neuger and his colleagues (Neuger, O'Leary & Fishburne, 1981). These investigators noted a slight slowing on a tapping task if it was administered later in the day. In this study, this task was administered early in the morning. There was no mention of when the task was administered in Hurley's study. Perhaps if it was administered at a different time of day it may explain the different findings.

Yet another explanation may be related to the normative data of this measure. The norms for this particular test were obtained from Knights and Norwood (1979). These investigators provide limited information about the norm group. In addition, little is known about the reliability and validity of the norms. As mentioned previously, the psychometric properties of test instruments are critically important in terms of influencing the likelihood that a strength or weakness in a particular skill area will be detected.

As anticipated, the majority of children exhibited considerable difficulty bilaterally on a test of fine motor coordination. That is, 58% of the sample showed significant impairment for the dominant hand and 64% for the nondominant hand. This finding is consistent with the very poor performance reported earlier on the coding subtest of the WISC-R, a measure of psychomotor speed.

On a test involving visual motor and visual sequencing skills (Trails), the myelomeningocele sample, as a group, performed within the average range when required to search through a visual array. That is, they correctly selected the proper sequence of numbers (Part A) and of letters associated with numbers (Part B). However, the myelomeningocele sample took significantly longer than the normative sample to complete the task (36% of the sample achieved significantly impaired scores on Part A and 30.5% on Part B), reflecting slow visuomotor performance. These results are consistent with the findings of Zeiner at al., (1985). In addition, Anderson (1976; 1979) concluded that at least two-thirds of children with spina bifida and hydrocephalus are likely to have poor motor skills and marked copying and writing difficulties. Similar results were obtained by Pearson and her colleagues (1984). These findings have important implications for educational personnel.

Several explanations for the presence of motor difficulties have been proposed and include: 1) lack of experience due to the use of the arms to provide support in upright positioning and to the emphasis placed in therapy on lower extremity functioning; 2) dysfunction of cerebellum due to the Arnold-Chiari malformation with resulting problems with control, preprogramming and the initiation of movements; 3) damage to the motor control centres and tracts secondary to the hydrocephalus--the pyramidal corticospinal system and; 4) malformations of the spinal cord above the level of the lesion (Emery, 1965; Grimm, 1976; Spain, 1974).

Difficulties on a variety of visual-spatial and motor tasks, particularly those involving speeded performance are common sequelae following severe CHI (Levin & Eisenberg, 1979; Bawden, Knights & Winogron, 1985).

4.1.9 Academic Achievement

Academic performance in reading was in the normal range. That is, as a group, the myelomeningocele children performed within the average range on the Reading Recognition and Reading Comprehension subtests of the PIAT. Only 5.5% of the sample obtained significantly low scores on the Reading Recognition subtest whereas 11% obtained such scores on the Reading Comprehension subtest. A mild degree of impairment was noted for 8% and 19% of the sample, respectively.

On the spelling subtest of the Wide Range Achievement Test-Revised, the myelomeningocele children, as a group performed within the average range ($\bar{X}$ = 90.389). Significant impairments were noted for 17% of the sample; 19% of the children obtained scores in the mildly impaired range. Shaffer and her colleagues (Shaffer et al., 1985) obtained similar results ($\bar{X}$ = 88.8).

On the arithmetic subtest of the WRAT-R, the sample, as a group performed within the mildly impaired range ($\bar{X}$ = 76.306). Significant impairment was evidenced by 30% of the sample. This mean T-score was considerably lower than that reported by Shaffer et al. (1985). These investigators reported a mean T-score which fell in the middle of the low average range ($\bar{X}$ = 85.5). Differences in sample composition may account for the incongruities; all the children in the Seattle study had uncomplicated unshunted myelomeningocele whereas in this study 50% of the children had a history of complications. This difference will be discussed more fully later on in the discussion.

Arithmetic deficiencies may be attributed to a variety of factors including spatial difficulties, poor memory, attentional problems, and slow information processing speed (Strang & Rourke, 1985). The qualitative analysis of the kinds of errors made on this subtest may provide further insight into the specific nature of the underlying deficits.

It is noteworthy that the examiner noted that the majority (approximately 70%) of the errors made by the children in this study were of a perceptual nature (e.g., misreading similar-looking signs or numbers, misaligning columns). These are precisely the types of errors one would expect if there were disturbances in right hemisphere-associated visuo-perceptual and visuo-spatial functions. Rourke (1982) believes that mathematical understanding in children is particularly disturbed by right-hemisphere dysfunction because it represents a unique form of nonverbal abstract conceptualization.

Poor arithmetic skills have also been reported in children receiving prophylactic treatment for cancer (Copeland, et al., 1985; Ivnik, Colligan, Obetz & Smithson, 1981), as well as in severely head-injured children (Fletcher, 1985).

4.1.10 Summary of Neuropsychological Data

It is important to keep in mind that the limited sample size and poor psychometric properties of many of the neuropsychological measures limits the interpretation of the findings.

Returning to the earlier question "Are children with myelomeningocele cognitively impaired?", the answer must be a qualified yes. The next question was whether or not there is a typical pattern of impairment associated with myelomeningocele.

In this study, the convergence of evidence would suggest that in terms of brain-behaviour relationships, the pattern of neuropsychological strengths and weaknesses is suggestive of the performance profile that would be expected with diffuse cerebral damage particularly of the right-hemisphere. Thus, the results supported hypothesis 1 which proposed that myelomeningocele children would experience difficulty in the skill areas assessed.

The myelomeningocele children performed as well as the normative samples on measures of auditory comprehension, fine motor speed, accuracy on a visuomotor speeded task, stereognosis, and single-word recognition.

There was substantial variability within the myelomeningocele sample in terms of level of cognitive performance. As a group with a few exceptions, they performed below the level expected for their age.

Results indicated that as a group, the mean composite scores on the WISC-R (FSIQ = 84.056, VIQ = 87.417, PIQ = 83.301) fell within the low average range of psychometric intelligence. However, examination of the data revealed a considerable degree of variability in test performance.

In general, the children exhibited significant difficulty on many tasks. The measures that seemed to be present the most difficulty were those requiring; 1) perceptual-motor skill and processing speed; 2) attention; and 3) measures of learning and storage of verbal and visually presented material. Poor performance on a measure of computational mathematics as well as a measure of verbal fluency, reflecting word-finding difficulties were also evident.

At this stage of the discussion, I will turn my focus to a review of the neuropsychological literature pertaining to other syndromes and disabilities that have been associated with diffuse cerebral dysfunction and/or right hemisphere dysfunction. I am exploring this area in an effort to establish if there are any common or distinctive features between various other disabilities and spina bifida.

Throughout the discussion of the neuropsychological deficits exhibited by myelomeningocele children, I have mentioned other conditions wnich exhibit similar neuropsychological results. For example, bearing a striking resemblance to the neuropsychological pattern of spina bifida children are children who have experienced moderate to severe head injuries as well as children with acute lymphocytic leukemia (ALL). Fletcher and Copeland (1988) hypothesized that similarity in performance of CNS leukemia and head-injury are related to disruption of subcortical white matter fibers.

Likewise, there is evidence to suggest that the nature of difficulties evidenced by children with Turner's syndrome (Rourke, Fisk & Strang, 1986, pp. 136-143), Asperger's syndrome (Baron, 1986; Wing, 1981), and children with congenital absence of the corpus callosum exhibit deficits comparable to those noted in myelomeningocele children with hydrocephalus.

There is evidence to suggest that there exists a type of child with a nonverbal learning disability (NVLD) whose pattern of strengths and weaknesses resembles those shown by the child with myelomeningocele (Strang & Rourke, 1983).

Current results indicated that myelomeningocele children with hydrocephalus evidenced impairments in: 1) visuo-spatial and visuo-perceptual abilities; 2) tactile-perceptual abilities; 3) psychomotor abilities; and 4) non-verbal concept formation. The above deficits therefore meet the criteria outlined by Rourke as suggestive of the nonverbal learning disability. However, in this study results indicated that these children also exhibited significant storage and retrieval difficulties for verbal information. Rourke (1987) proposed that nonverbal learning disabled children do not have difficulties per se in verbal abilities. However, it is noteworthy that Rourke makes no reference to the assessment of long-term memory. To date, Rourke's theory has not been replicated, nor has it been documented with neuroradiological data.

In summary, the results suggest that the myelomeningocele children, as a group experience difficulty on more or less all of the neuropsychological tests employed in this study. They appeared to have particular difficulty on measures of long-term verbal and visual memory, fine-motor coordination and tasks involving perceptual-motor skill and processing speed. This "pattern" of performance will be examined more closely in Section 4.3 when the role of certain socio-economic and medical factors will be explored.

4.2 BEHAVIOURAL SEQUELAE

The second objective of the current study was the evaluation of the behavioural sequelae that may be associated with myelomeningocele. Research on myelomeningocele children has emphasized primarily the cognitive and psychomotor functioning of this clinical population and generally has overlooked the affective/behavioural component.

In general, the research which has investigated the behavioural sequelae associated with myelomeningocele holds the view that myelomeningocele children are prone to socio-emotional difficulties. In an effort to expand and elaborate on these findings information was obtained from several sources.

The Child Behaviour Checklist (Parent and Teacher Forms) assess social competence and behaviour problems. The parents also completed an inventory of child personality characteristics (Personality Inventory for Children). In addition, the mother was interviewed using the Vineland Adaptive Behaviour Scale. This scale assesses adaptive functioning across five domains; 1) Communication; 2) Daily Living Skills; 3) Socialization; 4) Motor; and 5) Maladaptive Behaviour. Finally the myelomeningocele children completed a measure of self-concept as well as a measure of locus of control.

First, in terms of the self-report measures, the Piers-Harris Self-Concept Scale (Piers, 1984) was used in this study to measure self-concept. The respondent indicates whether the item describes the way he/she feels about himself or herself.

Piers (1984) recommended that scores below one standard deviation from the mean were suggestive of low self-concept. In this sample, 18% of the myelomeningocele children evidenced a general poor to low self-concept; 25% experienced specific difficulties with school related tasks (behaviour); 21% displayed low self-esteem in terms of body image (physical appearance and attributes); 24% felt very anxious; 21% had problems in the realm of interpersonal skills (popularity) and 24% were unhappy and longed for things to be different (happiness).

Results indicated that the myelomeningocele sample as a group, did not differ from the normative sample in terms of overall level of self-concept. Although still within the normal range, the myelomeningocele children did obtain lower scores on two of six cluster scales--popularity and happiness. The myelomeningocele children reported more feelings of general dissatisfaction with themselves, loneliness and reported having difficulty making and keeping friends.

This finding of an overall self-concept in the normal range has been reported in previous studies. MacBriar (1968) obtained a positive self-image as measured by the Piers-Harris Scale when she investigated the self-concept of preadolescent and adolescent spina bifida children relative to a sibling control group. As part of the follow-up phase of the Greater London Council's Spina Bifida Survey (GLC), Pearson and her colleagues (1985) tested adolescent myelomeningocele children on three different measures of self-concept (Piers-Harris; Which One is You, Homonyms Test). She also reported a positive self-concept that was no different form that of able-bodied peers.

However, these results are contrary to the findings of Hayden and her colleagues in Seattle (1985) who reported a negative self-image. It is important to note that Hayden (1985) used different measures of self-concept than those in the present study and that their sample composition was different. In the Seattle study, 55% of their sample had no shunts and had to obtain a minimum IQ level (i.e. IQ < 80), before participating in the study.

The Children's Nowicki-Strickland Scale (Nowicki & Strickland, 1973) was used to measure the construct of locus of control of reinforcement. Rotter (1966) has defined the locus of control as the perception of a connection between one's action and its consequences. There is data to show that children with various forms of handicaps (i.e., mental retardation, dyslexia and chronic illness) will show more of an external locus of control (i.e., perceive the occurrence of positive and negative events as independent of personal control) than those individuals not so affected (Eggland, 1973; & Tavormina, Kostner, Slater & Watt, 1975). Locus of control has also been related to various personality variables, indicating that an internal locus of control was associated with high self-esteem and with greater popularity (Gordon, 1977; Nowicki, 1975).

This study represents the first attempt to assess this construct with a sample of myelomeningocele children. As anticipated, results indicated that, as a group, the myelomeningocele children differed from the normative sample. The myelomeningocele children perceived the occurrence of positive and negative events as independent of personal control (i.e., external locus of control).

This finding needs to be replicated and investigated more thoroughly. Future research might address the utility of locus of control scores in predicting children's responses to certain treatments. Learning disabled adolescents with high externality have been reported to perform best when provided with a highly structured condition (Bendell, Tollefson & Fine, 1980).

Information obtained from the Child Behaviour Checklist, suggested that, as a group, the myelomeningocele children displayed significantly lower levels of social competence and more internalizing problems than expected for normal children.

Within the Social Competence domain the myelomeningocele sample were significantly lower than the normative sample with respect to their participation in activities, their social involvement (i.e., contact with social organizations and friends) and school performance. In fact, 42% of the children obtained scores in the significantly impaired range, nearly twice the proportion of children reported by Wallander and her associates (Wallander, Feldman & Varni, 1989). This suggests that the children in the present study are experiencing significantly more difficulty in the realm of social competence.

These results are consistent with the work of Hayden and her colleagues who also noted delayed social maturation in a group of myelomeningocele children. In fact, Sousa and her colleagues (1976), noted that social interaction skills were the only developmental parameters that failed to increase with age; rather social skills tended to decrease as individuals with spina bifida became older.

Several explanations can be advanced to account for this delayed attainment of interpersonal skills and social competency. One posits that underachievement in this area may be a function of inadequate (or an absence of) supportive community services (Francis, 1983). That is, architectural barriers and transportation problems may be contributing to the lack of activities outside the school or home.

Secondly, many of the children cannot participate in many of the activities that other children can do because of restricted physical development and decreased abilities. Frequent hospitalizations further separate these children from their peers. Furthermore, because of prolonged hospitalizations, several myelomeningocele children are a year or so behind their peers at school, and as a result most of their social contacts are with younger individuals.

More recently, the role of the integrity of brain-dependent functions which enable an individual to understand, think about and perceive social cues and social consequences has been emphasized. It has been suggested that if "right hemisphere " abilities are compromised in a child, a social-emotional handicap would be expected to develop (Rourke, 1982). Individuals who experience problems with the processing of visual-spatial information, are faced with serious difficulty in dealing with social and interpersonal situations. Poorly developed interpersonal skills frequently accompany such adaptive deficits. Wiener (1980) noted that learning-disabled children with conceptual and spatial disorders had difficulty acquiring positive peer relations. These findings are interesting in light of the neuropsychological deficits exhibited by the myelomeningocele children in this study.

In the literature, there has been an increased awareness that social skills are as essential as academic ones in preparing the child for success in dealing with life challenges (Peter & Spreen, 1979). Recent attention has been directed to the relationship between poor peer relations and later personal adjustment (see review by Parker & Asher, 1987). These investigators noted that children with poor peer relations are at risk for a variety of negative outcomes in later life. Whether this finding can be generalized to myelomeningocele children with hydrocephalus is an issue requiring investigation.

Internalizing disorders are characterized primarily by behavioural withdrawal, which might be exhibited by children referred to as anxious/withdrawn or depressed. Based on the reported internalizing problems, 12% of the sample were considered maladjusted (i.e., evidencing significant degree of behavioural disturbance). In the general population, the expected proportion of maladjustment would be 10%. These findings support those of Wallander and her colleagues (Wallander et al., 1989) in California. Mattson (1972) reported that myelomeningocele children may develop manipulative and demanding behaviour or may demonstrate regression and withdrawal as a response to stress in their lives.

In terms of the externalizing behaviour scale, the present study failed to replicate the findings of Wallander and her colleagues (1989). Current results found no differences between the myelomeningocele children, as a group, and the normative sample on this scale. In contrast, Wallander et al., (1989) found that the myelomeningocele children displayed on average, more externalizing problems than expected. A possible explanation for the discrepancy may lie in the fact that Wallander and her colleagues tested children from a broader age range (4-16 years) than the present study. It has been shown that externalizing behaviours, such as hyperactivity are reported more frequently in younger children. Perhaps the younger children in the Wallander study elevated the externalizing scale. Partial support for this hypothesis is obtained from the findings of Thompson and her colleagues (Thompson, Chapieski & Fletcher, 1989). In the Thompson study, these investigators found that myelomeningocele preschoolers displayed more externalizing problems on the CBCL relative to age matched controls; no differences were noted on the Internalizing Behaviour Problem Scale.

With regard to the individual behaviour scales young myelomeningocele boys (9-11 years of age) displayed more problems relative to age and sex-matched normal children on three internalizing scales and one externalizing scale: 1) Schizoid-Anxious reflecting fearful, shy behaviour; 2) Obsessive-Compulsive; and 3) Somatic Concern reflecting stomach aches and dizziness; and 4) Hyperactive scale. With the exception of the Schizoid-Anxious Scale which fell in the mildly impaired range, the other scale scores fell within the normal range. For older myelomeningocele boys (12-16 years), more problems were indicated on the Somatic scale, relative to age and sex-matched normal children.

Young myelomeningocele girls (9-11 years) displayed more social withdrawal and hyperactive behaviour problems than expected for their age. Relative to age and sex matched normal children, older myelomeningocele girls displayed more problems on the Somatic scale as well as the a scale which investigated peer relationship (cruel) scale.

The tendency for an increased vulnerability of girls to emotional problems supports the findings of Anderson (1979) which showed that girls, especially teenagers, had more difficulties in adjustment than SB boys of similar age and ability. It has been suggested that early maturation may make myelomeningocele girls even more disparate to their peers. It is well known that myelomeningocele females mature physically earlier than their peers; they frequently reach menarche before ten years (Hayden et al., 1985).

The Teacher's version of CBCL was administered in an attempt to assess behavioural functioning in the classroom environment. The myelomeningocele sample as a group were reported to display lower levels of social competence and more internalizing problems relative to their peers. Based on their reported internalizing, externalizing and total behavioural problems for each scale, 7% were classified as clinically maladjusted; 11.5% of the sample evidenced social competence difficulties in the defined maladjusted range.

With regard to the individual behaviour scales obtained from the Teacher scale, relative to the normative sample, young myelomeningocele boys (9-11 years), displayed more problems on the social withdrawal and inattentive scales. The Inattentive scale fell within the mildly impaired range of maladjustment. In contrast, no differences were apparent between the older myelomeningocele boys and normal older boys.

Young myelomeningocele girls (9-11) relative to the normative sample, displayed more problems on the Anxious, Inattentive, Unpopular and Self-Destructive scales. It is important to note that on the latter scale many of the parents were responding to items which asked if their children had eye problems.

Comparing both the Parent and Teacher scales, it was noted that the parents reported more internalizing behaviour problems. This pattern of results supports the findings of Verhulst and Akkerhuis (1989), who reported low to moderate agreement between parent and teacher ratings of behavioural/emotional problems of normal functioning children. In the latter study, the authors found that the parents reported more problems than teachers, and that agreement was higher for externalizing problems than for internalizing problems.

Evaluation of the mother's responses on the Personality Inventory for Children found that for the myelomeningocele sample, as a group, marked elevations (i.e., in the psychopathological range) were obtained for five of the eleven clinical scales - Cognitive Development (53% of the sample); Adjustment (68%); Intellectual Screening (68%); Delinquency (47%); and Psychosis (73%). Moderate scale elevations (i.e., T-score >60) were noted for the group on the F validity scale (20% significantly elevated); as well as four clinical scales: somatic concern (20%

significantly elevated); depression (20% significantly evaluated); withdrawal (29% significantly elevated); and hyperactivity (29% markedly elevated).

With regard to the remaining scales, although the myelomeningocele sample as a whole did not exhibit moderate to significant elevations, a number of children did obtain scores in these ranges. Significant elevations were noted on the Undisciplined (8%); Socialization (12%); Intellectual (18%); Defensiveness (9%); Achievement (9%); Family Relations (15%); Anxiety (15%); and Social Skills (12%) scales.

With the aid of the suggested interpretative paragraphs (Wirt et al., 1984), these elevations reflect concern over intellectual ability, poor study skills, as well as deficient gross and fine motor skills. Further, the children were described as overactive, restless, highly distractible and impulsive with a limited tolerance for frustration. Three of the four internalizing scales were elevated suggesting social isolation at home and at school. The children were frequently described as unhappy and/or sad and often seemed "confused or in a dream." Poor interpersonal skills were likely; many mothers reported that many of the children acted younger than their chronological age and were likely to have difficulty making and keeping friends. These findings collaborate the type of difficulties noted on the other behavioural measures employed in this study.

The present study replicates the findings obtained by Wicks and his colleagues (Wicks et al., 1985). For example, these investigators also found that 60% of the mothers noted difficulty with intellectual activities and/or development. Similarly, an item analysis of the psychosis scale suggested that these abnormal scores also reflected social isolation rather than childhood psychosis.

The final scale to be discussed in this section is the Vineland Adaptive Scale. Results indicated that for the myelomeningocele sample, as a group, their level of functioning in the Socialization domain fell at the lower end of the average range. In contrast, the level of functioning in the Daily Living Skills and Communication domains fell within the moderately low range. The majority of children (78%) were classified as evidencing deficient motor skills (gross and fine motor) on the estimated motor scale (i.e., below the norm for able-bodied 5-year old children).

Although many myelomeningocele children were reported to display adequate socialization skills, 11% of the parents reported that their children were deficient in this area. Further examination of this scale revealed that 6% were deficient with regard to interpersonal relationships; 14% lacked adequate play and leisure pursuits and 14% demonstrated poor coping skills (i.e., poor concept of responsibility, taking responsibility for one's own actions, poor decision-making skills). Furthermore, approximately 20% of the parents acknowledged that their children did not have an opportunity to participate in various social activities outside school (e.g., clubs).

Examination of the Communication domain revealed deficient abilities in areas of receptive skills (6% of the sample), expressive skills (11%) and school-related skills such as writing (36%). The latter finding is consistent with the significant deficient skills noted earlier on a fine motor coordination task and measures involving psychomotor speed.

With regard to the Daily Living Skills Domain, 28% of the sample exhibited delayed accomplishments of personal care skills (e.g., delay in learning self-toileting skills); 47% in terms of domestic skills (e.g., cleaning, cooking) and 31% involving skills necessary to tell time and use money. These results add to the accumulating literature indicating that myelomeningocele children are at risk for delayed achievement of necessary independent living skills.

Current results parallel those of Sousa and her colleagues (1976). These investigators assessed adaptive functioning by means of a Functional Activities Scale which also addressed issues such as self-care, locomotion, and social interaction. Thompson and her associates (1989) investigated adaptive functioning in a sample of myelomeningocele preschoolers. They found that the preschoolers were significantly delayed in accomplishment of daily living skills (eating, toileting, dressing) relative to age matched able-bodied children. However, their level of functioning in terms of communication and socialization skills were adequate.

Several explanations can be advanced to account for poor attainment of daily living skills. First, it may be that these children have lacked the opportunity to develop and practice these skills. This is a feasible hypothesis especially in light of the finding in this study that many parents reported that their children had no specific chores and obligations at home. Many parents felt that their children were too immature or physically handicapped to be involved in learning basic daily living skills. Hayden and her colleagues have also observed that parental attitude is an important determinant of when a skill will be mastered by a child.

Second, the neuropsychological difficulties already discussed greatly influence the abilities of the child. Difficulties with attention, organization, planning, monitoring and generating appropriate problem-solving activities, all pose impediments to learning in all environments (academic, home and community). Difficulties with poor coordination might interfere with maintenance of good hygiene practices during and after toileting. In addition memory impairments (difficulty storing and retrieving information) although typically associated with poor performance on standardized memory tasks and school performance can also seriously affect on individual's ability to earn an independent life (Schachter, Glisky & McGlynn, 1988). For example, the close relationship between organized behaviour and memory may be reflected in inefficiency in practical everyday tasks--not able to organize their activities (e.g., at school and/or at home) properly.

4.2.1 Summary of Behavioural Data

Information gleaned from the behavioural measures suggested delayed achievement in social competence skills, (e.g., interpersonal skills), daily living skills, as well as a tendency to exhibit more internalizing type of behaviours (e.g., social withdrawal). The myelomeningocele children were usually described as impulsive and inattentive. Contrary to what was predicted, the myelomeningocele children as a group did not exhibit a negative self-concept.

4.3 INFLUENCE OF SOCIO-ECONOMIC AND DEMOGRAPHIC VARIABLES

A third objective of this study was to investigate whether certain socio-economic and demographic variables influenced outcome of neuropsychological test performance.

4.3.1 Socio-Economic Variable

In the present study, an estimate of socio-economic status based on education and occupation (Hollingshead Index) placed the majority of households (39%) in the lowest two categories of the classification system. The percentages were as follows: major business and professional (6%); medium business, minor professional (19%); semi-skilled, machine operator (14%); and unskilled (25%).

It is difficult to compare between studies regarding socio-economic status (SES) because it is unclear from current research as to what proportion of myelomeningocele children fall within different SES levels. In addition, there are relatively few studies cited which have used the Hollingshead index with a Canadian sample. Cameron and Orr (1989) used this index with a sample of families from the southwestern Ontario who had a trainable mentally retarded child. They found that the families were distributed in approximately equal numbers across the five levels.

In this study, classification of myelomeningocele children with hydrocephalus based on socio-economic background, indicated that in general those children who came from families with more education and income were doing better in terms of cognitive test performance and achievement of daily living skills.

Consistent with previous research (Soare & Raimondi, 1977), the children who were classified as belonging to the lower socio-economic group showed deficiencies relative to the children belonging to the higher group in terms of general intelligence. The current results extended those findings to show that the children from the lower socio-economic group also performed significantly poorer on the VIQ scale as well as all of the verbal subtests with the exception of the comprehension subtest. Their verbal subtests scores fell within the borderline to low average range of ability, contrasting with the average performance of the higher SES group.

As mentioned earlier, the finding in this study of a low PIQ is almost entirely based on the group with high SES. It may be that this finding is an artifact, i.e., that it occurs only in children with well-to-do parents who provide lots of verbal stimulation (and perhaps better schooling) to their children.

Significant differences were also noted on measures of expressive single naming ability (EOWPT) and receptive understanding of vocabulary (PPVT-R). Performance of the low SES group fell within the low average to average range respectively. These results are also consistent with the explanation offered for the findings obtained from the WISC-R.

Current results also indicated that deficits on academic achievement measures, particularly measures of spelling and arithmetic ability were significantly related to SES level, with the low SES group resulting in greater performance deficits. Among the other skill areas considered, there was a general trend for the low SES group to obtain lower mean scores, although the differences did not reach statistical significance.

With regard to adaptive behaviour skills, the myelomeningocele children in the lower SES group were significantly delayed in their achievement of school-related activities, particularly their writing skills relative to the high SES group. In addition, children from the lower SES group had more difficulty following rules, making change, and telling time. They were described as impulsive and immature and needed more assistance in tasks of daily living such as toileting and bathing. Thus, the parents of the low SES group saw their children as less adaptable, more demanding and easily distractible.

As mentioned previously, it is difficult to conduct between study comparison regarding SES because it is unclear from earlier reports as to what proportion of myelomeningocele children fall within different levels.

Haynes and colleagues (Haynes, Cheek & Mintz, 1974) investigated differences in intellectual outcome of children from a poor SES background compared to myelomeningocele children from a middle-class background. These investigators found that there was a 50% mortality rate in myelomeningocele children from poor backgrounds in contrast to 22% found in the middle-class myelomeningocele group. In addition, 45% of the children from the low SES level had shunt procedures that became infected contrasting with 15% of the middle-class group who had shunt procedures.

Many investigators working with children in different clinical populations have also noted the importance of socio-environmental influences on cognitive performance.

Whitt and his colleagues (Whitt, Wells, Wilhelm & McMillan, 1984) administered a battery of neuropsychological tests to children with acute lymphocytic leukemia. These investigators noted that socioeconomic factors, especially parental education were more powerful correlates of neuropsychological performance than type of therapy, age at diagnosis or sex of the child.

In a follow-up study of young children who were diagnosed as nonorganic failure to thrive as infants, Drotar and Sturm (1988) found that environmental factors such as family income and maternal education were important indicators of intellectual outcome. In another follow-up study of similar children but at a later age, Oates and his colleagues (Oates, Peacock & Forest, 1985) found that children from low socio-economic environments were at special risk for academic difficulties at school. Finally, Bee and his associates (Bee, Barnard, Gray, Spietz, Synder & Clark, 1980) noted the disruptive influence of economic background on acquisition of language skills.

The human brain undergoes considerable postnatal development and a child's interactions with both the social and the physical environment appear to be extremely important for the normal development of brain structure and function. Berker and his colleagues (Berker, Lorber & Smith, 1980) analyzed the neuropsychological test performance of a group of hydrocephalic and normal children. They demonstrated that experiential and environmental factors may play a significant role following early brain insults. They found that regardless of the severity of the hydrocephalus, the cognitive development of the hydrocephalic children (as well as of normals) systematically increased with education and socioeconomic status of the parents.

Taken together, such findings indicate that environmental risk factors are important influences on learning ability of myelomeningocele children. These factors need to be taken into account when devising programmes for the myelomeningocele child and their families. Clearly, families from the lower SES background will require more guidance and financial resources. Finally, investigators should carefully define the nature of their samples so that the results of different studies can be related to one another and the findings integrated.

4.3.2 Age

In the current study, the younger myelomeningocele children (i.e., less than 13 years) scored significantly lower than the older myelomeningocele children on three measures: 1) the Picture Arrangement subtest of the WISC-R; 2) Token Test; and 3) immediate recall of a series of spatial dots (spatial memory).

On the other hand, the older myelomeningocele children obtained lower scores on tests measuring short-term verbal memory, expressive naming ability and complex tactual-perceptual skills (finger-tip writing). Dennis and her colleagues (Dennis et al., 1987) also noted that with increasing age, children with hydrocephalus appeared less able than normal children to maintain age-appropriate performance increments.

In terms of adaptive living skills, the older children were more delayed than the younger children on age-appropriate daily living skills such as housekeeping chores and food preparation. In addition, the older children were reported as having a poorer sense of responsibility, had more difficulty inhibiting impulses (i.e., tendency to rush into activities before weighing the consequences of their decisions); and were more immature in terms of interpersonal functioning.

These results are consistent with Bradshaw's (1988) findings that older adolescents need more resources and guidance than younger myelomeningocele children. Adolescents have more questions and doubts about their health, physical condition, and sexual normality (Hayden et al., 1979).

Adolescence at best is a difficult period in the life cycle, in the sense that it is a time of tremendous change and critical decision-making. It is a period of heightened sensitivity about one's own self, one's appearance and interests. While age-relevant issues of autonomy, sexuality, self-image, identity and achievement are noted, the capacity for resolving these issues may be lessened by neurobehavioural consequences of myelomeningocele and hydrocephalus.

Considering the neuropsychological deficits that these children exhibit, it is not surprising that the older myelomeningocele children appear to have more difficulty. It is a well known fact that the cognitive demands of junior and senior high school are very different from the elementary years. Reading and writing take on more weight as evaluative vehicles, through which judgements concerning acquisitions of information are made. Students at this level are expected to be more self-reliant and self-contained (i.e., bringing appropriate supplies/ books to each class, keeping track of assignment deadlines and preparing for examinations). Complex attentional skills are needed for activities such as note-taking while reading or listening as well as more demands on memory skills (i.e., associating new information to past learning, retrieving, integrating factual information). In terms of visuospatial functions more complex skills are needed for mental manipulation of more abstract information (i.e., geometry, geography, sciences). Also, qualities such as self-restraint, patience, and delay of gratification are more important.

Finally, there are relatively few studies which have assessed adaptive skills in spina bifida adults. In one such study (Lonton, O'Sullivan & Loughlin, 1983) it was found that only 23% were employed in spite of the fact that approximately one-half of the participants of the study had attended college. With regard to daily living skills, Lonton and his colleagues noted that only 37% of the spina bifida adults regularly did their own shopping; 87% did not cook their own meals (mothers did it for them). Many (44%) needed help in bathing. These results are comparable to the findings of Shurtleff and his colleagues (Shurtleff et al., 1975), who also found that one-third of their sample of normally functioning adults (i.e., IQ over 80) were partially or totally dependent on others for care. These results highlight the importance of teaching myelomeningocele children adaptive skills as early as possible. However, as noted earlier many of these children have significant neuropsychological deficits that will need to be addressed in order to establish a teaching style and/or compensatory mechanisms appropriate to learn such adaptive skills.

In summary, consistent with the findings of Dennis and her colleagues (1987), results suggest that some effects of hydrocephalus on cognitive performance may become increasingly apparent as the child develops.

4.4 INFLUENCE OF MEDICAL VARIABLES

4.4.1 History of Complications

In this study, 50% of the sample had a history of complications as defined by a history of seizures and/or infections associated with shunt functioning. This incidence is slightly higher than that reported by McLone and his associates (McLone et al., 1982). These investigators found that 33% of their myelomeningocele sample with hydrocephalus had a history of ventriculitis; the incidence of seizures was not reported. Shaffer and her associates (Shaffer et al., 1985) reported that 11% of their myelomeningocele sample had a history of CNS infection and/or bleeding. In another study Mapstone and his associates (Mapstone et al., 1984) found that 28% of their sample with hydrocephalus had a history of complications. However, it is important to note that their definition of complications was quite broad in that it included children with anoxia and CNS anomalies such as porencephaly.

In this study, despite lower IQ scores, the performance of children with complications was not significantly different from those children with no history of complications. Significant differences emerged on a test requiring attention and psychomotor efficiency as well as on a fine motor coordination test. For these particular measures, the children with complications performed in the mildly impaired range. Although still within normal limits, the children with complications did not perform as well on visuomotor drawing tasks (Rey Figure and DTVMI), simple motor speed of nondominant hand as well as accuracy on a visual-motor sequencing task (Trails A).

At first glance, these findings are at variance with those of other investigators. For example, McLone and his associates (1982) found that the mean full-scale IQ for the myelomeningocele children with complications fell in the borderline range (FSIQ = 73) whereas the performance of the shunted myelomeningocele children without a history of ventriculitis fell in the middle of the average range (FSIQ = 95).

Shaffer and her colleagues (Shaffer et al., 1985) also noted that children with complications obtained a mean full-scale IQ which also fell within the borderline range (FSIQ = 74) of ability. A similar finding was reported by Mapstone and colleagues (i.e., mean full-scale IQ of 70) for shunted myelomeningocele group.

Thus, all the studies cited above obtained a general cognitive functioning in the borderline range of ability for children with complications; the current study obtained a mean score which fell within the low average range (FSIQ = 83).

Several hypotheses may be offered to account for this difference. First, differences may reflect different selection procedures and sample ages. Second, due to the small number of subjects, sufficient power to detect "real" group differences may have been compromised. The latter hypothesis appears to be a reasonable one, since there is a trend in the data for the children in the complicated group to experience relatively greater difficulty on many of the measures.

Another explanation may be related to the severity of the infection. Although this information was not gathered for the current study, it was noted in the hospital records that five of the children with a history of infections had "mild infections." Furthermore, when the type of infections were examined, 84% of the children in this study had gram-positive infections whereas McLone and his associates reported more gram-negative infections. It has been suggested that gram-negative infections can have more deleterious effects on the brain (e.g., escherichia coli can produce cavitation in the white matter). Further research is needed to elucidate the exact effect of different bacterial pathogens on the central nervous system.

Finally, clinical management may differ in the two centers in a way which cannot be controlled and the results, therefore may reflect differences in therapeutic regimes between the two centers. The findings of this study stress the importance of organizing prospective clinical studies to address many of the above issues.

4.4.2 Ocular Abnormalities

In this study the majority of the myelomeningocele children (69%) had a history of ocular abnormalities. This incidence rate is comparable to that reported in other studies (80% - Clements & Kaushal, 1970; 54% - Rabinowicz, 1974). All these figures are extremely high when compared with reported incidences of between 2 and 6% in the normal child population (Black, 1980).

In the current study, a history of ocular abnormalities was associated with a significant decrease in performance IQ. Full-scale IQ and verbal IQ were also lower for the children with ocular abnormalities but not significantly so. These results are similar to those of Dennis and her colleagues (Dennis et al., 1981).

Differences were also present on tests that measure expressive single naming ability, sustained attention, speeded performance (Trail Making Test), copying and recall of a complex figure, various measures of tactile-perceptual ability (finger localization and astereognosis), as well as performance on a verbal long-term memory task (VSRT). An interesting finding on the latter task (VSRT), was the improved recall of the word list with the aid of repetition.

Although there are relatively few studies in the literature which have investigated the relationship between ocular abnormalities and cognitive test performance of a sample of myelomeningocele children, the current results are consistent with these studies.

For example, Tew and Laurence (1978) found that children with ocular difficulties (40%) obtained significantly lower scores on an intelligence measure (WISC-R), visuomotor integration task, as well as academic achievement measures of reading, spelling and arithmetic.

Zeiner and his associates (Zeiner et al., 1985) administered a more comprehensive battery of neuropsychological tests to a group of children with shunted, uncomplicated hydrocephalus. These authors noted that children with a history of ocular defects (53%) performed more poorly on visuospatial and verbal problem-solving tasks relative to the hydrocephalic children who did not have a history of ocular problems. They appeared to have more difficulty on measures involving visuomotor sequencing (Trails), long-term visual memory; and poorer verbal recall on a word list task. The results from the current study support these findings. In fact, the children in this study with ocular difficulties demonstrated difficulties on many more skill areas.

There is evidence to suggest that the presence of ocular abnormalities (excluding those which may appear as a result of shunt malfunction), may be an indicator of early neuropathological changes associated with the hydrocephalic process. The marked dilation of the posterior portion of the lateral ventricles and the subsequent stretching and elongation of white matter fibers could disrupt connections to the primary associative and visual cortex, constraining integration of visual input with other sensory modalities.

Another possibility may be that the hydrocephalic process may disrupt mitosis and migration of cells of origin. For example, Rakic (1979) has noted that embryologically the relative position of precursor cells lining the cerebral ventricles determines the time and rate of migration of cells destined for visual cortex in the primate neocortex. Dennis and her colleagues (1981) reported that visual disturbances frequently accompanying hydrocephalus in early infancy can compromise the formation of normal geniculocortical representations essential for visually mediated tasks.

As summarized by Zeiner and his colleagues (Zeiner et al., 1985), ocular abnormalities may be due to impairment of a number of mechanisms. These include: (1) ocular motor dysfunction; (2) cranial nerve dysfunction; (3) upward gaze paresis; (4) lesion of the brainstem; (5) frontal or occipital eye fields. In myelomeningocele children with hydrocephalus, the exact CNS level of dysfunction of the ocular abnormalities is not known.

In summary, myelomeningocele children with ocular difficulties exhibited a significant degree of impairment on many of the measures employed in this study. This area warrants considerable more attention, especially in light of the implications for educational planning.

4.4.3 Level of Myelomeningocele Lesion

Disturbed motor function is commonly associated with myelomeningocele. The degree of impairment has been found to vary with level of myelomeningocele lesion (Shurtleff et al., 1975).

In this study, based on Sharrard's (1964) functional motor classification system, 25% of the children had lesions L2 or above, 42% had lesions L3-L5 and 33% had lesions S1 and below. Using the same classification system, similar percentages were reported by Shurtleff (1975) for a sample of myelomeningocele children with and without shunts.

The results of this investigation contribute to the previous studies that have suggested that the intellectual abilities of myelomeningocele children vary according to the level of lesion. (Shurtleff et al., 1975; Diller et al., 1976). The children in the L2 or above group (i.e., high level lesion group) scored significantly lower than the other two groups in terms of level of functioning exhibited on performance and full scale IQ. The S1 group of children (i.e., lowest level lesion) achieved a full scale IQ (91.56) which fell within the average range; the L3-L5 group (82.40) performed within the low average range and the L2 or above group (76.8809) performed within the borderline range of intellectual functioning. Similar levels of functioning were exhibited on the performance IQ scale (i.e., 89.75; 84.60 and 72.77 respectively). With regard to verbal IQ, the mean level of functioning for L2 or above and L3-L5 groups fell within the low average range (84.22 and 83.26 respectively) whereas the S1 children group obtained VIQ score which fell in the middle of the average range (95.00).

Although Shaffer and her colleagues (Shaffer et al., 1985) also reported a similar "dose response relationship" associated with level of general intellectual functioning, this pattern was only found with children with uncomplicated, unshunted myelomeningocele. These investigations suggested that the lack of such a finding in the shunted group was probably related to factors such as type of location of shunt.

With regard to the neuropsychological tests, there was a general trend for the L2 or above group to exhibit the lowest mean scores, suggesting more cognitive impairment. This dose-response relationship was particularly evident on a measure of problem-solving ability where the performance of the L2 or above group fell within the clinically deficient range.

Among the other skill areas considered, significant group differences emerged on measures of language functioning (PPVT-R EOWPT); visual-motor integration (DVTMI); tactile-perceptual ability (finger localization of dominant hand), and academic achievement (spelling and arithmetic).

Inconsistent findings were obtained for the Continuous Performance task. The results indicated that the children in the L3-L5 group performed within the clinically deficient range in terms of sustained attention and were more impulsivity relative to the other 2 groups. The results also suggested that the L2 or above group were more impulsive than children in the L3-L5 group.

Information obtained from behavioural questionnaires and parent interviews suggested that the children in the L2 or above group were experiencing the most difficulty attaining independent adaptive skills. This finding suggests that the degree of independent achievement in daily living skills is related to the level of myelomeningocele lesion. These results support the findings of Sousa and her colleagues (Sousa et al., 1976).

Anderson (1979) also noted that the quality of life outside school was related to severity of handicap. She found that many severely disabled adolescents depended on their parents for physical care. It is interesting that this investigator found that approximately 1/3 of her participants felt that their parents gave them more help than they required.

In summary, it is interesting to examine the level of performance exhibited by the myelomeningocele children when they are classified according to their lesion level. The results suggest that the higher the lesion, the more severe the impairment, but with the pattern of performance remaining relatively the same at all three levels. This offers a built-in replication of the results obtained when the performance of the myelomeningocele sample was investigated as a group.

Finally, it is important to note that many investigators such as Rokos (1979) have documented the enormous variability of malformations of the spinal cord in individual cases and at different levels of the cord. Thus, while level of lesion is an important variable to keep in mind in terms of hypothesizing about cognitive and adaptive difficulties a particular myelomeningocele child may exhibit, other factors also play a significant role in the clinical picture.

4.4.4 Intrauterine Hydrocephalus

Little research has been reported on the effects of Intrauterine Hydrocephalus (IUH) on the myelomeningocele child. Investigators such as Cochrane and his colleagues (Cochrane, Myers, Nimrod, Sugarman & Wittman,

1985) purport that the overall prognosis from hydrocephalus diagnosed in utero is poor. In contrast, a number of investigators have indicated that the initial degree of hydrocephalus does not determine later outcome (Dennis et al., 1981; Laurence, 1960; Laurence & Coates, 1962; Raimondi & Soare, 1974; Tromp, van der Burg, Jansen & de Vires, 1979; Yashon, Jane & Sugar, 1965).

In this study, the presence of intrauterine hydrocephalus (39% of the sample) inferred on the basis of head circumference at birth, appeared to be associated with poorer performance on certain neuropsychological measures.

Current study indicated that the VIQ of the children with intrauterine hydrocephalus (IUH) at birth fell at the lower end of the low average range whereas those children without such a history exhibited VIQ score that fell at the lower end of the average range. In terms of PIQ and FSIQ, those children with IUH for both composite scores exhibited a level of functioning which fell in the middle at the borderline range. This contrasts with the low average performance of children without such a history.

Among the other skills areas considered, significant group differences emerged on tests requiring expressive single naming ability (EOWPT) constructional skills (DTVMI), long-term memory for visual and verbally presented information as well as tests requiring visual search and speeded performance (Underlining subtests 2, Trails A and B). In addition, significant lower academic achievement levels emerged in spelling and arithmetic. For all of these tests, the children with IUH scored significantly lower. In fact, the children with a negative history of IUH performed within the average range on the spelling subtest of the WRAT-R and the Expressive Picture Vocabulary Test.

With regard to the behavioural and adaptive information, children with IUH were significantly impaired in terms of Daily Living skills. Age-appropriate levels of adaptive functioning related to areas of personal-self care skills and domestic chores were associated with a negative history of IUH. The parents of children with IUH reported more problems in terms of academic achievement, expressive skills and attainment of social skills. No differences were noted on self-esteem measures.

These findings support the work of Mealey and his associates (Mealey, Gilmor & Budd, 1973). In that study, of the patients treated with VA shunts, only 44% had survived and half had normal intelligence. Oberbauer (1985) evaluated CT scans of hydrocephalic infants and compared the results with psychomotor development. He found no overall correlation between initial ventricular size and developmental performance. However, when he separated the cases with gross or extreme hydrocephalus from the other cases, he noted that a quarter of those "extreme cases" exhibited significant psychomotor impairment.

Support for the notion that children with intrauterine hydrocephalus may exhibit more cognitive impairments is also obtained from experimental and structural investigations. Rubin et al., (1972) described irreversible rupture of axons with significant reduction of galactose, as remyelination did not occur. Raimondi (1969) and Wozniak and his as‹. ci. (Wozniak, McLone & Raimondi, 1975) reported marked and possibly irreversible changes on the cerebral vasculature. Weller and Shulman (1972) examined the brains of hydrocephalic infants and puppies, and found edema, axonal degeneration and astrocytosis in white matter, and damage of cortical layers. These investigators proposed that progressive hydrocephalus with a rising CSF pressure may result in failure of brain growth and mental retardation unless ventricular drainage is instituted prior to the time neural damage is irreversible. A similar hypothesis was advanced by Oberbauer (1985).

Thus, it may be that the inconsistent results in the literature may be related to factors such as the onset and duration of the intrauterine hydrocephalus. The reactions of embryonic neural tissue to injury vary at different stages of development. In this study, because 92% of the children with intrauterine hydrocephalus also had a history of ocular abnormalities, it could be hypothesized that this sample of children with IUH had experienced irreversible damage. Carrying this hypothesis a little further, perhaps, the children in other studies benefitted more from the shunting process because the degree and extent of hydrocephalus was not as severe and therefore damage to the brain tissue was less. With the recent advances in fetal diagnostic techniques, perhaps more exact information with regard to the onset of the hydrocephalus can be obtained and studies designed to investigate the above hypothesis.

Another possible factor which may be related to the poor performance in the children with IUH may be related to intracranial birth injury due to the large head (Cochrane et al., 198'

The present study suggest that intrauterine hydrocephalus is a pathological condition which merits further examination.

4.4.5 Summary of Medical Variables

Variations in outcome appeared to be related to medical factors. Results suggested that the degree of neuropsychological impairment was related to the level of myelomeningocele lesion, a history of ocular abnormalities and intrauterine hydrocephalus. That is, the pattern of neuropsychological impairments was similar for the myelomeningocele children as a group, but the degree of impairment appeared to be related to medical factors. Although there was a general lowering of level of performance with a history of complications, the effect was more pronounced for the above-mentioned variables.

It was suggested that the findings may be related to early neuropathological changes resulting from the hydrocephalic process and the myelomeningocele lesion.

In all structures of the developing central nervous system (CNS), the generation of neural constituents and their migration to appropriate positions relative to other structures are critical developmental events (Rakic, 1979). It is known that the precise timing of migration of cells to different cytoarchitectonic regions varies with the particular area in question.

Children who have hydrocephalus as a result of a neural tube defect may suffer alteration of neural circuitry during intrauterine stages of development (Rakic, 1979). It has been established that early brain damage may be caused by a variety of agents, all of which may differ significantly in terms not only of the specific brain system they may alter but also upon the maturational level of the system at the time of insult (Johnson & Almli, 1978).

In this study it has been suggested that the presence of ocular abnormalities and "intrauterine" hydrocephalus may be indicators of a more severe degree of disruption of the developing central nervous system. As such, it is not surprising that children who have a history of either of these variables tend to exhibit a more marked level of impairment on neuropsychological and adaptive behavioural measures when compared with children with a negative history of such variables.

In summary, the developmental pattern depends on such factors as the sort of tissue destroyed, the functions involved, the environmental interaction experienced, and probably most of all, the growth and differentiation of the brain. More research is needed to elucidate this complex relationship between medical and socio-demographic variables. While the complete unravelling of different influences is probably unlikely, the results have important implications in determining appropriate social and educational programmes to enhance the lives of myelomeningocele children and their families.

4.5 CONCLUSION

Myelomeningocele children with hydrocephalus are a heterogenous group of children who differ considerably in terms of their environmental and biological risk factors (e.g., level of myelomeningocele lesion, ocular abnormalities and socio-economic status).

The findings of this study emphasize the importance of a comprehensive assessment of multiple factors and the interaction between these factors. Central nervous system dysfunction (i.e., brain damage) can be considered only one of several influences on the ability structure of myelomeningocele children. Other influences that may moderate this brain-behaviour relationship include socio-cultural and environmental variables, some of which were highlighted in this study. The nature of these extrinsic factors vary from case to case and are not specific to brain-injured children. Thus, further investigations of learning and behaviour subsequent to myelomeningocele would seem to demand an appreciation for multifactorial models of development.

The functional model proposed by Fletcher and Taylor (1984) is an example of a multifactorial approach. In this model, four variables are taken into consideration: 1) the manifest form of the disability (e.g., attentional difficulties of the child with myelomeningocele); 2) the behavioural and cognitive correlates of the manifest disability (.e.g, performance on neuropsychological measures with an attentional component such as the Continuous Performance Test); 3) consideration of socio-cultural and motivational-attitudinal variables likely to be more extrinsively determined (i.e., moderator variables). These factors include the child's ability to compensate for his/her weaknesses, the attitudes of the child towards learning and the stimulation and encouragement provided by family and school. The nature of these moderator variables vary from case to case and are not specific to brain-injured children.

Family financial resources are important in terms of planning treatment/remediation. For example, it would be fruitless to recommend private tutorials (that may benefit some children) without the family having adequate financial resources. In the absence of funds, it may be necessary to try to modify a school curriculum or to use community resources, which may reduce flexibility in arranging for intervention: 4) the biological or neurological substrate underlying the above mentioned variables (e.g., level of myelomeningocele lesion and/or history of intrauterine hydrocephalus that may influence ability development). In short, the model encourages the examiner to assess the "whole" child. As outlined by Taylor (1984), this requires a thorough understanding of the complexities of child behaviour, good clinical judgement, and multi-disciplinary involvement.

In order to achieve this understanding, future research will require collaboration with other institutions to achieve adequate patient numbers and share information.

Without this fund of knowledge, myelomeningocele children may never have the opportunity to achieve their maximum potential. This study hopefully is a step in this direction. Clearly, this study is far from definitive. The limited sample size, large standard deviations and poor psychometric properties of many of the neuropsychological tests limits the interpretation of the findings. Until further research with larger samples provides firm empirical support for many of the findings of the study, the results may be viewed as intriguing and exciting in terms of providing stepping stones for future research.

REFERENCES

Achenbach, T.M. (1978). Psychopathology of childhood: Research problems and issues. Journal of Consulting and Clinical Psychology, 46, 759-776.

Achenbach, T.M., & Edelbrock, C. (1983). Manual for the Child Behaviour Checklist. New York: Queen City Printers.

American Psychological Association, 1977. Standards for Educational and Psychological Tests. Washington, D.C.: American Psychological Association.

Anderson, E.M. (1973). Cognitive deficits in children with spina bifida and hydrocephalus: A review of the literature. British Journal of Educational Psychology, 43, 257-268.

Anderson, E.M. (1976). Handwriting difficulties in children with spina bifida and hydrocephalus. Special Education: Forward Trends, 3(2), 17-20.

Anderson, E.M. (1979). Helping spina bifida pupils with handwriting. Special Education - Forward Trends, 6(1), 15-17.

Anderson, E.M. (1979). The psychological and social adjustment of adolescents with cerebral palsy or spina bifida and hydrocephalus. International Journal of Rehabilitation Research, 2, 245-248.

Anderson, E.M., Clarke, L., & Spain, B. (1982). Disability in Adolescence. London: Methuen Press.

Anderson, E.M., & Plewis, I. (1977). Impairment of motor skill in children with spina bifida cystica and hydrocephalus: An exploratory study. British Journal of Psychology, 68, 61-70.

Anderson, E.M., & Spain, B. (1977). The Child With Spina Bifida. London: Methuen Press.

Andrews, L.G. (1967). Spina bifida cystica: a follow-up survey. Journal of Canadian Medical Association, 97, 280.

Andrews, R.J., & Elkins, J. (1981). The management and education of children with Spina Bifida and Hydrocephalus. (ERDC Report No. 32). Australia: Corberra, Australian Government Publishing Service.

Badell-Ribera, A., Shulman, K., & Paddock, N. (1966). The relationship of non-progressive hydrocephalus to intellectual functioning in children with spina bifida cystica. Pediatrics, 37, 787-793.

Barkley, R.A. (1981). Hyperactive Children: A handbook of diagnosis and treatment. New York: Guilford Press.

Baron, I.S. (1986). The childhood presentation of social-emotional learning disabilities: on the continuum of Asperger's Syndrome. Journal of Clinical and Experimental Neuropsychology, 9, 30.

Barry, A, Patten, B.M., & Stewart, B.H. (1957). Possible factors in the development of the Arnold-Chairi Malformation. Journal of Neurosurgery, 14, 285.

Barson, A.J. (1970). Spina bifida: the significance of the level and extent of the defect to the morphogenesis. Developmental Medicine and Child Neurology, 12, 129-144.

Bartoshesky, L.E., Haller, J., Scott, M.R., & Wolick, C. (1985). Seizures in children with meningomyelocele. American Journal of Diseases in Children, 139, 400-405.

Bawden, H.N., & Gates, R. (1986). Intelligence of young children with spina bifida. Paper presented at the Annual Meeting of the International Neuropsychology Society, Houston, Texas.

Bawden, H.N., Knights, R.M., & Winogron, H.W. (1985). Speeded performance following head injury in children. Journal of Clinical Neuropsychology, 7, 39-54.

Beck, A.T. (1976). Cognitive therapy and the Emotional Disorders. New York: New American Library.

Beckwith, L., Cohen, S.E., & Kopp, C.B. (1976). Caregiver-infant interactions and early cognitive development in preterm infants. Child Development, 47, 579-587.

Bee, H.C., Barnard, K.E., Eyres, S.J., Gray, C.L., Hammond, M.A., Spietz, A.L., Synder, C., & Clark, B. (1982). Prediction of IQ and language skill from perinatal status, child performance, family characteristics, and mother-infant interaction. Child Development, 53, 1134-1156.

Beery, K.E. (1982). Revised administration, scoring and teaching manual for the developmental Visual-Motor Integration. Chicago: Follett Press.

Bell, J.E., Gordon, A., & Maloney, F.J. (1980). The association of hydrocephalus and arnold-chiari malformation with spina bifida in the fetus. Neuropathology and Applied Neurobiology, 6, 29-39.

Bendell, D., Tollefson, N., & Fine, M. (1980). Interaction of locus-of-control orientation and the performance of learning disabled adolescents. Journal of Learning Disabilities, 13, 32-35.

Benton, A. (1985). Visuoperceptual, visuospatial and visuoconstructive disorders. In K. Heilman & E. Valenstein (Eds.), Clinical Neuropsychology. London: Oxford University.

Benton, A.L. (1969). Constructional apraxia: some unanswered questions. In A.L. Benton, Contributions to Clinical Neuropsychology. New York: Aldine Press.

Berger, H. (1921). Gesamte Nerolgoie Psychiatrie, 69, 46.

Berker, E., Lorber, J., & Smith, A. (1983, February). Influences of extra-cerebral factors on cerebral development of 289 patients with varying degrees of hydrocephalus. Paper presented at the 11th Annual Meeting of the International Neuropsychological Society, Mexico City.

Black, P.D. (1980). Ocular defects in children with cerebral palsy. British Medical Journal, 3, 487-488.

Blackwood, W., McMenemry, W.H., Meyer W.H., Norman, R.M., & Russell, D. (1963), Greenfield's Neuropathology, (second ed.) (pp. 345). London: Edward Arnold.

Bordeaux, J.D., Dowell, R.E., Copeland, D.R., Fletcher, J.M., & Van Eys, J. (1988). Neuropsychological sequelae of pediatric brain tumours. Journal of Child Neurology, 3, 63-68.

Bower, T.G.R.C. (1974). Development in Infancy. San Francisco: W.H. Freeman.

Bradshaw, J. (1988). The social impact of childhood disablement. Zeitschrift fur Kinderchirurgie, 43(2), 5-11.

Breslau, N. (1985). Psychiatric disorder in children with physical disabilities. Journal of the American Academy of Child Psychiatry, 24, 87-94.

Brocklehurst, G. (1968a). The significance of the pathogenesis of spina bifida to its treatment. Unpublished Master's Thesis, University of Cambridge, England.

Brocklehurst, G. (1969). The development of the human cerebrospinal fluid pathway with particular reference to the roof of the fourth ventricle. Journal of Anatomy, 105, 467-469.

Brunt, D. (1980). Characteristics of upper limb movements in a sample of meningomyelocele children. Perceptual and Motor Skills, 51, 431-437.

Brunt, D. (1981). Characteristics of upper limb movements in a sample of meningomyelocele children. Perceptual and Motor Skills, 51, 431-437.

Buschke, H. (1974). Components of verbal learning in children: Analysis by selective reminding. Journal of Exceptional Child Psychology, 18, 488-496.

Cameron, S.J., & Orr, R.R. (1989). Stress in families of school-aged children with delayed mental development. Canadian Journal of Rehabilitation, 2(3), 137-144.

Campbell, M.M., Hayden, P.W., & Davenport, S. (1977). Psychological adjustment of adolescents with myelodysphasia. Journal of Youth and Adolescents, 6, (4), 397-407.

Carr, J., Halliwell, M.D., & Pearson, A.M. (1981). Educational attainments of Spina Bifida children attending ordinary and special schools. Zeitschrift fur Kinderchirurgie, 34, 364-370.

Carr, J., Halliwell, M., & Pearson, A. (1984). The relationship of disability and school type to everyday life. Zeitschrift fur kinderchirurgie, 39, 135-137.

Carr, J., Pearson, A., & Halliwell, M. (1983). The GLC Spina Bifida Survey: Follow up at 11 and 12 years. ILEA, London.

Carter, C.O. (1974). Clues to the aetiology of neural tube malformations. Developmental Medicine and Child Neurology, 16 (Suppl. 32), 3-15.

Chadwick, O., Rutter, M., & Brown, G. (1981). A prospective study of children with head injuries: cognitive sequelae. Psychological Medicine, 11, 49-61.

Chance, P.F., & Smith, D.W. (1978). Hyperthermia and meningomyelocele and anencephaly. Lancet, 1, 769-770.

Chovanes, G.I., McAllister, J.P., Lamperti, A.A., Salotto, A.G., & Truex, R.C. (1988). Monamine alterations during experimental hydrocephalus in neonatal rats. Neurosurgery, 22, 86-91.

Clements, D.B., & Kaushal, K. (1970). A study of the ocular complications of hydrocephalus and meningomyelocele. Transactions of the Ophthalmology Society, 90, 383-390.

Cochrane, D.D., Myles, S.T., Nimrod, C., Still, D.K., Sugarman, R.G., & Wittmann, B.K. (1985). Intrauterine hydrocephalus and ventriculomegaly: associated anomalies and fetal outcome. Canadian Journal of Neurological Science, 12, 51-59.

Connell, H.M., & McConnel, T.S. (1981). Psychiatric sequelae in children treated operatively for hydrocephalus in infancy. Developmental Medicine and Child Neurology, 23, 505-517.

Connolly, C.J. (1975). External Morphology of the Primate Brain. Springfield, Ill.: C.J. Thomas.

Copeland, D.R., Fletcher, S. M. Pfefferbaum-Levin, B., Saffe, N., Ried, H., & Maor, M. (1985). Neuropsychological sequelae of childhood cancer in long-term survivors. Pediatrics, 75, 745-753.

Creary, M.R., & Alberman, E.D. (1976). Congenital malformations of the central nervous system in spontaneous abortion. Journal of Medical Genetics, 13, 9-16.

Culatta, B., & Egolf, D. (1980). Perceptual and linguistic performance of spina bifida-hydrocephalic children. Spina Bifida Therapy, 1, 235-247.

Cull, C., & Wyke, M.A. (1984). Memory function of children with spina bifida and shunted hydrocephalus. Developmental Medicine and Child Neurology, 26, 177-183.

Del Bigio, M.R., Bruni, E., & Fewer, H.D. (1985). Human neonatal hydrocephalus - An electron microscopic study of the periventricular tissue. Journal of Neurosurgery, 63, 56-63.

Dennis, M., Fitz, C.R., Netly, C.T., Sugar, J., Harwood-Nash, D.C., Hendrick, E.B., Hoffman, H.J., & Humphreys, R.F. (1981). The intelligence of hydrocephalic children. Archives of Neurology, 38, 607-615.

Dennis, M., Hendrick, E.B., Hoffman, H.J., & Humphreys, R.P. (1987). Language of hydrocephalic children and adolescents. Journal of Clinical and Experimental Neuropsychology, 9(5), 593-621.

Diller, L., Gordon, W.A., & Swinyard, C. (1969). Psychological and educational studies with spina bifida children. ERDC Document EDO 34347, US DHEW. Washington: D.B., US Office of Education.

DiSimoni, F.G. (1978). The Token Test for Children Manual. Hingham, MA: Teaching Resources Corporation.

Donauer, E., Wussow, W., & Rascher, K. (1988). Experimental hydrocephalus and hydrosyringomyelia. Computertomographic studies. Neurosurgical Review, 11(1), 87-94.

Dorner, S. (1976). Psychological and Social Problems of families of adolescent spina bifida patients: a preliminary report. Developmental Medicine and Child Neurology, 15 (Suppl. 29), 24-26.

Drotar, D., & Sturm, L. (1988). Prediction of intellectual development in young children with early histories of nonorganic failure-to-thrive. Journal of Pediatric Psychology, 13(2), 281-296.

Dunn, L.M., & Dunn, L.M. (1981). Peabody Picture Vocabulary Test-Revised. Circle Pines, MN: American Guidance Service.

Dunn, L.M., & Dunn, L.M. (1981). Peabody Picture Vocabulary Test-Revised Manual. Minnesota: American Guidance Service.

Dunn, L.M., & Markwardt, F.C. (1970). Peabody Individual Achievement Test. Circle Pines, MN: American Guidance Service.

Dunn, O.J. (1961). Multiple comparisons among means. Journal of the American Statistical Association, 56, 52-64.

Edwards, J.H. (1958). Congenital malformations of the central nervous system in Scotland. British Journal of Preventive Social Medicine, 12, 115-130.

Eggland, E.T. (1973). Locus of control and children with cerebral palsy. Nursing Research, 22(4), 329-333.

Elwood, J.H. (1976). Major central nervous system malformations notified in Northern Ireland, 1969-1973. Developmental Medicine and Child Neurology, 18, 512-520.

Elwood, J.M., & Elwood, J.H. (1980). Epidemiology of anencephalus and spina bifida. New York: Oxford Press.

Emery, J.L. (1965). Intracranial effects of long-standing decompression of the brain in children with hydrocephalus and myelomeningocele. Developmental Medicine and Child Neurology, 7, 302.

Emery, J.E., & Lendon, R.G. (1972). Clinical Implications of cord lesions in neurospinal dysgraphism. Developmental Medicine and Child Neurology, 14, (Suppl. 27), 45-51.

Emery, J.L., & Naik, D.R. (1968). Spinal cord segment lengths in children with meningomyelocele and the "Arnold-Chairi" deformity. British Journal of Radiology, 41, 287-290.

Emery, J.L., & Svitok, I. (1968). Inter-hemispherical distances in congenital hydrocephalus associated with meningomyelocele. Developmental Medicine and Child Neurology, 21, 25-29.

Eng, C.C. (1981). The relationship between the eye-hand coordination and visual perception test scores of children with myelomeningocele. Masters Thesis, University of Washington.

Epstein, F., Maidich, T., Kricheff, L., Chase, N., Lin, J., & Ransohoff, J. (1977). Role of computerized axial tomography in diagnosis, treatment and follow-up of hydrocephalus. Preliminary considerations. Child's Brain, 3, 91-100.

Ewing-Cobbs, L., Fletcher, S.M., & Levin, H.S. (1985). Neuropsychological sequelae following pediatric head injury. In M. Ylvisaker (Ed.). Closed head injury rehabilitation: Children and adolescents (pp. 71-89), San Diego: College Hill.

Ferguson, B. (1985). Norms for the Continuous Performance Test. University of Carleton, Ottawa: Available from Author.

Ferguson-Smith, M.A. (1983). The reduction of anencephalic and spina bifida births by maternal serum alphafetoprotein screening. British Medical Bulletin, 39, 365-372.

Fitzhugh, K.B., Fitzhugh, L.C., & Reitan, R.M. (1962). Wechsler-Bellevue comparisons in groups with "chronic" and "current" lateralized and diffuse brain lesions. Journal of Consulting and Clinical Psychology, 26, 306-310.

Fletcher, J.M. (1985). Memory for verbal and nonverbal stimuli in learning disability subgroups: Analysis by selective reminding. Journal of Experimental Child Psychology, 40, 244-259.

Fletcher, J.M., & Levin, H.S. (1989). Neurobehavioural effects of brain injury in children. In D.K. Routh (Ed.). Handbook of pediatric psychology. New York: Guilford.

Fletcher, J.M., & Taylor H.G. (1984). Neuropsychological approaches to children: Towards a developmental neuropsychology. Journal of Clinical Neuropsychology, 6, 24-37.

Fletcher, S.M., & Copeland D.R. (1988). Neuro-behavioural effects of central nervous system prophylactic treatment of cancer in children. Journal of Clinical and Experimental Neuropsychology, 10(4), 495-538.

Francis, R.A. (1983). The development of federal accessibility laws. Journal of Rehabilitation, 49, 29-36.

Fraser, F.C., Czeizel, A., & Hanson, C. (1982). Increased frequency of neural tube defects in siblings of children with other malformations. Lancet, 144-145.

Gadsdon, D.R., Variend, S., & Emery, T.L. (1979). Myelination of the corpus callosum: The effect of relief of hydrocephalus upon the process of myelination. Zeitschrift fur kinderchirurgie, 28, 314-321.

Gardner, M.F. (1979; 1981). Expressive One-Word Picture Vocabulary Test. Novato, CA: Academic Therapy Publications.

Glasscock, R. (1978). A Neuropsychological Investigation of Spina Bifida Cystica. Ph.D. Thesis, University of Minnesota.

Goldberg, E., & Costa, L.O. (1981). Hemispheric differences in the acquisition and use of descriptive systems. Brain and language, 14, 144-173.

Goldman, P.S. (1978). Neuronal plasticity in primate telencephalon: anomalous crossed cortico-caudate projections induced by prenatal removal of frontal association cortex. Science 202, 768-770.

Gordon, D.A. (1977). Children's beliefs in internal-external control and self-esteem as related to academic achievement. Journal of Personality Assessment, 41, 383-386.

Grant, D.W. (1985). Right hemisphere function in hydrocephalic children. Neuropsychologia, 23, 285-289.

Grant, D.W., Goldberg, C., Guiney, E.J., & Fitzgerald, R.J. (1986). Should the tradition of right cerebral hemisphere shunting still prevail? Zeitschrift fur Kinderchirurgie, 41, 48-50.

Gressang, J.D. (1974). Perceptual processes of children with myelomeningocele and hydrocephalus. American Journal of Occupacional Therapy, 28(4), 226-230.

Grimm, R.A. (1976). Hand function and tactile perception in a sample of children with myelomeningocele. American Journal of Occupational Therapy, 340(4), 234-240.

Guiney, E.J., Fitzgerald, R.J., & Goldberg, C. (1984). A review of the management policy for new-born spina bifida children at our lady's hospital for sick children, Crumlin, Ireland, 1973-1983. Zeitschrift fur kinderchirurgie, 39, 114-116.

Guiney, E.J., & MacCarthy, P. (1981). Implications of a selective policy in the management of spina bifida. Journal of Pediatric Surgery, 16(2), 136-138.

Gur, R.C., Pack, I.K., Hungerbuhler, S.P., Reivich, M., Obrist, W.D., Amarnek, W.S., & Sackheim, H.A. (1979). Differences in the distribution of gray and white matter in human cerebral hemispheres. Science, 207, 1226-1228.

Hadenius, A. (1962). The natural prognosis of Infantile Hydrocephalus. Acta Pediatrica, 51, 117-118.

Hagberg, B., & Sjogren, I. (1966). The chronic brain syndrome of infantile hydrocephalus. American Journal of Diseases in Children, 112, 189.

Hall, J.G., Keena, B.A., & Pupkin, J. (1986, August). Level of lesion, associated anomalies and recurrence risk in a large group of clinic patients with neural tube defects. Presentation at the David W. Smith Workshop on Malformations and Morphogenesis, Burlington, VT.

Halliwell, M.D., Carr, J.G., & Pearson, A.M. (1980). The intellectual and educational functioning of children with neural tube defects. Zeitschrift fur kinderchirurgie und Grenzebiete, 31, 375-381.

Hammock, M.K., Milhorat, T.H., & Baron, I.S. (1976). Normal Pressure Hydrocephalus in patients with myelomeningocele. Developmental Medicine and child neurology, 18 (Suppl. 37), 55-68.

Hayden, P.W. (1985). Adolescents with meningomyelocele. Pediatric Review, 6(8), 245-252.

Hayden, P.W., Davenport, L.H., & Campbell, M.M. (1979). Adolescents with myelodysplasia: Impact of physical disability on emotional maturation. Pediatrics, 64(1), 53-59.

Haynes, B.F., Cheek, W.R., & Mintz, A. (1974). Treatment of meningomyelocele in indigent and nonindigent patients. American Journal of Diseases in Children, 127, 182-186.

Heilman, K.M., Browers, D., Valenstein, E., & Watson, R.T. (1986). The right hemisphere: neuropsychological function. Journal of Neurosurgery, 64, 693-704.

Hewitt, D. (1963). Geographical variations in the mortality attributed to spina bifida and other congenital malformations. British Journal of Preventive Social Medicine, 17, 13-22.

Hollingshead, A.B. (1975). Four factor index of social status. Available from Author, Yale University.

Horn, D.G., Lorch, E.P., & Lorch, R.F. (1985). Distractibility and vocabulary deficits in children with spina bifida and hydrocephalus. Developmental Medicine and Child Neurology, 27, 713-720.

Howe, M.J. (1978). Human Learning, In B.M. Foss (Ed.) Psychology Survey, (pp. 143-155). London: George Allen, & Unwin.

Hunt, G.M., & Holmes, A.E. (1975). Some factors relating to intelligence in treated children with spina bifida cystica. Developmental Medicine and Child Neurology, 17, (Suppl. 35), 65-70.

Hurley, A.D., Laatsch, L.K., & Dorman, C. (1983). Comparison of spina bifida, hydrocephalic patients and matched controls on neuropsychological tests. Zeitschrift fur kinderchirurgie, 17, 65-70.

Ingram, F.D., & Scott, H.W. (1943). Spina bifida and cranium bifidum. The arnold-chiari malformation - a study of 20 cases. New England Journal of Medicine, 229, 108.

Ingram, T.T.S., & Naughton, J.A. (1962). Pediatric and psychological aspects of cerebral palsy associated with hydrocephalus. Development Medicine and Child Neurology, 4, 287-291.

Isaacson, R.L. (1975). The myth of recovery from early brain damage. In N. Ellis (Ed.), Aberrant Development in Infancy. London: Wiley.

Ivnik, R.J., Colligan, R.C., Obetz, S.W., & Smithson, W.A. (1981). Neuropsychological performance among children in remission from acute lymphocytic leukemia. Developmental and Behavioural Pediatrics, 2, 29-34.

Jacobsen, C.B., & Berlin, C.M. (1972). Possible reproductive detriment in LSD users. Journal of the American Medical Association, 222(11), 1367-1373.

Jaffe, M., & Glasser, N. (1981) Adolescents with hydrocephalus and spina bifida: Impact on their families. Spina bifida therapy.

Janerich, D.T. (1973). Maternal age and spina bifida: Longitudinal versus cross-sectional analysis. American Journal of Epidemiology, 96, 389-395.

Jastak, J.F., & Jastak, S.R. (1978). The Wide Range Achievement Test-Revised Edition. Wilmington, DE: Jastak Associates.

Johnson, A.F. (1984). Psycho-social achievement in the latency-aged child with spina bifida within the family structure. Zeitschrift fur kinderchirurgie, 39, 138-140.

Johnson, D., & Almli, C.R. (1963) Age, brain damage, and performance. In S. Finger (Ed), Recovery from brain damage: Research and theory. New York: Plenum Press.

Jones, H.C. (1984). The development of congenital hydrocephalus in the mouse. Zeitschrift fur Kinderchirurgie, 11, 87-88.

Joschko, M., & Rourke, B.P. (1985). Neuropsychological subtypes of learning-disabled children who exhibit the ACID pattern on the WISC. In B.R. Rourke (Ed.), Neuropsychology of Learning Disabilities: Essentials of subtype analysis, (pp. 65-88). New York: Guilford Press.

Kaufman, A.S. (1979). Intelligent testing with the WISC-R. New York: Wiley Press.

Klonoff, H., Low, M.D., & Clark, C. (1977). Head injuries in children: A prospective five year follow-up. Journal of Neurology, Neurosurgery and Psychiatry, 40, 1211-1219.

Klove, H. (1963). Clinical neuropsychology. In F.M. Forster (Ed.). The Medical Clinics of North America. New York: Saunders.

Knights, R.M., & Moule, A.D. (1967). Normative and reliability data on finger and foot tapping in children. Perceptual and Motor Skills, 25, 717-720.

Knights, R.M., & Norwood, J.A. (1979). A Neuropsychological test battery for children: Examiner's manual. Ottawa: Psychological Consultants.

Kolb, B., & Whishaw, I. (1985). Fundamentals of Human Neuropsychology (second ed.), New York: W.H. Freeman & Company.

Kolin, I.S., Scherzer, A.L., New. B., & Garfield, M. (1971). Studies of the school-age child with meningomyelocele: Social and emotional adaption. Journal of Pediatrics, 78(b), 1013-1019.

Laatsch, L.K., Dorman, C., & Hurley, A.D. (1984). Neuropsychological testing and survey forms to indicate possible loss of neurological functioning. Zeitschrift fur kinderchirurgie, 39, 125-128.

Land, L.C. (1977). A study of the sensory integration of children with meningomyelocele. In R.L. McLaurin (Ed.). Myelomeningocele. New York: Grune & Stratton.

Laurence, K.M. (1960). Hydrocephalus and disability. Cerebral Palsy Bulletin, 2, 170-179.

Laurence, K.M., & Coates, S. (1962). The natural history of hydrocephalus. Detailed analysis of 182 unoperated cases. Archives of Diseases in Children, 34, 345.

Laurence, K.M., & Tew, B.J. (1967). Follow up of 65 survivors from the 425 cases of spina bifida born in South Wales between 1956 and 1962. Developmental Medicine and Child Neurology, 13, 1-3.

Laurence, K.M., & Tew, B.J. (1971). The natural history of spina bifida cystica and cranium bifidum cysticum: Major central nervous system malformations in South Wales. Archives of Diseases in Childhood, 46, 127-138.

Layde, P.M., Edmonds, L.D., & Erickson, J.D. (1980). Maternal fever and neural tube defects. Teratology, 21, 105-108.

Layde, P.M., Von Allmen, S.D., & Oakley, G.P. (1979). Maternal serum alphafetoprotein screening. A cost benefit analysis. American Journal of Public Health, 69, 566-572.

Lemire, R.J., Loeser, J.D., Leach, R.W., & Alvord, A. (1975). Normal and abnormal development of the human nervous system. Hagerstown, NY: Harper, & Row.

Lendon, R.G. (1968). Studies on the embryogenesis of spina bifida in the rat. Developmental Medicine and Child Neurology, 16, 54-61.

Levin, H.S., & Eisenberg, H.S. (1979). Neuropsychological outcome of closed head injury in children and adolescents. Child's Brain, 5, 281-292.

Levin, H.S., & Eisenberg, H.M. (1982). Memory and intellectual ability after head injury in children and adolescents. Neurosurgery, 11, 668-673.

Levin, H.S., & Grossman, R.G. (1976). Effects of closed head injury on storage and retrieval in memory and learning of adolescents. Journal of Pediatric Psychology, 1, 38-42.

Lonton, A. (1976). Hand preference in children with myelomeningocele and hydrocephalus. Developmental Medicine and Child Neurology, 37, 143.

Lonton, A.P. (1979). The relationship between intellectual skills and the computerized axial tomograms of children with spina bifida and hydrocephalus. Zeitschrift fur kinderchirurgie und Grenzebiete, 28, 368-374.

Lonton, A.P., O'Sullivan, A., & Loughlin, A. (1983). Spina bifida adults. Zeitschrift fur Kinderchirurgie, 38, 110.

Lorber, J. (1965). The family history of spina bifida cystica. Paediatrics, 35, 589-595.

Lorber, J. (1971). Results of treatment of myelomeningocele: An analysis of 524 unselected cases, with special reference to possible selection for treatment. Developmental Medicine and Child Neurology, 13, 279-303.

Lorber, J. (1972). Spina Bifida Cystica: Results of treatment of 270 consecutive cases with criteria for selection for the future. Archives of Diseases in children, 47, 854-873.

Lorber, J., & Salfield, S.A. (1981). Results of selective treatment of spina bifida cystica. Archives of Diseases in children, 56, 822-830.

MacBriar, B.R. (1983). Self concept development of preadolescent and adolescent children with a myelomeningocele. Pediatric Nursing, 6, 1-11.

Malamud, N. (1964). Neuropathology. In H.A. Stevens and R. Heber (Eds.). Mental Retardation, a review of research. Chicago: University of Chicago Press.

Martin, R.A., Fineman, R.M., & Jorde, C.B. (1983). Phenotypic heterogeneity of neural tube defects: A clue to causal heterogeneity. American Journal of Medical Genetics, 16, 519-525.

Mapstone, T.B., Rekate, H.L., Nulsen, F.E., Dixon, M.S., Glasser, N., & Jaffe, M. (1984). Relationship of CSF shunting and IQ in children with myelomeningocele: A retrospective analysis. Child's Brain, 11, 112-118.

Mattson, A. (1972). Long term physical illness in childhood: A challenge to psychosocial adaptation. Pediatrics, 50, 801-811.

Mawdsley, T., Richkham, P.P., & Roberts, J.R. (1967). Long term results of early operation of open myelomeningocele and encephaloceles. British Medical Journal, 1, 663-666.

McAllister, J., Maugans, T.A., Shah, M.V., & Truex, R.C. (1985). Neuronal effects of experimentally induced hydrocephalus in newborn rats. Journal of Neurosurgery, 63, 776-783.

McAndrew, I. (1979). Adolescents and young people with spina bifida. Developmental Medicine and Child Neurology, 21, 619-629.

McLaughlin, S.F., Shurtleff, D.B., & Lemire, R.J. (1982). A process for care selection in myelodysphasia. Zeitschrift fur kinderchirurgie, 37, 161-164.

McLone, D.G. (1980). Technique for closure of myelomeningocele. Child's Brain, 6, 65-73.

McLone, D.G., Czyzewski, D., Raimondi, A.T., & Sommer, R.C. (1982). Central nervous system infections as a limiting factor in intelligence of children with myelomeningocele. Pediatrics, 70, 338-342.

Mealey, J., Gilmor, R.L., & Budd, M.P. (1973). The prognosis for hydrocephalus overt at birth. Journal of Neurosurgery, 39, 348-355.

Menelaus, M.B. (1980). Orthopedic Management of Spina Bifida Cystica (pp. 57-60). (2nd Ed.). New York: Churchill Livingstone.

Menkes, J.H. (1974). Textbook of child neurology. Philadelphia: Lea, & Febiger.

Michejda, M., & McCollough, D. (1987). New animal model for the study of neural tube defects. Zeitschrift fur Kinderchirurgie, 42, 32-35.

Milhorat, I.H. (1972). Hydrocephalus and cerebral spinal fluid. Baltimore: William and Wilkins.

Miller, E., & Sethi, L. (1971). Tactile matching in children with hydrocephalus. Neuropediatric, 3, 191-194.

Milunsky, A., Graef, J.W., & Gaynor, M.F. (1968). Methotrexate-induced congenital malformations. Pediatrics, 72, 790-795.

Murch, R.L. & Cohen, L.H. (1989). Relationships among life stress, perceived family environment, and the psychological distress of spina bifida adolescents. Journal of Pediatric Psychology, 14, 193-214.

Naggon, L., & McMahon, L.C. (1967). Ethnic differences in the prevalence of anencephaly and SB in Boston, Massachusetts. New England Journal of Medicine, 327, 1119-1123.

Neuger, G.J., O'Leary, D.S., & Fishburne, F. (1981). Order effects on the Halstead-Reitan Neuropsychological Test Battery and allied procedures. Journal of Consulting and Clinical Psychology, 49, 722-730.

Nichols, M.M. (1973). Fetal anomalies following maternal trimethadione ingestation. Journal of Pediatrics, 82, 885-886.

Nielsen, H.H. (1980). A longitudinal study of the psychological aspects of myelomeningocele. Scandinavian Journal of Psychology, 21, 45-54.

Nowicki, S., & Strickland, B.R. (1973). A locus of control scale for children. Journal of Consulting and Clinical Psychology, 40(1), 148-154.

Nowicki, S. (1975). The effect of locus of control on peer relationships across age groups. Journal of Genetic Psychology, 43, 275-280.

Nulsen, F.E., & Spitz, E.B. (1952). Treatment of hydrocephalus by direct shunt from ventricle to jugular vein. Surgical Forum, 2, 399-401.

Oates, R.K., Peacock, A., & Forest, D. (1985). Long-term effects of nonorganic failure to thrive. Pediatrics, 30, 957-962.

Oberbauer, R.W. (1985). The significance of morphological details for developmental outcome in infantile hydrocephalus. Child's Nervous System, 1, 329-336.

Obzrut, J.E., Hynd, G.W., Obzrut, A., & Pirozzolo, F. (1981). Effect of selective attention on cerebral asymmetries in normal and learning disabled children. Developmental Psychology, 17, 118-125.

Oka, N., Nakada, J., & Takaku, A. (1985-86). Angioarchitecture in experimental hydrocephalus. Pediatric Neuroscience, 12(6), 294-299.

O'Leary, D.S., & Boll, T.J. (1984). Neuropsychological correlates of early generalized brain dysfunction in children. In C.R. Almli and S. Finger (Eds.), Early Brain Damage, Volume I. New York: Academic Press.

Osaka, K., Tanimura, T., Hirayama, A., & Matsumoto, S. (1978). Myelomeningocele before birth. Journal of Neurosurgery, 49, 711-724.

Osterrieth, P.A. (1944). Le test de copie d'une figure a complex: contribution a l'etude de la perception et de la memoire. Archives de Psychologie, 30, 286-356.

Padget, D.H. (1970). Neuroschisis and human embryonic maldevelopment. Journal of Neuropathology Experimental Neurology, 29, 192-216.

Page, R.B. (1975). Scanning electron microscopy of the ventricular system in normal and hydrocephalic rabbits. Preliminary report and atlas. Journal of Neurosurgery, 42, 646-664.

Parker, J.C., & Asher, S.R. (1987). Peer relations and later personal adjustment: Are low-accepted children at risk?. Psychological Bulletin, 102, 357-389.

Parsons, J.G. (1969). Short-term verbal memory in Hydrocephalic children. Developmental Medicine and Child Neurology, 20, 75-79.

Parsons, J.G. (1972). Assessment of aptitudes in young people of school leaving age handicapped by hydrocephalus or spina bifida cystica. Developmental Medicine and Child Neurology, 27, 101-105.

Passarge, E., True, C.W., & Sueoka, W.T. (1966). Malformations of the central nervous system in trisomy 18 syndrome. Journal of Pediatrics, 69, 771-778.

Patterson, T.M., & McCubbin, H.I. (1983). Chronic Illness: Family stress and coping. In C.R. Fingley and H.I. McCubbin (Eds.). Stress and the Family, Vol, II (pp. 21-36). New York: Brunner Mazel.

Pearson. A., Carr, T., & Halliwell, M. (1985). The Self Concept of Adolescents with Spina Bifida. Zeitschrift fur Kinderchirurgie, 40, 27-30.

Peter, B.M., & Spreen, O. (1979). Behaviour rating and personal adjustment scales of neurologically and learning handicapped children during adolescents and early adulthood: Results of a follow-up study. Journal of Clinical Neuropsychology, 1, 75-92.

Piaget, J. (1972). The principles of Genetic Epistemology. New York: Basic Books.

Piers, E.V. (1984). Piers-Harris Children's Self-Concept Scale: Revised manual. Los Angeles: Western Psychological Services.

Pless, I.B., & Roghmann, K.J. (1971). Chronic illness in childhood: Part 1: Epidemiological and clinical characteristics. Journal of Pediatrics, 79, 351-359.

Polubinski, J., Melamed, L.E., & Prinzo, O.V. (1986). Factor structure evidence for developmental levels of perceptual processing on the Developmental Test of Visual-Motor Integration. Psychology in the Schools, 23, 337-341.

Posner, M.I. (1980). Orienting of attention. Journal of Experimental Psychology, 32, 3-26.

Posner, M.I., & Boies, S.W. (1971). Components of attention. Psychological Review, 78, 391-408.

Pratt, L. (1984). Integrating the child with Spina Bifida into school. Health Visitor, 57, (2), 242-243.

Prigatano, G.P., Zeiner, H.K., Pollay, M., & Kaplan, R.J. (1983) Neuropsychological functioning in children with shunted uncomplicated hydrocephalus. Child's Brain, 10, 112-120.

Purpura, D.P. (1975). Dendritic spine "dysgenesis" and mental retardation. Science, 186, 1126-1128.

Rabinowicz, I.M. (1974). Visual function in children with hydrocephalus. Transactions of the Ophthalmology Society, 94, 353-366.

Raimondi, A J. (1969). Angiographic diagnosis of hydrocephalus. Journal of Neurosurgery, 31, 550-560.

Raimondi, A.J., & Soare, P. (1974). Intellectual Development in shunted hydrocephalic children. American Journal of Diseases in Children, 127, 664-671.

Rakic, P. (1979). Developmental events leading to laminer and neural organization of the cortex. In F.O. Schmitt, F.G. Worden, G., Adelmen, & S.G. Dennis (Eds.) The organization of the cerebral cortex. Cambridge, Mass.: MIT. Press.

Rakic, P. (1979). Prenatal development of the visual system in rhesus monkey. Philos Transactions, 278, 245-260.

Record, R.G., & McKeown, T. (1951). Congenital malformations of the central nervous system. Data on sixty-nine pairs of twins. Annals Eugenics, 15, 285.

Reitan, R.M. (1979). Manual for Administration of Neuropsychological Test Batteries for Adults or Children. Tucson, Arizona: Neuropsychological Laboratory.

Reitan, R.M., & Davison, L.A. (1974). Clinical Neuropsychology: Current status and applications. Washington, D.C.: Winston, & Sons.

Renwick, J.H. (1972). Hypothesis: Anencephaly and spina bifida are usually preventable by avoidance of a specific but unidentified substance present in certain potato tubers. British Journal of Preventive Social Medicine, 26, 67-88.

Rey, A. (1941). L'examen psychologique dans les cas d'encephalopathie traumatique. Archives de Psychologie, 28, 286-340.

Robert, E., & Guibaud, P. (1982). Maternal valproic acid and congenital neural tube defect. Lancet, 937.

Rogers, S.C. (1969). Epidemiology of stillbirths from congenital abnormalities in England and Wales, 1961-66. Developmental Medicine and Child Neurology, 11, 617-629.

Rokos, J. (1979). The pathogenesis of spina bifida and related malformations. Recent advances in Neuropathology, 1, 225-245.

Ross, E.D. (1981) The Aprosodics: Functional - Anatomic organization of the affective components of language in the right hemisphere. Archives of Neurology, 38, 561-569.

Rosvold, H.E., Mirsky, A.F., Sarason, I., Bransome, E.D., & Beck, L.H. (1956). A continuous performance test of brain damage. Journal of Consulting and Clinical Psychology, 20, 343.

Rotter, J.B. (1966). Generalized expectancies for internal versus external control of reinforcement. Psychological Monographs, 80(1), Serial No. 609.

Rourke, B.P. (1975). Brain-behaviour relationships in children with learning disabilities: A research program. American Psychologist, 30, 911-920.

Rourke, B.P. (1982). Central processing deficiencies in children: toward a developmental neuropsychological model. Journal of Clinical Neuropsychology, 4, 1-18.

Rourke, B.P. (1987). Syndrome of nonverbal learning disabilities: The final common pathway of white matter disease/dysfunction. The Clinical Neuropsychologist, 1, 209-234.

Rourke, B.P., & Fisk, J.L. (1981). Socio-emotional disturbances of learning disabled children: The role of central processing deficits. Bulletin of the Orton Society, 31, 77-88.

Rourke, B.P., Fisk, J.L., & Strang, J.D. (1986). Neuropsychological assessment of children: A treatment-oriented approach. (pp. 136-143) New York: Guilford Press.

Rourke, B.P., & Gates, R.D. (1980). Underlining Test: Preliminary norms. Windsor, Ontario: Authors.

Rourke, B.P., & Petrauskas, R.J. (1977). Underlining test (Revised). Windsor, Ontario: Authors.

Rourke, B.P., & Strang, J.D. (1983). Subtypes of reading and arithmetical disabilities: A neuropsychological analysis. In M. Rutter (Ed.): Developmental Neuropsychiatry. (pp. 473-483). New York: Guilford Press.

Rourke, B.P., Young, G.C., Strang, J.D., & Russell, D. (1985). Adult outcomes of central processing deficiencies in childhood. In I. Grant & K.M. Adams (Eds.). Neuropsychological assessment in neuropsychiatric disorders: Clinical methods and empirical findings. New York: Oxford University Press.

Rubin, R.C., Hochwald, G., Liell, M., Bolek, L., & Epstein, F. (1975). Reconstitution of the cerebral cortical mantle in shunt-corrected hydrocephalus. Developmental Medicine and Child Neurology, 126, 143-144.

Rubin, R.C. Hochwald, G., Liwnicz, B., Tiell, Mizutan, H., & Shulman, K. (1972). The effect of severe hydrocephalus on size and number of brain cells. Developmental Medicine and Child Neurology, 14, (Suppl. 27), 117-120.

Rutter, M., Graham, P., & Yule, W. (1970). A neuro-psychiatric study in childhood. London: Heinemann Press.

Sameroff, A.J., & Chandler, M.J. (1975). Reproductive risk and the continuum of caretaking causality. In F. Horowitz (Ed.). Review of child development research (vol 5), pp. 187-244. Chicago: University of Chicago Press.

Sand, P. L., Taylor, N., Rawlings, M., & Chitnis, S. (1973). Performance of children with spina bifida manifesta on the Frostig Developmental Test of Visual Perception. Perceptual Motor Skills, 37, 539-546.

Satz, P., & Fletcher, J. (1982). Florida Kindergarten Screening Battery. Florida: Psychological Assessment Resources.

Schachter, D.L., Glisky, E.L., & McGlynn, S.M. (1988). Impact of memory disorder on everyday life. Awareness of deficits and return to work. In D. Tupper, & K.Cicerone (Eds.). The Neuropsychology of everyday life. Theories and basic competencies. Boston: Martinus Nijhoff.

Seidel, U.P., Chadwick, O., & Rutter, M. (1975). Psychological disorders in crippled children. A comparative study of children with and without brain damage. Developmental Medicine and Child Neurology, 17, 563-573.

Sella, A., Foltz, E., & Shurtleff, D. (1966). A three year developmental study of treated and untreated hydrocephalic children. Journal of pediatrics, 69, 887-888.

Shaffer, J., Friedrich, W.N., Shurtleff, D.B., & Wolf, L. (1985). Cognitive and achievement status of children with myelomeningocele. Journal of Pediatric Psychology, 10(3), 325-356.

Sharrard, W.J.W. (1964). The segmental innervation of the lower limb muscles in man. Annals of the Royal College of Surgeons of England, 35, 106-112.

Shepherd, C. (1969). Childhood chronic illness and visual motor perceptual development. Exceptional Child, 36, 39-42.

Shurtleff, D.B. (1973). Central nervous system infection with hydrocephalus and myelodysplasia. Clinics in Pediatrics, 12, 310-314.

Shurtleff, D.B. (1977). Independence achievement of congenitally handicapped children. Pediatric Digest, 19, 15-22.

Shurtleff, D.B., Foltz, E.L., & Loeser, J.D. (1973). Hydrocephalus: A definition of its progression and relationship to intellectual functions, diagnosis and complications. American Journal of Diseases in Children, 125, 688-693.

Shurtleff, D.B., Hayden, P.W., & Chapman, W.H. (1975). Myelodysplasia: Problems of long-term survival and social function. Western Journal of Medicine, 122, 199-205.

Shurtleff, D.B., Kronmal, R., & Foltz, E.L. (1975). Follow-up comparison of hydrocephalus with and without myelomeningocele. Journal of Neurosurgery, 42, 61-68.

Shurtleff, D.B., & Lamers, J. (1978). Clinical considerations in the treatment of myelodysplasia. In O.B. Crandall and M.A.B. Brazier (Eds.) The prevention of Neural Tube Defects: The role of Alpha-Fetoprotein (pp. 103-122). Orlando, Florida: Academic Press.

Simms, B. (1986). Learner Drivers with Spina Bifida and Hydrocephalus. The relationship between perceptual-cognitive deficit and driving performance. Zeitschrift fur kinderchirurgie, 41, 1, 51-55.

Smith, E.D. (1965). Spina Bifida and the total care of spinal myelomeningocele. Springfield, Il.: Charles C. Thomas.

Smithells, R.W. (1976). Environmental teratogens of man. British Medical Bulletin, 32, 27-33.

Smithells, R.W., Nevin, M.C., & Sellar, M.J. (1983). Further experience of vitamin supplementation for prevention of neural tube defect recurrences. Lancet, 1, 1027-1031.

Smithells, R.W., Shepard, S., Schorah, C.J. (1976). Vitamin deficiencies and neural tube defects. Archives of Diseases in Children, 51, 944-950.

Soare, D.L., & Raimondi, A.J. (1977). Intellectual and perceptual motor characteristics of treated myelomeningocele children. American Journal of Diseases in Children, 131, 199-204.

Sohlberg, M.M., & Mateer, C.A. (1986). Attention process training (APT). Puyallup, WA.: Association for Neuropsychological Research and Development.

Soler, N.G., Walsh, C.H., & Malins, J.M. (1976). Congenital malformations in infants of diabetic mothers. Quarterly Journal of Medicine, 45, 303-313.

Sousa, J.C., Gordon, L.H., & Shurtleff, D.B. (1976). Assessing developmental daily living skills in patients with spina bifida. Developmental Medicine and Child Neurology, 18, 134-142.

Spain, B. (1974). Verbal Performance and ability in preschool children with spina bifida. Developmental Medicine and Child Neurology, 16, 773-780.

Sparrow, S., Balla, D.A., & Cicchetti, D. (1984). Vineland Adaptive Behaviour Scales. Circle Pines, MN: American Guidance Service.

Spreen, O., & Benton, A.L. (1969). Neurosensory center comprehensive examination for aphasia. Victoria, B.C.: Neuropsychology Laboratory, Department of Psychology, University of Victoria.

Spreen, O., Tupper, D., Risser, A., Tuokko, H., & Edgell, D. (1984). Human developmental neuropsychology. New York: Oxford University Press.

SPSSX: Statistical package for the social sciences. (1986). New York: McGraw-Hill Book Co.

Stark, G.D. (1977). Spina Bifida: Problems and Management, London: Blackwell.

Strang, J.D., & Rourke, B.P. (1983). Concept-formation/non-verbal reasoning abilities of children who exhibit specific academic problems with arithmetic. Journal of Clinical Child Psychology, 12, 33-39.

Strang, J.D., & Rourke, B.P. (1985b). Arithmetic disability subtypes: The neuropsychological significance of specific arithmetic impairment in childhood. In B.P. Rourke (Ed.), Neuropsychology of Learning Disabilities: Essentials of Subtype Analysis (pp. 167-183). New York: Guilford Press.

Strassburg, M.A., Greenland, S., & Portigal, L.D. (1983). A population-based case-control study of anencephalus and spina bifida in a low-risk area. Developmental Medicine and Child Neurology, 25, 632-641.

Swinyard, C.A., Chaube, S., & Nishimura, H. (1978). Spina bifida as a prototype defect for decision making: nature of the defect. In C.A. Swinyard (ed.). Decision Making in the Defective Newborn. Springfield, Ill.: Charles C. Thomas.

Taussig, H.B. (1962). A study of the german outbreak of phocomelia. The thalidomide syndrome. Journal of the American Medical Association, 180, 1106-1114.

Tavormina, J.B., Kastner, L.S., Slater, P.M., & Watt, S.L. (1975). Chronically ill children: A psychologically and emotionally deviant population. Paper presented at the Society of Research in Child Development Meetings, Denver, Colorado.

Taylor, H.G., & Fletcher, J.M., & Satz, P. (1984). Neuropsychological assessment of children. In G. Goldstein, & M. Hersen (Eds.), Handbook of Psychological Assessment (pp. 211-234). New York: Peragamon Press.

Taylor, H.G. (1984). Early brain injury and cognitive development. In C.R. Almli, & S. Finger (Eds.), Early brain injury, (vol. 1). New York: Academic Press.

Taylor, H.G., & Albo, V.C., Phebus, C.K., Sachs, B.R., & Bierl, P.G. (1987). Postirradiation treatment outcomes for children with acute lymphocytic leukemia: clarification of risks. Journal of Pediatric Psychology, 12(3), 395-411.

Taylor, H.G., Fletcher, J.M., & Satz, P. (1982). Component processes in reading disabilities: A neuropsychological approach. In R.N. Malatesha, & P.G. Aaron (Eds.). Reading Disorders: Varieties and Treatments, (pp. 121-147). New York: Academic Press.

Taylor, H.G., Michaels, R.H., Mazur, P.M., Bauer, R.E., & Liden, C.B. (1984). Intellectual, neuropsychological, and achievement outcomes six to eight years after recovery from Haemophilus influence meningitis. Pediatrics, 74(2), 198-205.

Taylor, L.B. (1969). Localization of cerebral lesions by psychological testing. Clinical Neurosurgery, 16, 269-287.

Tew, B. (1979). The "cocktail party syndrome" in children with hydrocephalus and spina bifida. British Journal of Disorders of communication, 14, 89-101.

Tew, B., Evans, R., Thomas, M., & Ford, J. (1985). The results of a selective surgical policy on the cognitive abilities of children with Spina Bifida. Developmental Medicine and Child Neurology, 27, 606-614.

Tew, B., & Laurence, K.M. (1972). The ability and attainments of spina bifida patients born in South Wales between 1856-62. Developmental Medicine and Child Neurology, 27, 124-131.

Tew, B., & Laurence, K.M. (1975). The effects of hydrocephalus on intelligence, visual perception and school attainment. Developmental Medicine and Child Neurology, (Suppl. 35), 239-242.

Tew, B., & Laurence, K.M. (1978). Differences in reading achievement between spina bifida children attending normal schools and those attending special schools. Child: Care, Health and Development, 4, 317-326.

Tew, B.J., & Laurence, K.M. (1978). Ocular defect, intellectual and motor performance in children with spina bifida cystica. Zeitschrift fur Kinderchirurgie, 25, 324-330.

Tew, B., & Laurence, K.M. (1984). The relationship between intelligence and academic achievements in Spina Bifida adolescents. Zeitschrift fur kinderchirurgie, 39, 122-124.

Tew, B., & Laurence, K.M. (1985). Possible personality problems among 10-year-old spina bifida children. Child: care, health and development, 11, 375-390.

Thompson, N.M., Chapieski, L., & Fletcher, J.M. (1988, February). Neuropsychological characteristics of preschool children with spina bifida. Paper presented at the sixteenth annual meeting of the International Neuropsychology Society, New Orleans, LA.

Thompson, N.M., Chapieski, L., Fletcher, J.M., Bixby, J., Miner, M.E., & Davidson, K. (1989 February). Psychosocial adjustment in myelomeningocele: preschool children. Paper presented at the seventeenth annual meeting of the International Neuropsychological Society, Vancouver, B.C. Canada.

Torgesen, J., & Kail, R.V. (1980). Memory processes in exceptional children. In B. Keagh (ed.), Advances in special education: Basic constructs and theoretical orientations (Vol. I). Greenwich, Connecticut: Jai Press.

Torgesen, J.K. (1977). The role of non-specific factors in the task performance of learning disabled children: A theoretical assessment. Journal of Learning Disabilities, 10, 27-34.

Torkelson, R.D., Leibrock, L.G., Gustavson, J.L., & Sundell, R.R. (1985). Neurological and neuropsychological effects of cerebral spinal fluid shunting in children with assumed arrested ("normal pressure") hydrocephalus. Journal of Neurology, Neurosurgery and Psychiatry, 43, 799-806.

Tromp, C.N., Van den Burg, W., Jansen, A., & de Vires, S.J.J.M. (1979) Nature and severity of hydrocephalus and its relation to later intellectual function. Zeitschrift fur kinderchirurgie, 28, 354-360.

Vaishnav, A., & MacKinnon, A.E. (1986). Progressive hydrocephalus in Teenage Spina Bifida Patients. Zeitschrift fur kinderchirurgie, 41, 1, 36-37.

Venes, J.L. (1976). Control of shunt infection: Report of 150 consecutive cases. Journal Of Neurosurgery, 45, 311-314.

Venes, J.L. (1980 December). Mental retardation in children with myelomeningocele: An acquired disease?. Paper presented at the annual meeting of the American association of neurological surgeons, pediatric section, New York.

Verhulst, F.C., & Akkerhuis, G.W. (1989). Agreement between parents' and teachers' ratings of behavioural/emotional problems of children aged 4-12. Journal of Child Psychology and Psychiatry, 30(1), 123-136.

Visser, R.S.H. (1973). Manual of the Complex Figure Test. Amsterdam: Swets & Zeitlinger.

Voelker, S.L., Carter, R.A., Sprague, D.J., Gadowski, C.L., & Lachar, D. (1989). Developmental trends in memory and metamemory in children with attention deficit disorder. Journal of Pediatric Psychology, 14(1), 75-88.

Von Recklinghausen, F.D. (1886). Untersuchungen uber die spina bifida. Virchows archiv fur pathologische anatomie fur klinische medizin, 105, 243-330.

Waber, D.P., & Holmes, J.M. (1985). Assessing children's copy productions of the Rey-Osterrieth Complex Figure. Journal of Clinical and Experimental Neuropsychology, 7, 264-280.

Waber, D.P., & Holmes, J.M. (1986). Assessing children's memory productions of the Rey-Osterrieth Complex Figure. Journal of Clinical and Experimental Neuropsychology, 8(5), 563-580.

Wallace, S.J. (1973). The effect of upper-limb function or mobility of children with myelomeningocele. Developmental Medicine and Child Neurology, 15, 84-91.

Wallander, J.L., Varni, J.W., Babani, L., Banis, H.T., & Wilcox, K.T. (1988a). Children with chronic physical disorders: Maternal reports of their psychological adjustment. Journal of Pediatric Psychology, 13, 197-212.

Wallander, J.L., Varni, J.W., Babani, L., Banis, H.T., Dettaan, C.B., & Wilcox, K.T. (1989). Disability parameters, chronic strain, and adaptation of physical handicapped children and their mothers. Journal of Pediatric Psychology, 14, 23-42.

Warkany, J., & O'Toole, B.A. (1981). Experimental spina bifida and associated malformations. Child's Brain, 8, 18-30.

Wechsler, D. (1974). Manual for the Wechsler Intelligence Scale for Children - Revised. New York: Psychological Corporation.

Weller, R.O., & Shulman, K. (1972). Infantile hydrocephalus: clinical, histological, and ultrastructural study of brain damage. Journal of Neurosurgery, 36, 255-265.

Weller, R.O., Wisniewski, H., Ishiia, N., Shulman, K., & Terry, R.D. (1969). Brain tissue damage in hydrocephalus. Developmental Medicine and Child Neurology, 1, 55-65.

Werner, E.E. (1980). Environmental interaction in minimal brain dysfunctions. In H.C. Rie, & H.D. Rie (Eds.). Handbook of minimal brain dysfunction: A critical review (pp. 210-231). New York: Wiley Press.

Whitt, J.K., Wells, R.J., Lauria, M.M., Wilhelm, C.L., & McMillan, C.W. (1984). Cranial radiation in childhood acute lymphocytic leukemia: Neuropsychologic Sequelae. American Journal of Diseases in Children, 138, 730-736.

Wicks, J., Varzos, N., & Wicks, D. (1985). Personality characteristic of teenagers with myelomeningocele. Developmental Medicine and Child Neurology, 51-52.

Wiener, J. (1980). A theoretical model of the acquisition of peer relationships of learning disabled children. Journal of Learning Disabilities, 13(9), 43-47.

Wing, L. (1981) Asperger's Syndrome: a clinical account. Psychological Medicine, 11, 115-129.

Wozniak, M., McLone, D.G., & Raimondi, A.J. (1975). Micro-and macrovascular changes as the direct cause of parenchymal destruction in congenital murine hydrocephalus. Journal of Neurosurgery, 43, 535-545.

Yakovlev, P.L. (1947). Paraplegias of hydrocephalus. A clinical note and interpretation. American Journal of Mental Diseases, 51, 561.

Winogron, H.W., Knights, R.M., & Bawden, H.N. (1984). Neuropsychological deficits following head injury in children. Journal of Clinical Neuropsychology, 6, 269-286.

Wirt, R.D., Lachar, D., Klinedinst, J.K., & Seat, R.D. (1984). Multidimensional description of child personality: A manual for the Personality Inventory for Children. Los Angeles: Western Psychological Services.

Worden, F.G. (1966). Attention and auditory electrophysiology. In E. Stellar, & J.M. Sprague (Eds.), Progress in physiological psychology (Vol. 1). New York: Academic Press, 1966.

Wybar, K., & Walker, (1980). The surgical management of strabismus in hydrocephalus. Transactions of the Ophthalmology Society, 100, 475-478.

Yashon, D. (1963). Prognosis in infantile hydrocephalus: past and present. Journal of Neurosurgery, 20, 105-111.

Yashon, D., Jane, J.A., & Sugar, O. (1965). The course of severe untreated infantile hydrocephalus. Prognostic significance of the cerebral mantle. Journal of Neurosurgery, 23, 509-516.

Young, H.F., Nulsen, F.E., Weiss, M.H., & Thomas, P. (1973). The relationship of intelligence and the cerebral mantle in treated infantile hydrocephalus. Pediatrics, 52, 38-44.

Zeiner, H.K., & Prigatano, G.P. (1982). Information processing deficits in hydrocephalic and letter reversal children. Neuropsychologia, 20, 483-492.

Zeiner, H.K., Prigatano, G.P., Mollay, M., Biscoe, B.J., & Smith, R.V. (1985). Ocular motility, visual acuity and dysfunction of neuropsychological impairment in children with shunted uncomplicated hydrocephalus. Child's Nervous System, 1, 115-122.

APPENDIX A

TABLE A-1

Information obtained from a chart review of Spina Bifida Children in the 7-16 year old range (n = 150)

1) Children with no CNS complications (i.e., bleeding, infections and/or seizures associated with shunts) n = 38

Lesions	Above L2	
	9-16 years of age	10 cases (3 Intrauterine Hydrocephalus)
	7-9 years of age	2 cases (1 Intrauterine Hydrocephalus)
	L3-L5	
	9-16 years of age	12 cases (4 Intrauterine Hydrocephalus)
	7-9 years of age	4 cases (1 Intrauterine Hydrocephalus)
	S1 Level	
	9-16 years of age	8 cases
	7-9 years of age	2 cases

2) Children with a history of ventriculitis and seizures (n = 20).

Lesions	Above L2	
	9-16 years of age	8 cases (2 Intrauterine Hydrocephalus)
	L3-L5	
	9-16 years of age	8 cases (7 Intrauterine Hydrocephalus)
	S1 Level	
	9-16 years of age	4 cases (1 Intrauterine Hydrocephalus)

3) Children with Spina Bifida and no associated Hydrocephalus (n = 6).

Lesions	Above L2	
	9-16 years of age	5 cases
	S1 Level	
	9-16 years of age	3 cases
	7-9 years of age	1 case

4) Children with Meningoceles (n = 20)

9-16 years of age	13 cases
7-9 years of age	7 cases

5) Children with cysts (n = 2)

9-16 years of age	1 case with Posterior Fossa Cyst
7-9 years of age	1 case with Dandy Walker Cyst

6) Children with Spina Bifida and Encephalocele (n = 4)

7-9 years of age	3 occipital cases
	1 frontal encephalocele

7) Children with a history of a Head Injury (n = 2)

9-16 years of age	1 case
7-9 years of age	1 case

8) Deceased (usually within the first month of life)

(n = 43)

9-16 years of age	36 cases
7-9 years of age	7 cases

9) Unsuitable because moved to another province (n = 16)

9-16 years of age	12 cases
7-9 years of age	4 cases

The IZAAK WALTON KILLAM
HOSPITAL for CHILDREN
5850 UNIVERSITY AVENUE • P O BOX 3070 • HALIFAX, N S • B3J 3G9

Consent Form for Spina Bifida Study

Dear Parents:

We are inviting your child ______________________ to participate in a study that is designed to explore the learning and behaviour problems in children with Spina Bifida. We are carrying out this study in order to help develop more realistic and more carefully tailored remediation programs in educational, vocational and social settings for Spina Bifida children.

Participation in the study will involve your child spending one day at the I.W.K. for psychological testing. The testing will include intelligence, academic achievement, memory and motor skills tests, as well as questionnaires that allow your child to describe how he or she sees himself. At the same time we will ask you to fill out questionnaires that describe your child's behaviour. Your child's teacher will also be asked to fill out similar questionnaires.

A psychologist or psychology intern will explain these test results and their implications to you if you wish. This information may help you to better understand your child and may help with his/her school work.

All of the information that we collect about your child will be kept confidential. At any time, you may withdraw your child from participating in this study knowing that his/her treatment will not be changed in any way.

If you have any questions about this study, please feel free to contact either Dr. Harry Bawden or Martina O'Connor at 428-8454.

Child Name ______________________ Parents' Signature ______________________

Witness ______________________ Date ______________________

APPENDIX C

TABLE C-1

Selected Examples from Hollingshead Index

Occupation	SES Index
Major Business, Professional; Architect, Psychologist	V
Medium Business, Minor Professional; Social Worker, Artists	IV
Skilled Craftsmen, Clerical; Sales Workers	III
Machine Operators, Semi-Skilled Workers; Bus Drivers	II
Unskilled Labourers, Unskilled Workers; Chambermaids	I

APPENDIX D

TEST DESCRIPTIONS

1. INTELLECTUAL CAPACITY (3 variables)

    a) Wechsler Intelligence Scale for Children-Revised (WISC-R), (Wechsler, 1974).

The WISC-R is a well standardized test of cognitive functioning of children from 6.5 to 16.5 years of age. Eleven subtests, of which ten are used in deriving the IQ scores, are presented to the child. The 11 subtests are grouped into 2 scales: Verbal and Perceptual-Performance. It also yields an overall index of cognitive functioning (Full Scale IQ; x = 100; SD = 15). Norms, reliability and validity are excellent. Standardization of the test was based on a nationwide stratified sample representative of children in the United States, and taking into account various ethnic, regional, and socioeconomic factors. Administration time varies in length depending on the ability of the child, but usually takes about 50 minutes to complete.

Verbal Subtests:

Information: This subtest measures elementary general knowledge of history, geography, current events, literature, and general science. Score: number of items correct.

Comprehension: This subtest assesses the ability to answer questions about everyday social and practical situations. Score: number of items correct.

Arithmetic: This subtest measures mental computation of orally presented arithmetic problems. Score: number of problems correctly solved, within time credit.

Similarities: This subtest assesses verbal concept formation. Score: number of items correct.

Vocabulary: This subtest measures the ability to define words orally (Word Knowledge). Score: number of words correct.

Digit Span: This subtest measures immediate recall of number series. It involves repetition in forward order of three-to-nine digit numbers and repetition in reversed order of two-to-eight-digit numbers Score: total of forward and reversed digit span.

Performance Subtests:

Picture Completion: This subtest measures visual alertness and ability to analyze visual detail. The child is required to identify the missing part from simple line drawings of familiar objects. Score: number of missing parts correctly identified.

Picture Arrangements: This subtest measures understanding of the antecedents and consequences of social situations. The child is required to place in the correct order a series of picture cards to form the most probable sequence of events.

Score: Total credits for speed and accuracy of arrangement.

Block Design: This is a measure of nonverbal concept formation. The child is required to arrange blocks to match a printed design. Score: total score for speed and accuracy of block placement.

Object Assembly: This subtest assesses the ability to assemble abstract puzzle pieces. Score: total score for speed and accuracy of assembly.

Coding: This is a clerical transcription task which involves psychomotor speed, attention and short-term memory. Score: number of correct symbols written below digits within 120 seconds.

2. LANGUAGE (4 Variables)

a) Peabody Picture Vocabulary Test-Revised (PPVT-R), Form L (Dunn & Dunn, 1981).

This is a recently revised and restandardized measure of receptive language ability (vocabulary comprehension). It requires the child to select one of four pictures which correspond to a spoken word. Form L contains 5 training items, followed by 175 test items arranged in order of increasing difficult. The normative data is excellent. Reliability and validity are marginally satisfactory. It yields IQ (x = 10; SD = 3) and mental age scores for analysis, and requires about 10 minutes to administer. Score: number of correct responses.

b) Expressive One-Word Picture Vocabulary Test (EOWPT), (Gardner, 1978, 1981).

This is a measure of expressive single-word naming ability. There are two versions of this test; for children from 2 to 12 years of age and the upper extension version for use with children from ages 12 to 16 years. The child is required to give a single-word response to a series of line-drawings that are arranged progressively according to difficulty. The pictures presented range from single concrete objects to collections of objects that represent abstract concepts. The normative data for this test is excellent. Reliability and validity are satisfactory. Score: number of correct responses.

c) Verbal Fluency Test (Knights & Norwood, 1979)

This is a phonetically-cued test which taps productive language and word retrieval abilities. The child is required to name as many words as he/she can within 60 seconds, which begin with the sound "p" as in "pig." This is repeated with the sound "c" or "k" as in "cat" or "kangaroo." Score: mean number of correct words for the two trials. The norms for this test are limited. Little is known about the reliability and validity of the test.

d) Token Test - Part 5 (DiSimoni, 1978).

This test is a measure for assessing subtle receptive language dysfunction in children. It taps auditory comprehension, attention and working memory capacity. The child is required to manipulate plastic tokens in accordance with spoken instructions. Score: total number correctly performed. The norms for this test are limited. More information is needed on the reliability and validity of this measure, especially for the individual subtests.

3. MEMORY AND LEARNING (variables)

a) Verbal Selective Reminding Test (Buschke, 1974; Taylor, Michaels, Mazur, Bauer & Liden, 1984).

This is a test of learning and long-term verbal memory. The child is required to learn a list of 12 unrelated words over successive trials. On each trial, only those items not recalled on the previous trial are presented to the child. This procedure continues until the child either recalls the entire list twice in succession, or until the maximum number of trials have been given. This procedure provides separate measures of words immediately recalled, long-term storage, and consistent long-term retrieval abilities. There are several different versions of this tests depending on the age of the child. For 8-12 year old children 12 words from the same category are presented over 8 trials, while children 13 and older receive a list of 12 words from different categories for 8 trials. Administration times vary with age, but rarely exceed 10 minutes. The normative sample is adequate for this test. This measure has been shown to be highly sensitive to the effects of brain injury in children (Fletcher & Levin, 1989).

b) Nonverbal Selective Reminding Test (Copeland, Fletcher & Pfefferbaum, 1983).

This test is the visual-spatial analogue of the procedure just described. Here, the child is presented with a two-dimensional array of 8 squares or boxes, arranged in two rows of 4 boxes each. In each box there is a random arrangement of five dots. The examiner points to one of the dots in each box and then asks the child to point out those same dots. After each trial, the examiner points to the dots that the child failed to locate, and then again asks the child to point to the correct dot in each box. This procedure is carried out to a criterion of three successive trials in which all dots are correctly located, or to a maximum of 8 trials. Because the child is not required to perform any complicated motoric activity the test assesses visual-spatial memory unconfounded by motor or construction problems. Like the verbal version of the Selective Reminding procedure, the nonverbal version yields three age-normed measures (immediate recall, long-term storage and consistent long-term retrieval). This task and in conjunction with the Verbal Selective Reminding task, has been shown to differentiate a variety of developmentally disabled populations (Copeland, Fletcher, et al., 1983). Normative data for children aged 8 and up is available. The task requires about 10 minutes.

c) Sentence Memory Test (Spreen & Benton, 1969; Knights & Norwood, 1979).

This is a test of verbal short-term memory for meaningful sentences (26 sentence forms). The child is required to repeat sentences of gradually increasing length and complexity. The score is the number of sentences correctly repeated.

d) Rey Osterrieth Complex Figure (Rey 1959; Taylor 1962; Waber & Holmes, 1985, 1986).

This test is discussed more fully along with the Visuo-spatial and Constructional Tasks. The child is required to recall from long-term memory a complex figure. The design is scored for: 1) number of parts present; 2) style (holistic vs. part-oriented); and 3) organizational integrity (intersection of major lines). Although the norm group is satisfactory, little information is known about the reliability and validity of the test.

4. VISUOSPATIAL AND CONSTRUCTIONAL (2 Variables)

a) Developmental Test of Visual-Motor Integration (Beery, 1982).

This test is an age-normed perceptual-motor test for children. It requires the child to copy two-dimensional designs of increasing complexity. The score is the total number of designs correctly copied by the child. The Beery has been standardized on a larger and more representative sample of children than any other test of this type. It requires less than 10 minutes for administration.

Limited information is provided about the norm group. Reliability is satisfactory, but more information is needed about the validity of the revised norms.

b) Rey-Osterrieth Complex Figure (Rey, 1959; Taylor 1962; Waber & Holmes, 1985).

The task is to copy a complex figure. The child uses coloured pencils in a fixed order for thirty seconds each. The order of the colours is used to retrieve the order in which the design was copied. The designs are scored for: 1) number of parts present; 2) style (holistic vs. part-oriented); and 3) organizational integrity. Administration time is approximately five minutes.

5. ATTENTION AND PSYCHOMOTOR EFFICIENCY (2 variables)

a) Continuous Performance Test (Ferguson, 1985; Rosvold, Mirsky, Sarasoni & Beck, 1956).

This is a computerized vigilance test measuring ability to sustain attention and inhibit impulsive responding. The child sits before a computer screen, and a series of letters are shown on the screen. The child is required to press a button on a joystick whenever the letter b is followed immediately by the letter x. This test provides separate measures of sustained attention (errors of omission) and impulsivity (errors of commission). Administration is approximately 20 minutes. The normative group for this test was very limited. No information is available on reliability and validity.

b) Underlining Test (Rourke & Gates, 1980; Rourke & Petrauskas, 1977)

This test is intended to assess speed and accuracy of visual discrimination for various kinds of visual stimuli presented singly. The child is required to underline visual stimuli. A short practice session is given for each subtest. Normative data is adequate. Little is known about the reliability and validity of the test.The following four subtests were administered.

Subtest 1: Single Number.

The child is required to underline the number 4 each time it appears on a printed page containing a random sequence of single numbers. An example of the number to be identified is printed at the top of the page. A short practice session is given. Score: separate measure of sustained attention (errors of omission) and impulsivity (errors of commission) in 30 seconds.

Subtest 2: Single Geometric Forms.

The child is required to underline a greek cross each time it appears in random sequence among a series of geometric forms, including squares, stars, circles and triangles, and so forth. Score: number of errors of omission and errors of commission in 30 seconds.

Subtest 4: Gestalt Figure.

The figure to be underlined is a diamond about 8 mm in height containing a square which in turn contains a diamond. This figure is interspersed among similar figures in random sequence of figures. Score: number of errors of omission and errors of commission in 60 seconds.

Subtest 5: Four-Letter Nonsense Syllable, Unpronounceable.

The child is required to underline a four-letter nonsense syllable ("fsbm") interspersed among other four-letter nonsense syllables. All syllables are made up of the consonants f, s, b, and m, which renders them unpronounceable. Score: number of errors of omission and errors of commission in 60 seconds.

6. MOTOR (6 variables)

The norms used for all of the motor tests were developed by Knights and Norwood (1979). The norm group is limited and little information is known on the reliability and validity of the tests.

a) Finger-Tapping Test (Knights & Norwood, 1979; Reitan & Davison, 1974).

This test of motor speed requires the child to depress a telegraph key as rapidly as possible with the index finger of the dominant and nondominant hands. Four trials of 10 seconds are given for both hands. The score is the average of the four trials.

b) Grooved Pegboard Test (Klove, 1963; Knights & Moule, 1967).

This is a measure of speed and accuracy in eye-hand coordination. The child is required to fit 25 keyboard-shaped pegs into similarly shaped holes in a board as quickly as possible. One trial is performed with the dominant hand followed by one trial with the nondominant hand. The scores obtained are the length of time taken to complete the board with each hand and the total number of times the pegs are dropped with each hand. Norms for children aged 5-adult are available (Knights & Norwood, 1979).

c) Trail Making Test. (Knights & Norwood, 1979; Reitan & Davison, 1974).

This is a measure of visual-motor and visual sequencing skills. It consists of two parts, A and B. In A, the child is required under time pressure to connect numbers arranged randomly on a page. The requirements are similar in Part B, except that it is necessary to alternate between the numeric and the alphabetic series. The scores rendered are the number of seconds required to complete each series as well as the number of errors made on each part. Administration time is approximately 5 minutes.

7. PROBLEM SOLVING, CONCEPT FORMATION, REASONING.

a) Halstead Category Test (Knights & Norwood, 1979; Reitan & Davison, 1974)

This is a complex test of concept formation, cognitive flexibility, and the ability to test hypotheses and to modify them with positive or negative reinforcing feedback. This test consists of visual stimulus figures and is divided into 6 subtests. The items on slides are presented to the child individually by a self-contained projection apparatus. The child is required to press one of four answer buttons which are individually identified by the numbers 1, 2, 3, and 4 on a panel. A series of subtests are presented, each of which has an underlying principle which the child must attempt to discover through trial and error. A pleasant bell sounds after each incorrect response. The child should soon learn from the pattern of bell and buzzers to modify responses by developing and testing new hypotheses until the correct principle is achieved. Such principles include the concept of oddity, numerosity, spatial position, and relative extent. The final subtest has no underlying principle, but is a selection of previously-presented items and the child must recall the principle from memory. The score is the total number of errors. Administration is approximately 20 minutes.

Norms are limited and little is known about the reliability and validity of the test.

8. TACTILE-PERCEPTUAL

a) Halstead Tactile Perceptual Examination (Knights & Norwood, 1979; Reitan & Davison, 1974)

1. Finger Agnosia: The child is required to identify (without vision) which of his/her fingers have been touched; a shield covers the hand. Each of the five fingers are stimulated four times in a random order. The score is the number of errors made with each finger for each hand.

2. Dysgraphesthesia; Finger-Tip Number-Writing Perception: The child is required to verbalize (without vision) which of the numbers 3, 4, 5, or 6 has been written on his/her fingertip. Numbers are presented in random order in four trials for each finger of the dominant hand, and

repeated on the nondominant hand. The score is the number of errors made with each finger for each hand.

3. Astereognosis; Tactile Form Recognition: The child manipulates a geometric shape placed in their hand behind a shield and then identifies it by pointing to one of an array of 4 geometric shapes (circle, square, triangle, and cross). Two trials are given to the dominant and nondominant hands. The score is the number of errors made with each hand.

9. ACADEMIC ACHIEVEMENT (4 variables)

a) Wide Range Achievement Test-Revised (WRAT-R), (Jastak & Jastak, 1978)

The Spelling and Arithmetic subtests of the WRAT-R were administered. The norm group is generally representative of the population. Reliability and validity are satisfactory.

Spelling Subtest. This is a standardized test of written spelling achievement to dictation. A standard score and percentile score based on the total number of words correctly spelled are determined. Administration time is approximately 15 minutes.

Arithmetic Subtest: This is a standardized test of written arithmetic achievement. A standard score and percentile score based on the total number of correct solutions to progressively more difficult arithmetic problems are derived. Each subtest is divided into 2 levels; I and II.

Level I is designed for use with children between the ages of 5 years 0 months and 11 years 11 months. Level II is intended for persons 12 years 0 months to adulthood.

b) Peabody Individual Achievement Test (PIAT) (Dunn & Markwardt, 1970).

The Reading Recognition and Reading Comprehension subtests were administered. The norm group is excellent. However, although the reliability and validity are excellent for the total score, they are less satisfactory for the subtests.

(a) Reading Recognition Subtest: This is a standardized test of reading decoding (word recognition). The child is required to read aloud the single words. Administration time is approximately 5 minutes.

(b) Reading Comprehension Subtest: This subtest assesses reading comprehension. Each item consists of two pages. The first page contains a sentence that the child reads once silently. The second page, which is exposed to the child after he/she has read the passage, has four alternate illustrations on it. The child is asked to select the one which best represents the meaning of the sentence just read. Reliability and variability coefficients in the manual are excellent. Administration time is approximately 15 minutes.

10. BEHAVIOUR AND SOCIAL COMPETENCE

a) Parent:

1. Vineland Adaptive Behaviour Scales (VABS), (Sparrow, Balla & Cicchetti, 1984).

This scale assesses the children's functioning in their environment. The four domains of adaptive behaviour assessed include; communication, socialization, daily living and motor skills. Scoring of the VABS is based on a structured parent interview procedure of about 30 minutes. The test yields an age-based standard score for each of these domains. The VABS has been standardized on a large stratified sample of 3,000 children from birth to 19 years of age. Reliability and validity are excellent for the overall score but less adequate for individual domain scores.

2. Personality Inventory for Children-Revised (PIC), (Wirt, Lachar, Klinedinst & Seat, 1984).

This scale seeks to provide clinically relevant personality descriptions of individuals primarily in the range of 6-16 years of age. The PIC-R contains 4 factor scales and 16 profile scales. The Factor Scales include the following: Undisciplined/Poor Self-Control; Social Incompetence; Internalization/Somatic Symptoms and Cognitive Development. The Profile Scales can be divided further into three validity scales (the Lie, F and Defensiveness Scales), one screening scale for general maladjustment (the Adjustment Scale), and 12 clinical scales. The clinical scales include the following: Achievement, Intellectual Screening; Development; Somatic Concern; Depression, Family Relations;

Delinquency; Withdrawal; Anxiety; Psychosis; Hyperactivity; and Social Skills. Score elevations in the positive direction (e.g.; > 70 T) increase the likelihood of significant pathology for each of these scales. Most parents require about 20 minutes to complete the PIC-R.

The normative sample is adequate and reliability and validity are marginally satisfactory.

3. Child Behaviour Checklist (CBCL) (Achenbach & Edelbrock, 1978; 1983).

This is a 113 item rating scale which has two sections--one assessing social competence and the other assessing behaviour problems. It provides a generally comprehensive assessment of parent ratings of most of the commonly occurring dimensions of psychopathology in children. This well-constructed measure has been separately factor analyzed and standardized for children of each sex at ages 4 to 5, 6 to 11, and 12 to 16. The norm group, reliability and validity of the test are satisfactory.

To aid interpretation, Achenbach (1978) recommended that a cutoff score of greater than 70 reflected clinical maladjustment (i.e., significant behavioural disturbance). For the social competence scale a cutoff score of less than 30 reflected delayed attainment of adaptive behaviour.

For boys aged 6-11, the internalizing dimension is composed of the following scales: Schizoid or Anxious; Depressed; Uncommunicative; Obsessive-Compulsive and Somatic Complaints. The externalizing dimension includes Delinquent; Aggressive; and Hyperactive Scales. Mixed syndrome factors include the Social; and Withdrawal Scales. For boys aged 12-16 years, the internalizing dimension includes Somatic Complaints, Schizoid, Uncommunicative, Immature and Obsessive-Compulsive Scales. Mixed syndrome factors include the Hostile; and Withdrawal Scales. The externalizing dimension consists of the Hyperactive; Aggressive and Delinquent Scales.

For girls aged 6-11 years, the internalizing dimension includes Somatic Complaints; Depressed; Social Withdrawal; and Schizoid-Obsessive Scales. The externalizing dimension is composed of the scales: Cruel; Aggressive; Delinquent; Sex Problems and Hyperactive. For girls between 12 and 16 years of age, the internalizing dimension consists of the following scales: Anxious - Obsessive; Somatic Complaints; Schizoid; and Depressed - Withdrawal. Mixed syndrome factors include the Immature and Hyperactive Scales. The externalizing dimension includes the Cruel; Aggressive; and Delinquent Scales. Most parents require approximately 15 minutes to complete the CBC.

b) Teacher:

1. Teacher's Child Behaviour Checklist (CBCL-T), (Achenbach & Edelbrock, 1983).

The CBCL-T which is the teacher equivalent of the CBCL, provides information regarding teacher's impressions of adaptive functioning in school and behaviour problems. The CBC-T requires about 15 minutes to complete.

Teachers are asked to rate the child based on how they view the child currently or within the previous two months. It asks the teacher to rate how hard the child is working, how appropriately they are behaving, how well they are learning and how happy they are within the classroom. Two summary scores compose the adaptive functioning section: one for school performance and the other for total adaptive functioning (sum of remaining four scales). The Behaviour Scales are Anxious, Social-Withdrawal, Unpopular, Self-Destructive, Obsessive-Compulsive, Inattentive, Nervous-Overactive and Aggressive. Normative standards (for children 6-16 years of age) permit assessment of the degree of deviancy relative to age expectations. Four variables will be analyzed for both parent and teacher forms: Social Competency, Behaviour Problems, and the Internalizing and Externalizing scales.

11. SELF-CONCEPT

a) Piers-Harris Children's Self-Concept Scale (Piers, 1984).

This is a measure of self-concept for children 8 and older.

It has acceptable internal consistency and test-retest reliability and moderate validity when compared with other self-esteem measures. This scale requires about 10 minutes to complete.

b) Internal-External Locus of Control Scale (Nowicki & Strickland, 1973).

This is a measure of locus of control. It is constructed to determine whether children generally perceive that reinforcement or events are contingent upon their own actions or characteristics (internal) or are under the control of others, fate, or locus of control chance (external locus of control). Little is known about reliability and validity of the test.

APPENDIX E

TABLE E-1

Intellectual Ability: Descriptive Statistics and T-Test Results for Low and High Socioeconomic Groups

		N	Mean	Stdev	T	DF	Sig of T
<u>Intellectual Domain</u>							
VIQ	G1	18	37.7778	8.395	-2.69	34	.005**
	G2	18	45.4444	8.690			
PIQ	G1	18	37.6667	9.737	-.64	34	.263
	G2	18	40.1481	13.274			
FSIQ	G1	18	36.6296	8.041	-1.79	34	.041*
	G2	18	42.1111	10.188			
<u>Verbal Subtests</u>							
Information	G1	18	36.6667	9.901	-3.34	34	.001***
	G2	18	47.2222	9.021			
Similarities	G1	18	42.9630	6.456	-2.51	34	.008**
	G2	18	49.2593	8.445			

G1 - Low Socioeconomic Group
G2 - High Socioeconomic Group

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE E-2

Intellectual Ability: Descriptive Statistics and T-Test Results for Low and High Socioeconomic Groups

		N	Mean	Stdev	T	DF	Sig of T
<u>Verbal Subtests</u>							
Arithmetic	G1	18	40.5556	8.651	-1.89	34	.033*
	G2	18	45.1852	5.742			
Vocabulary	G1	18	38.7037	8.940	-2.06	34	.023*
	G2	18	45.7407	11.365			
Comprehension	G1	18	41.8519	7.857	-1.23	34	.114
	G2	18	45.3704	9.298			
Digit Span	G1	18	39.4444	8.343	-3.35	34	.001**
	G2	18	48.8889	8.556			

G1 - Low Socioeconomic Group
G2 - High Socioeconomic Group

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE E-3

Intellectual Ability: Descriptive Statistics and T-Test Results
for Low and High Socioeconomic Groups

		N	Mean	Stdev	T	DF	Sig of T
<u>Performance Subtests</u>							
Picture Completion	G1	18	45.0000	10.981	-.10	34	.461
	G2	18	45.3704	11.611			
Picture Arrangement	G1	18	43.1481	8.964	-.10	34	.456
	G2	18	43.5185	12.339			
Block Design	G1	18	39.4444	10.369	-1.28	34	.104
	G2	18	44.0741	11.235			
Object Assembly	G1	18	40.0000	12.783	-.51	34	.307
	G2	18	42.4074	15.543			
Coding	G1	18	36.1111	9.514	.00	34	.50
	G2	18	36.1111	10.862			

G1 = Low Socioeconomic Group
G2 = High Socioeconomic Group

<u>Note</u>: No significant differences at .05 one-tailed level of significance

TABLE E-4

Language Ability: Descriptive Statistics and T-Test Results for Low and High Socioeconomic Groups

		N	Mean	Stdev	T	DF	Sig of T
Peabody Picture Vocabulary Test	G1	18	41.9259	11.078	-1.73	34	.046*
	G2	18	48.4074	11.411			
Expressive One-Word Test	G1	18	36.0000	9.978	-3.10	34	.002**
	G2	18	45.5926	8.510			
Fluency	G1	18	36.0853	8.521	-.67	34	.253
	G2	18	38.5575	13.067			
Token	G1	18	52.2355	14.487	-.56	33	.289
	G2	18	54.7860	12.308			

G1 = Low Socioeconomic Group
G2 = High Socioeconomic Group

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE E-5

Memory Ability: Descriptive Statistics and T-Test Result
for Low and High Socioeconomic Median

		N	Mean	Stdev	T	DF	Sig of T
Verbal Memory							
VSRT[1] - Recall	G1	6	21.3962	18.483	.42	15	.339
	G2	11	16.2213	26.493			
VSRT - Long Term Storage	G1	18	20.5413	19.297	.69	34	.247
	G2	18	15.0264	27.860			
VSRT-Consistent Retrieval	G1	18	28.9646	11.590	-1.54	34	.066
	G2	18	35.6967	14.449			
Sentence Memory	G1	18	39.2589	13.279	-1.38	34	.087
	G2	18	44.5662	9.391			

G1 = Low Socioeconomic Group
G2 = High Socioeconomic Group

Note: No significant differences at .05 one-tailed level of significance

[1]VSRT = Verbal Selective Reminding Test

TABLE E-6

Memory Ability: Descriptive Statistics and T-Test Results for Low and High Socioeconomic Groups

		N	Mean	Stdev	T	DF	Sig of T
<u>Nonverbal Memory</u>							
NVSRT[1] - Recall	G1	18	32.9591	8.589	.40	34	.345
	G2	18	31.4319	13.676			
NVSRT - Long Term Storage	G1	18	31.2620	10.678	-.29	34	.388
	G2	18	32.3737	12.584			
NVSRT-Consistent Retrieval	G1	18	31.7008	5.798	-.83	34	.206
	G2	18	33.5358	7.372			
Rey-Figure Recall	G1	18	27.3954	10.146	-.58	34	.284
	G2	18	29.5759	12.419			
Rey-Figure Re-organization	G1	18	34.0063	5.876	.49	34	.313
	G2	18	33.0288	6.043			

G1 = Low Socioeconomic Group
G2 = High Socioeconomic Group

<u>Note</u>: No significant differences at .05 one-tailed level of significance

[1]NVSRT = Nonverbal Selective Reminding Test

TABLE E-7

Construction and Problem-Solving Abilities: Descriptive Statistics and T-Test Results for Low and High Socioeconomic Groups

		N	Mean	Stdev	T	DF	Sig of T
<u>Construction</u>							
DTVMI[1]	G1	18	31.4815	10.430	-1.01	34	.159
	G2	18	35.1852	11.503			
Rey-Figure	G1	18	45.1015	8.908	-.94	34	.176
Copy	G2	18	47.8699	8.730			
Rey-Figure	G1	18	32.7708	8.913	-1.36	34	.091
Organization	G2	18	36.7540	8.636			
<u>Problem-Solving</u>							
Halstead	G1	18	33.6128	12.498	-.33	34	.371
Category	G2	18	35.2510	16.850			

G1 - Low Socioeconomic Group
G2 - High Socioeconomic Group

<u>Note</u>: No significant differences at .05 one-tailed level of significance

[1]DTVMI - Developmental Test of Visuomotor Integration

TABLE E-8

Attention: Descriptive Statistics and T-Test Results for Low and High Socioeconomic Groups

		N	Mean	Stdev	T	DF	Sig of T
CPT[1] Omission Errors	G1	18	25.9789	50.813	-.46	27.48	.326
	G2	18	32.3609	28.861			
CPT Commission Errors	G1	18	21.9081	41.747	-.66	32	.257
	G2	18	30.8999	37.183			
Underlining Subtest 1	G1	18	28.8341	12.397	-.96	32	.173
	G2	16	32.4354	9.044			
Underlining Subtest 2	G1	18	24.5333	15.156	-.81	31	.212
	G2	15	28.4013	11.572			
Underlining Subtest 4	G1	18	40.4681	8.267	-1.21	31	.117
	G2	15	43.9633	8.205			
Underlining Subtest 5	G1	18	32.7585	8.365	-1.44	31	.079
	G2	15	37.3606	9.970			

G1 = Low Socioeconomic Group
G2 = High Socioeconomic Group

Note: No significant differences at .05 one-tailed level of significance

[1]CPT = Continuous Performance Test

TABLE E-9

Motor Abilities: Descriptive Statistics and T-Test Results for Low and High Socioeconomic Groups

		N	Mean	Stdev	T	DF	Sig of T
Finger Tapping	G1	18	46.7557	13.708	-1.33	34	.095
(dominant)	G2	18	54.5136	20.539			
Finger Tapping	G1	18	45.9163	14.927	-1.65	34	.053
(nondominant)	G2	18	53.4328	12.191			
Pegs	G1	18	9.5306	28.618	.27	24.50	.395
(dominant)	G2	18	5.3512	59.339			
Pegs	G1	18	-3.2229	40.795	.27	23.76	.394
(nondominant)	G2	18	-9.7023	91.689			
Trails A	G1	17	33.6052	25.986	.42	33	.337
(time)	G2	18	30.3771	18.540			
Trails A	G1	17	54.5098	20.382	.89	33	.189
(error)	G2	18	48.6481	18.432			
Trails B	G1	17	27.8984	20.437	-1.08	33	.144
(time)	G2	18	36.0709	24.029			
Trails B	G1	17	50.5833	12.784	-.37	33	.356
(error)	G2	18	52.4282	16.226			

G1 - Low Socioeconomic Group
G2 - High Socioeconomic Group

Note: No significant differences at .05 one-tailed level of significance

TABLE E-10

Tactile-Perceptual Ability: Descriptive Statistics and T-Test Results for Low and High Socioeconomic Groups

	N	mean	Stdev	T	DF	Sig of T
Agnosia	18	41.5556	23.147	.74	21.67	.233
(dominant)	18	30.0278	61.887			
Agnosia	18	51.1111	9.386	1.23	21.78	.116
(nondominant)	18	43.4444	24.774			
Dysgrapethesia	18	-2.1623	75.618	-1.67	20.70	.055
(dominant)	18	29.2111	25.095			
Dysgraphethesia	18	-17.5819	90.656	-1.77	21.53	.045*
(nondominant)	18	22.7756	33.383			
Astereognosis	18	59.3709	4.473	.54	22.29	.296
(dominant)	18	57.8263	11.196			
Astereognosis	18	53.6376	18.535	-.83	25.69	.206
(nondominant)	18	57.7403	9.716			

G1 - Low Socioeconomic Group
G2 - High Socioeconomic Group

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE E-11

Academic Ability: Descriptive Statistics and T-Test Results
for Low and High Socioeconomic Groups

		N	Mean	Stdev	T	DF	Sig of T
WRAT-R Spelling	G1	18	38.8889	11.831	-2.65	34	.006**
	G2	18	48.2963	9.278			
WRAT-R Arithmetic	G1	18	29.8148	10.773	-2.92	34	.003**
	G2	18	38.5926	6.860			
PIAT-Reading Recognition	G1	18	47.5185	14.261	-2.46	33	.009**
	G2	18	57.5294	9.018			
PIAT-Reading Comprehension	G1	18	40.9259	10.933	-1.81	34	.039*
	G2	18	47.9259	12.218			

G1 = Low Socioeconomic Group
G2 = High Socioeconomic Group

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE E-12

Vineland Adaptive Behaviour Scale: Descriptive Statistics and T-Test Result for Low and High Socioeconomic Groups

Vineland Domains		N	Mean	Stdev	T	DF	Sig of T
Communication	G1	18	30.3704	8.639	-3.14	34	.002**
	G2	18	40.0741	9.877			
Daily Living Skills	G1	18	29.8889	13.351	-1.21	34	.117
	G2	18	35.3704	13.820			
Socialization	G1	18	40.0000	9.634	-1.51	34	.070
	G2	18	44.8148	9.540			
Motor (estimate)	G1	18	19.5556	13.144	-.93	34	.179
	G2	18	24.0741	15.254			
Maladaptive	G1	18	51.1618	7.312	.82	34	.208
	G2	18	49.3005	6.232			

G1 - Low Socioeconomic Group
G2 - High Socioeconomic Group

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE E-13

Vineland Subdomains: Descriptive Statistics and T-Test Results for Low and High Socioeconomic Groups

		N	Mean	Stdev	T	DF	Sig of T
<u>Communication</u>							
Receptive	G1	18	48.7103	8.265	1.31	18.48	.102
	G2	18	36.1772	39.583			
Expressive	G1	18	41.5857	9.775	-.66	34	.255
	G2	18	43.8737	10.899			
Written	G1	18	28.0659	12.645	-3.30	34	.001**
	G2	18	40.7640	10.346			
<u>Daily Living Skills</u>							
Personal	G1	18	34.0665	23.080	-.88	34	.193
	G2	18	41.8361	29.750			
Domestic	G1	18	29.9864	11.146	-1.04	34	.152
	G2	18	33.5737	9.389			
Community	G1	18	32.8816	9.261	.12	23.99	.451
	G2	18	32.2448	19.966			

G1 = Low Socioeconomic Group
G2 = High Socioeconomic Group

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE E-14

Vineland Subdomains: Descriptive Statistics and T-test Results for Low and High Socioeconomic Groups

		N	Mean	Stdev	T	DF	Sig of T
<u>Socialization</u>							
Interests	G1	18	46.3692	10.698	.07	24.58	.472
	G2	18	45.9616	22.060			
Play	G1	18	39.8004	11.877	-.80	34	.213
	G2	18	42.9342	11.514			
Coping Skills	G1	18	40.0389	12.064	-2.48	34	.009**
	G2	18	48.6079	8.311			

G1 = Low Socioeconomic Group
G2 = High Socioeconomic Group

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE E-15

Behaviour and Social Competence: Descriptive Statistics and T-Test Results for Low and High Socioeconomic Groups

		N	Mean	Stdev	T	DF	Sig of T
<u>Parent Achenbach</u>							
Social Competence	G1	10	31.4117	10.016	-.76	24	.228
	G2	16	35.2560	13.882			
Internalization	G1	17	55.4378	11.561	.15	32	.440
	G2	17	54.8559	10.899			
Externalizing	G1	17	52.0530	11.823	.82	22.88	.211
	G2	17	49.4586	5.620			
Total Problems	G1	17	56.0677	13.478	.58	32	.283
	G2	17	53.8998	7.499			

G1 - Low Socioeconomic Group
G2 - High Socioeconomic Group

<u>Note</u>: No significant differences at .05 one-tailed level of significance

TABLE E-16

Behaviour and Social Competence: Descriptive Statistics and T-Test Results for Low and High Socioeconomic Groups

		N	Mean	Stdev	T	DF	Sig of T
<u>Teacher's Achenbach</u>							
Adaptive Functioning	G1	15	40.7060	6.894	-.58	24	.283
	G2	11	42.2600	6.491			
Internalizing	G1	15	55.9452	16.317	-.14	26	.446
	G2	13	56.6592	9.761			
Externalizing	G1	15	51.2695	11.965	-.31	26	.379
	G2	13	52.4902	8.042			
Total Problems	G1	15	53.4738	15.632	-.05	26	.480
	G2	13	53.7239	9.429			

G1 - Low Socioeconomic Group
G2 - High Socioeconomic Group

<u>Note</u>: No significant differences at .05 one-tailed level of significance

APPENDIX F

TABLE F-1

Intellectual Ability: Descriptive Statistics and T-Test Results for Median-Age Variable

		N	Mean	Stdev	T	DF	Sig of T
VIQ	G1	18	42.0370	8.050	.27	34	.393
	G2	18	41.1852	10.579			
PIQ	G1	18	36.5556	12.728	-1.23	34	.113
	G2	18	41.2593	10.027			
FSIQ	G1	18	38.2963	9.501	-.68	34	.252
	G2	18	40.4444	9.574			
<u>Verbal Subtests</u>							
Information	G1	18	43.1481	8.592	.67	34	.255
	G2	18	40.7407	12.709			
Similarities	G1	18	47.5926	9.275	1.11	34	.138
	G2	18	44.6296	6.582			
Arithmetic	G1	18	41.6667	6.691	-.95	34	.175
	G2	18	44.0741	8.445			

G1 = Young group
G2 = Old group

<u>Note</u>: No significant differences at .05 one-tailed level of significance

TABLE F-2

Intellectual Ability: Descriptive Statistics and T-Test Results for Median Age Variable

		N	Mean	Stdev	T	DF	Sig of T
<u>Verbal Subtests</u>							
Vocabulary	G1	18	41.2963	8.866	-.51	34	.305
	G2	18	43.1481	12.445			
Comprehension	G1	18	45.1852	7.341	1.09	34	.141
	G2	18	42.0370	9.778			
Digit Span	G1	18	47.2222	10.306	1.99	34	.027*
	G2	18	41.1111	8.003			
<u>Performance Subtests</u>							
Picture	G1	18	43.5185	11.853	-.90	34	.188
Completion	G2	18	46.8519	10.446			

G1 = Young group
G2 = Old group

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE F-3

Intellectual Ability: Descriptive Statistics and T-Test Results for Median Age Variable

		N	Mean	Stdev	T	DF	Sig of T
<u>Performance Subtests</u>							
Picture Arrangement	G1	18	40.0000	11.771	-1.96	34	.029*
	G2	18	46.6667	8.402			
Block Design	G1	18	40.0000	11.991	-.97	34	.170
	G2	18	43.5185	9.733			
Object Assembly	G1	18	39.0741	13.711	-.91	34	.186
	G2	18	43.3333	14.507			
Coding	G1	18	35.0000	11.785	-.66	34	.258
	G2	18	37.2222	8.185			

G1 - Young group
G2 - Old group

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE F-4

Language Ability: Descriptive Statistics and T-Test Results for Median Age Variable

		N	Mean	Stdev	T	DF	Sig of T
Peabody Picture	G1	18	46.3704	11.484	.62	34	.270
Vocabulary Test	G2	18	43.9630	11.841			
Expressive	G1	18	44.8889	7.518	2.55	34	.007**
One-Word Test	G2	18	36.7037	11.345			
Fluency	G1	18	38.0913	8.249	.42	28.37	.340
	G2	18	36.5516	13.315			
Token	G1	18	47.7695	13.646	-2.93	33	.003**
	G2	17	59.6646	9.960			

G1 = Young group
G2 = Old group

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE F-5

Memory Ability: Descriptive Statistics and T-Test Results for Median Age Variable

		N	Mean	Stdev	T	DF	Sig of T
<u>Verbal Memory</u>							
VSRT[1] - Recall	G1	16	18.4977	24.188			
	G2	1	10.8475				
VSRT - Long Term Storage	G1	18	15.0158	27.644	-.69	34	.246
	G2	18	20.5519	19.602			
VSRT-Consistent Retrieval	G1	18	35.6645	13.412	1.53	34	.068
	G2	18	28.9967	12.793			
Sentence Memory	G1	18	45.6077	8.300	1.98	28.27	.028*
	G2	18	38.2174	13.477			

G1 - Young group
G2 - Old group

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

[1]VSRT - Verbal Selective Reminding Test

TABLE F-6

Memory Ability: Descriptive Statistics and T-Test Results for Median Age Variable

		N	Mean	Stdev	T	DF	Sig of T
<u>Nonverbal Memory</u>							
NVSRT[1] - Recall	G1	18	27.6554	13.393	-2.61	24.06	.007**
	G2	18	36.7357	6.247			
NVSRT - Long Term Storage	G1	18	32.7075	10.646	.46	34	.325
	G2	18	30.9282	12.571			
NVSRT-Consistent	G1	18	33.2361	6.450	.56	34	.291
	G2	18	32.0004	6.880			
Rey-Figure Recall	G1	18	27.3545	8.462	-.60	34	.277
	G2	18	29.6169	13.615			
Rey-Figure Reorganization	G1	18	33.2255	4.677	-.29	34	.385
	G2	18	33.8096	7.035			

G1 = Young group
G2 = Old group

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

[1]NVSRT = Nonverbal Selective Reminding Test

TABLE F-7

Construction and Problem-Solving Ability: Descriptive Statistics and T-Test Results for Median Age Variable

		N	Mean	Stdev	T	DF	Sig of T
<u>Construction</u>							
DTVMI[1]	G1	18	35.0000	8.264	.91	34	.185
	G2	18	31.6667	13.198			
Rey-Figure	G1	18	47.3388	8.882	.58	34	.284
Copy	G2	18	45.6325	8.899			
Rey-Figure	G1	18	35.4013	6.883	.43	34	.336
Organization	G2	18	34.1235	10.686			
<u>Problem-Solving</u>							
Halstead	G1	18	32.5830	17.026	-.75	34	.228
Category	G2	18	36.2809	12.018			

G1 - Young group
G2 - Old group

<u>Note</u>: No significant differences at .05 one-tailed level of significance

[1]DTVMI - Developmental Test of Visuomotor Integration

TABLE F-8

Attention: Descriptive Statistics and T-Test Results for Median Age Variable

		N	Mean	Stdev	T	DF	Sig of T
CPT[1] Omission Errors	G1	16	28.4537	29.382	-.07	27.77	.472
	G2	18	29.4520	50.744			
CPT Commission Errors	G1	16	33.5067	32.363	1.03	32	.155
	G2	18	19.5909	44.524			
Underlining Subtest 1	G1	16	30.2428	10.351	-.14	32	.444
	G2	18	30.7831	11.731			
Underlining Subtest 2	G1	15	26.7454	13.928	.17	31	.432
	G2	18	25.9132	13.678			
Underlining Subtest 4	G1	15	45.9484	6.509	2.68	31	.006**
	G2	18	38.8138	8.402			
Underlining Subtest 5	G1	15	35.6618	11.736	.43	21.73	.335
	G2	18	34.1742	6.895			

G1 - Young group
G2 - Old group

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

[1]CPT - Continuous Performance Test

TABLE F-9

Motor: Descriptive Statistics and T-Test Results for Median Age Variable

		N	Mean	Stdev	T	DF	Sig of T
Finger-Tapping (dominant)	G1	18	52.4467	17.397	.61	34	.273
	G2	18	48.8226	18.221			
Finger-Tapping (nondominant)	G1	18	50.3229	13.608	.27	34	.392
	G2	18	49.0262	14.673			
Pegs (dominant)	G1	18	2.3796	56.975	-.66	26.95	.259
	G2	18	12.5022	32.389			
Pegs (nondominant)	G1	17	-17.8076	91.453	-.91	33	.184
	G2	18	4.0721	43.323			
Trails A (time)	G1	18	27.0336	28.467	-1.36	22.54	.088
	G2	17	37.1454	11.370			
Trails A (error)	G1	18	43.7037	22.288	-2.71	25.45	.006**
	G2	17	59.7451	11.259			

G1 - Young group
G2 - Old group

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE F-10

Motor Ability: Descriptive Statistics and T-Test Results for Median Age Variable

		N	Mean	Stdev	T	DF	Sig of T
Motor							
Trails B	G1	18	30.6897	26.674	-.38	33	.353
(time)	G2	17	33.5961	17.523			
Trails B	G1	18	52.3681	15.901	.35	33	.365
(error)	G2	17	50.6471	13.220			

G1 = Young group
G2 = Old group

Note: No significant differences at .05 one-tailed level of significance

TABLE F-11

Tactile-Perceptual Ability: Descriptive Statistics and T-Test Results for Median Age Variable

		N	Mean	Stdev	T	DF	Sig of T
Agnosia (dominant)	G1	18	26.1389	62.376	-1.26	20.02	.111
	G2	18	45.4444	18.659			
Agnosia (nondominant)	G1	18	44.1111	22.037	-1.01	34	.160
	G2	18	50.4444	15.038			
Dysgraphethesia (dominant)	G1	18	33.3493	21.059	2.17	19.68	.021*
	G2	18	-6.3005	74.787			
Dysgraphethesia (nondominant)	G1	18	24.3401	27.696	1.92	20.07	.034*
	G2	18	-19.1463	91.799			
Astereognosis (dominant)	G1	18	56.6056	11.314	-1.44	19.70	.083
	G2	18	60.5915	3.196			
Astereognosis (nondominant)	G1	18	52.9519	12.411	-1.12	34	.135
	G2	18	58.4259	16.642			

G1 - Young group
G2 - Old group

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE F-12

Academic Ability: Descriptive Statistics and T-Test Results for Median Age Variable

		N	Man	Stdev	T	DF	Sig of T
WRAT-R Spelling	G1	18	45.6296	10.957	1.06	34	.147
	G2	18	41.5556	12.002			
WRAT-R Arithmetic	G1	18	33.2222	10.201	-.59	34	.281
	G2	18	35.1852	9.890			
PIAT-Reading Recognition	G1	17	55.4118	9.709	1.37	33	.090
	G2	18	49.5185	14.996			
PIAT-Reading Comprehension	G1	18	46.1852	12.002	.88	34	.192
	G2	18	42.6667	12.007			

G1 = Young group
G2 = Old group

Note: No significant differences at .05 one-tailed level of significance

TABLE F-13

Behaviour and Social Competence: Descriptive Statistics and T-Test Results for Median Age Variable

		N	Mean	Stdev	T	DF	Sig of T
<u>Communication</u>							
Receptive	G1	18	40.9987	33.291	-.30	34	.384
	G2	18	43.8889	24.608			
Expressive	G1	18	44.5167	9.320	1.05	34	.151
	G2	18	40.9428	11.113			
Written	G1	18	38.5933	10.492	2.00	34	.027*
	G2	18	30.2366	14.327			
<u>Daily Living Skills</u>							
Personal	G1	18	39.3248	27.569	.31	34	.380
	G2	18	36.5778	26.185			
Domestic	G1	18	34.8487	8.469	1.84	34	.037*
	G2	18	28.7114	11.292			
Community	G1	18	32.2566	19.900	-.12	24.23	.453
	G2	18	32.8699	9.403			

G1 - Young group
G2 - Old group

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE F-14

Behaviour and Social Competence: Descriptive Statistics and T-Test Results for Median Age Variable

		N	Mean	Stdev	T	DF	Sig of T
<u>Socialization</u>							
Interests	G1	18	45.1718	21.310	-.34	26.85	.366
	G2	18	47.1590	12.040			
Play	G1	18	44.0380	9.328	1.40	34	.086
	G2	18	38.6966	13.294			
Coping Skills	G1	18	48.2941	7.283	2.27	26.81	.015*
	G2	18	40.3527	12.925			

G1 - Young group
G2 - Old group

<u>Note</u>: All values represent one-tailed tests
* p<.05 ** p<.01 *** p<.001

TABLE F-15

Behaviour and Social Competence: Descriptive Statistics and T-Test Results for Median Age Variable

		N	mean	Stdev	T	DF	Sig of T
<u>Vineland Domains</u>							
Communication	G1	18	39.4444	9.807	2.64	34	.006**
	G2	18	31.0000	9.387			
Daily Living Skills	G1	18	35.5926	13.472	1.31	34	.099
	G2	18	29.6667	13.604			
Socialization	G1	18	44.5556	8.001	1.34	34	.095
	G2	18	40.2593	11.059			
Motor (estimated)	G1	18	19.6296	11.055	-.90	34	.187
	G2	18	24.0000	17.395			
Maladaptive	G1	18	49.9382	6.383	-.26	34	.399
	G2	18	50.5241	7.295			

G1 = Young group
G2 = Old group

<u>Note</u>: All values represent one-tailed tests
* *p*<.05 ** *p*<.01 *** *p*<.001

TABLE F-16

Behaviour and Social Competence: Descriptive Statistics and T-Test Results for Median Age Variable

		N	Mean	Stdev	T	DF	Sig of T
<u>Parent Achenbach</u>							
Social Competence	G1	16	32.9214	13.699	-.44	24	.333
	G2	10	35.1471	10.745			
Internalizing	G1	18	54.9575	12.867	-.10	32	.459
	G2	16	55.3599	9.040			
Externalizing	G1	18	51.3576	7.968	.40	32	.346
	G2	16	50.0787	10.664			
Total Problems	G1	18	55.0261	10.610	.02	32	.490
	G2	16	54.9362	11.351			

G1 = Young group
G2 = Old group

Note: No significant differences at .05 one-tailed level of significance

TABLE F-17

Behaviour and Social Competence: Descriptive Statistics and T-Test Results for Median Age Variable

		N	Mean	Stdev	T	DF	Sig of T
<u>Teacher's Achenbach</u>							
Social Competence	G1	12	40.5938	5.422	-.54	24	.297
	G2	14	42.0232	7.673			
Internalizing	G1	14	56.1316	7.415	-.06	17.34	.478
	G2	14	56.4218	17.886			
Externalizing	G1	14	51.5625	6.308	-.14	18.63	.445
	G2	14	52.1100	13.218			
Total Problems	G1	14	53.0358	7.042	-.22	17.25	.413
	G2	14	54.1441	17.176			

G1 = Young group
G2 = Old group

<u>Note</u>: No significant differences at .05 one-tailed level of significance

APPENDIX G

TABLE G-1

Intellectual Ability: Descriptive Statistics and T-Test Results for Complication Variable

		N	Mean	Stdev	T	DF	Sig of T
VIQ	G1	18	42.4815	10.277	.56	34	.290
	G2	18	40.7407	8.361			
PIQ	G1	18	36.4815	13.547	-1.27	34	.106
	G2	18	41.3333	8.847			
FSIQ	G1	18	38.7407	11.195	-.39	34	.348
	G2	18	40.000	7.629			
<u>Verbal Subtests</u>							
Information	G1	18	42.7778	13.346	.46	27.12	.325
	G2	18	41.1111	7.670			
Similarities	G1	18	44.8148	7.603	-.96	34	.171
	G2	18	47.4074	8.522			

G1 - History of Complications
G2 - No Complications

Note: No significant differences at .05 one-tailed level of significance

TABLE G-2

Intellectual Ability: Descriptive Statistics and T-Test Results for Complication Variable

		N	Mean	Stdev	T	DF	Sig of T
<u>Verbal Subtests</u>							
Arithmetic	G1	18	43.5185	7.625	.51	34	.308
	G2	18	42.2222	7.754			
Vocabulary	G1	18	43.8889	11.041	.93	34	.178
	G2	18	45.5556	10.369			
Comprehension	G1	18	45.1852	8.419	1.09	34	.141
	G2	18	42.0370	8.866			
Digit Span	G1	18	44.6296	9.438	.29	34	.388
	G2	18	43.7037	10.025			

G1 - History of Complications
G2 - No Complications

<u>Note</u>: No significant differences at .05 one-tailed level of significance

TABLE G-3

Intellectual Ability: Descriptive Statistics and T-Test Results for Complication Variable

		N	Mean	Stdev	T	DF	Sig of T
Performance Subtests							
Picture	G1	18	43.5185	12.445	-.90	34	.188
Completion	G2	18	46.8519	9.733			
Picture	G1	18	41.1111	11.716	-1.26	34	.107
Arrangement	G2	18	45.5556	9.218			
Block Design	G1	18	39.8148	12.756	-1.07	34	.145
	G2	18	43.7037	8.623			
Object	G1	18	39.2593	15.988	-.82	34	.207
Assembly	G2	18	43.1481	12.017			
Coding	G1	18	34.0741	11.522	-1.22	34	.115
	G2	18	38.1481	8.183			

G1 = History of Complications
G2 = No Complications

Note: No significant differences at .05 one-tailed level of significance

TABLE G-4

Language Ability: Descriptive Statistics and T-Test results
for Complication Variable

		N	Mean	Stdev	T	DF	Sig of T
Language							
Peabody Picture	G1	18	46.0741	11.822	.47	34	.322
Vocabulary Test	G2	18	44.2593	11.561			
Expressive	G1	18	39.9632	11.103	-.48	34	.318
One-Word Test	G2	18	41.6296	9.796			
Fluency	G1	18	39.0437	11.662	.94	34	.176
	G2	18	35.5992	10.213			
Token	G1	17	53.5209	11.047	-.01	33	.495
	G2	18	53.5720	15.410			

G1 = History of Complications
G2 = No Complications

Note: No significant differences at the .05 one-tailed level of significance

TABLE G-5

Memory Ability: Descriptive Statistics and T-Test Results for Complication Variable

		N	Mean	Stdev	T	DF	Sig of T
Verbal Memory							
VSRT[1] - Recall	G1	9	15.1131	22.115	-.53	15	.300
	G2	8	21.3492	26.060			
VSRT - Long Term Storage	G1	18	12.1445	23.908	-1.44	34	.079
	G2	18	23.4232	22.928			
VSRT - Consistent Retrieval	G1	18	29.7911	12.172	-1.15	34	.130
	G2	18	34.8702	14.327			
Sentence Memory	G1	18	43.4221	13.687	.77	34	.222
	G2	18	40.4030	9.341			

G1 = History of Complications
G2 = No Complications

Note: No significant differences at .05 one-tailed level of significance

[1]VSRT = Verbal Selective Reminding Test

TABLE G-6

Memory Ability: Descriptive Statistics and T-Test Results for Complication Domain

		N	Mean	Stdev	T	DF	Sig of T
Nonverbal Memory							
NVSRT[1] - Recall	G1	18	32.5094	11.258	.16	34	.435
	G2	18	31.8816	11.624			
NVSRT - Long Term Recall	G1	18	31.0604	10.909	-.39	34	.349
	G2	18	32.5753	12.362			
NVSRT-Consistent Retrieval	G1	18	31.5784	6.808	-.94	34	.176
	G2	18	33.6582	6.412			
Rey-Figure Recall	G1	18	26.9742	11.369	-.80	34	.213
	G2	18	29.9972	11.207			
Rey-Figure Reorganization	G1	18	33.1739	6.795	-.35	34	.366
	G2	18	33.8612	5.013			

G1 = History of Complications
G2 = No Complications

<u>Note</u>: No significant differences at .05 one-tailed level of significance

[1]NVSRT = Nonverbal Selective Reminding Test

TABLE G-7

Construction and Problem-Solving Abilities:
Descriptive Statistics and T-Test Results for Complication Variable

		N	Mean	Stdev	T	DF	Sig of T
<u>Construction</u>							
DTVMI[1]	G1	18	33.8889	11.333	.30	34	.383
	G2	18	32.7778	10.922			
Rey-Figure Copy	G1	18	44.0712	9.588	-1.69	34	.050
	G2	18	48.9002	7.440			
Rey-Figure Organization	G1	18	33.9513	8.853	-.54	34	.295
	G2	18	35.5735	9.092			
<u>Problem-Solving</u>							
Halstead Category	G1	18	32.5674	15.949	-.76	34	.226
	G2	18	36.2964	13.409			

G1 - History of Complications
G2 - No Complications

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

[1]DTVMI - Developmental Test of Visual-Motor Integration

TABLE G-8

Attention: Descriptive Statistics and T-Test Results for Complication Variable

		N	Mean	Stdev	T	DF	Sig of T
CPT	G1	17	26.0630	29.349	-.41	25.36	.344
Omission errors	G2	17	31.9015	51.636			
CPT	G1	17	21.4326	44.432	-.69	32	.247
Commission Errors	G2	17	30.8464	34.198			
Underlining	G1	17	27.3077	10.460	-1.77	32	.043*
Subtest 1	G2	17	33.7500	10.741			
Underlining	G1	16	21.4586	14.478	-2.08	31	.022*
Subtest 2	G2	17	30.8401	11.271			
Underlining	G1	16	41.7803	9.128	-.18	31	.428
Subtest 4	G2	17	42.3170	7.737			
Underlining	G1	16	33.7345	7.789	-.66	31	.255
Subtest 5	G2	17	35.9006	10.624			

G1 - History of Complications
G2 - No Complications

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

[1]CPT - Continuous Performance Test

TABLE G-9

Motor Ability: Descriptive Statistics and T-Test Results for Complication Variable

		N	Mean	Stdev	T	DF	Sig of T
Finger-Tapping (dominant)	G1	18	49.0934	18.241	-.52	34	.304
	G2	18	52.1758	17.432			
Finger-Tapping (nondominant)	G1	18	44.4315	13.196	-2.40	34	.011**
	G2	18	54.9176	13.000			
Pegs (dominant)	G1	18	-6.1826	58.212	-1.85	22.49	.038*
	G2	18	21.1645	23.704			
Pegs (nondominant)	G1	17	-27.2763	90.867	-1.70	20.99	.052
	G2	18	13.0148	37.268			
Trails A (time)	G1	18	28.7000	28.830	-.91	22.78	.187
	G2	17	35.3810	11.775			
Trails A (error)	G1	18	44.9074	23.492	-2.23	23.71	.018*
	G2	17	58.4706	10.405			
Trails B (time)	G1	18	27.1905	27.007	-1.37	27.27	.091
	G2	17	37.3011	15.389			
Trails B (error)	G1	18	55.7685	19.036	1.89	18.83	.037*
	G2	17	47.0466	4.296			

G1 = History of Complications
G2 = No Complications

Note: All values represent one-tailed tests
* $p<.01$ ** $p<.01$ *** $p<.001$

TABLE G-10

Tactile-Perceptual Ability: Descriptive Statistics and T-Test Results for Complication Variable

		N	Mean	Stdev	T	DF	Sig of T
Agnosia (dominant)	G1	18	35.0556	31.461	-.09	26.02	.463
	G2	18	36.5278	58.696			
Agnosia (non-dominant)	G1	18	48.3704	16.053	.34	34	.367
	G2	18	46.1852	21.743			
Dysgraphethesia (dominant)	G1	18	3.5399	74.296	-1.04	23.72	.155
	G2	18	23.5090	33.733			
Dysgraphethesia (nondominant)	G1	18	-14.4843	89.217	-1.48	23.64	.076
	G2	18	19.6780	40.220			
Astereognosis (dominant)	G1	18	55.9883	11.471	-1.93	17.16	.035*
	G2	18	61.2089	.776			
Astereognosis (nondominant)	G1	18	54.9658	13.349	-.29	34	.386
	G2	18	56.4120	16.356			

G1 - History of Complications
G2 - No Complications

Note: All values represent one-tailed tests
* $p<.05$ *** $p<.01$ *** $p<.001$

TABLE G-11

Academic Ability: Descriptive Statistics
and T-Test Results for Complication Variable

		N	Mean	Stdev	T	DF	Sig of T
WRAT-R	G1	18	41.8148	11.576	-.92	34	.181
Spelling	G2	18	45.3704	11.498			
WRAT-R	G1	18	32.4074	9.428	-1.09	34	.142
Arithmetic	G2	18	36.0000	10.401			
PIAT-Reading	G1	18	51.7778	14.242	-.28	33	.390
Recognition	G2	17	53.0196	11.655			
PIAT-Reading	G1	18	45.3704	13.848	.47	34	.321
Comprehension	G2	18	43.4815	10.055			

G1 - History of Complications
G2 - No Complications

Note: No significant differences at .05 one-tailed level of significance

TABLE G-12

Vineland Adaptive Behaviour Domains: Descriptive Statistics and T-Test Results for Complication Variable

		N	Mean	Stdev	T	DF	Sig of T
Communication	G1	18	34.5556	9.142	-.38	34	.353
	G2	18	35.8889	11.727			
Daily Living	G1	18	29.8889	16.501	-1.21	27.75	.118
Skills	G2	18	35.3704	9.847			
Socialization	G1	18	40.8519	11.403	-.96	34	.173
	G2	18	43.9630	7.806			
Motor (estimated)	G1	18	19.1852	14.026	-1.09	34	.142
	G2	18	24.4444	14.951			
Maladaptive	G1	18	51.7145	8.439	1.33	25.19	.097
	G2	18	48.7478	4.275			

G1 - History of Complications
G2 - No Complications

Note: No significant differences at .05 one-tailed level of significance

TABLE G-13

Vineland Subdomains: Descriptive Statistics and T-Test Results for Complication Variable

		N	Mean	Stdev	T	DF	Sig of T
<u>Communication</u>							
Receptive	G1	18	33.4788	39.198	-1.93	17.26	.035*
	G2	18	51.4087	3.400			
Expressive	G1	18	40.4533	10.129	-1.35	34	.093
	G2	18	45.0062	10.176			
Written	G1	18	34.6641	11.564	.11	34	.455
	G2	18	34.1658	14.780			
<u>Daily Living Skills</u>							
Personal	G1	18	31.6798	31.304	-1.44	34	.079
	G2	18	44.2228	19.660			
Domestic	G1	18	30.1114	10.451	-.97	34	.169
	G2	18	33.4487	10.202			
Community	G1	18	29.0829	18.442	-1.38	27.59	.089
	G2	18	36.0436	10.902			

G1 = History of Complications
G2 = No Complications

<u>Note</u>: All values represent one-tailed values
* *p*<.05 ** *p*<.01 *** *p*<.001

TABLE G-14

Vineland Subdomains: Descriptive Variables
and T-Test Results for Complication Variable

		N	Mean	Stdev	T	DF	Sig of T
<u>Socialization</u>							
Interests	G1	18	44.2864	23.726	-.65	18.85	.260
	G2	18	48.0444	5.548			
Play	G1	18	39.8072	13.691	-.80	34	.214
	G2	18	42.9274	9.287			
Coping Skills	G1	18	42.2682	12.781	-1.12	34	.136
	G2	18	46.3786	9.011			

G1 - History of Complications
G2 - No Complications

<u>Note</u>: No significant differences at .05 one-tailed level of significance

TABLE G-15

Behaviour and Social Competence: Descriptive Statistics and T-Test Results for Complication Variable

		N	Mean	Stdev	T	DF	Sig of T
Parent Achenbach							
Social Competence	G1	12	31.4120	12.516	-.89	24	.190
	G2	14	35.8050	12.517			
Internalization	G1	17	57.2298	12.302	1.10	32	.139
	G2	17	53.0639	9.595			
Externalizing	G1	17	52.1317	11.741	.87	23.26	.197
	G2	17	49.3799	5.750			
Total Problems	G1	17	57.0478	13.654	1.12	23.28	.137
	G2	17	52.9197	6.702			

G1 = History of Complications
G2 = No Complications

Note: No significant differences at .05 one-tailed level of significance

TABLE G-16

Behaviour and Social Competence: Descriptive Statistics
and T-Test Results for Complication Variable

		N	Mean	Stdev	T	DF	Sig of T
<u>Teacher's Achenbach</u>							
Social Competence	G1	13	41.7961	7.373	.33	24	.373
	G2	13	40.9309	6.080			
Internalizing	G1	15	57.9070	15.358	.68	26	.250
	G2	13	54.3956	11.129			
Externalizing	G1	15	53.3083	12.800	.82	26	.210
	G2	13	50.1377	5.965			
Total Problems	G1	15	55.1487	15.894	.68	26	.251
	G2	13	51.7914	8.529			

G1 - History of Complications
G2 - No Complications

<u>Note</u>: No significant differences at .05 one-tailed level of significance

APPENDIX H

TABLE H-1

Intellectual Ability: Descriptive Statistics and T-Test Results for Ocular Variable

		N	Mean	Stdev	T	DF	Sig of T
VIQ	G1	25	40.7200	8.821	-.87	34	.196
	G2	11	43.6364	10.385			
PIQ	G1	25	36.6400	12.042	-1.84	34	.037*
	G2	11	44.0606	8.725			
FSIQ	G1	25	37.7600	9.487	-1.57	34	.062
	G2	11	43.0303	8.730			
<u>Verbal Subtests</u>							
Information	G1	25	40.4000	9.580	-1.31	34	.099
	G2	11	45.4545	12.847			
Similarities	G1	25	46.2667	8.731	.17	34	.432
	G2	11	45.7576	6.682			
Arithmetic	G1	25	41.8667	7.270	-1.20	34	.119
	G2	11	45.1515	8.214			
Vocabulary	G1	25	40.8000	9.684	-1.21	34	.117
	G2	11	45.4545	12.585			

G1 - Ocular Abnormalities
G2 - No Ocular Abnormalities

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE H-2

Intellectual Ability: Descriptive Statistics
and Z-test Results for Ocular Variable

		N	Mean	Stdev	T	DF	Sig of T
<u>Verbal Subtests</u>							
Comprehension	G1	25	43.8667	8.481	.26	34	.397
	G2	11	43.0303	9.482			
Digit Span	G1	25	44.6667	10.541	.47	34	.322
	G2	11	43.0303	7.372			
<u>Performance Subtests</u>							
Picture Completion	G1	25	43.3333	11.587	-1.53	34	.067
	G2	11	49.3939	9.167			
Picture Arrangement	G1	25	40.9333	11.284	-2.14	34	.019*
	G2	11	48.7879	6.544			
Block Design	G1	25	40.0000	11.785	-1.48	34	.073
	G2	11	45.7576	7.614			
Object Assembly	G1	25	[illegible].3333	13.944	-1.21	34	.117
	G2	11	45.4545	14.085			
Coding	G1	25	34.9333	10.098	-1.06	34	.148
	G2	11	38.7879	9.919			

G1 = Ocular Abnormalities
G2 = No Ocular Abnormalities

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE H-3

Language Ability: Descriptive Statistics
and T-Test Results for Ocular Variable

		N	Mean	Stdev	T	DF	Sig of T
Peabody Picture	G1	25	44.4800	12.581	-.53	34	.299
Vocabulary Test	G2	11	46.7273	9.167			
Expressive							
One-Word	G1	25	38.1333	9.557	-2.49	34	.009**
Vocabulary	G2	11	46.8485	9.898			
Fluency	G1	25	38.1429	7.578	.51	11.87	.308
	G2	11	35.4545	16.610			
Token	G1	24	51.0942	13.220	-1.66	33	.053
	G2	11	58.8989	12.291			

G1 = Ocular Abnormalities
G2 = No Ocular Abnormalities

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE H-4

Memory Ability: Descriptive Statistics and T-Test Results for Ocular Variable

		N	Mean	Stdev	T	DF	Sig of T
Verbal Memory							
VSRT[1] - Recall	G1	12	15.0463	23.512	-.81	15	.216
	G2	5	25.2511	24.404			
VSRT - Long Term Storage	G1	25	12.4229	23.339	-2.14	34	.020*
	G2	11	29.9678	20.918			
VSRT-Consistent Retrieval	G1	25	28.9453	10.530	-2.45	34	.009**
	G2	11	40.0245	16.253			
Sentence Memory	G1	25	42.7438	11.904	.64	34	.263
	G2	11	40.0234	11.371			
Nonverbal Memory							
NVSRT[2] - Recall	G1	25	31.3767	11.903	-.65	34	.259
	G2	11	34.0566	9.998			
NVSRT - LTS	G1	25	29.8012	10.789	-1.62	34	.057
	G2	11	36.4012	12.310			

G1 = Ocular Abnormalities
G2 = No Ocular Abnormalities

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

[1]VSRT = Verbal Selective Reminding Test
[2]NVSRT = Nonverbal Selective Reminding Test

TABLE H-5

Memory Ability: Descriptive Statistics and T-Test Results for Ocular Variable

		N	Mean	Stdev	T	DF	Sig of T
<u>Nonverbal Memory</u>							
NVSRT[1]-Consistent	G1	25	31.6433	6.576	-1.35	34	.092
Retrieval	G2	11	34.8342	6.404			
Rey-Figure	G1	25	25.9038	8.932	-2.19	34	.018*
Recall	G2	11	34.3537	13.980			
Rey-Figure	G1	25	32.5110	5.273	-1.58	34	.062
Reorganization	G2	11	35.8052	6.828			

G1 - Ocular Abnormalities
G2 - No Ocular Abnormalities

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

[1]NVSRT - Nonverbal Selective Reminding Test

TABLE H-6

Construction and Problem-Solving Abilities: Descriptive Statistics and T-Test Results for Ocular Variable

		N	Mean	Stdev	T	DF	Sig of T
Construction							
DTVMI[1]	G1	25	31.8667	10.762	-1.22	34	.116
	G2	11	36.6667	11.255			
Rey-Figure	G1	25	44.5264	8.751	-2.11	34	.021*
Copy	G2	11	50.9386	7.493			
Rey-Figure	G1	25	33.2784	8.448	-1.54	34	.066
Organization	G2	11	38.1351	9.319			
Problem-Solving							
Halstead	G1	25	33.6588	15.882	-.47	34	.320
Category	G2	11	36.1890	11.847			

G1 = Ocular Abnormalities
G2 = No Ocular Abnormalities

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

[1]DTVMI = Developmental Test of Visualmotor Integration

TABLE H-7

Attention: Descriptive Statistics and T-Test Results for Domain for Ocular Variable

		N	Mean	Stdev	T	DF	Sig of T
CPT[1] Omission Errors	G1	25	23.2672	46.528	-2.06	31.77	.024*
	G2	9	44.8571	14.541			
CPT Commission Errors	G1	25	30.5697	36.788	1.10	32	.140
	G2	9	13.8334	45.713			
Underlining Subtest 1	G1	24	29.8476	10.650	-.56	32	.291
	G2	10	32.1639	12.030			
Underlining Subtest 2	G1	23	24.4053	14.310	-1.22	31	.116
	G2	10	30.6297	11.191			
Underlining Subtest 4	G1	23	41.8536	7.603	-.21	31	.417
	G2	10	42.5242	10.192			
Underlining Subtest 5	G1	23	35.6298	9.045	.73	31	.236
	G2	10	33.0577	10.048			

G1 - Ocular Abnormalities
G2 - No Ocular Abnormalities

[1]CPT - Continuous Performance Test

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE H-8

Motor Ability: Descriptive Statistics
and T-Test Results for Ocular Variable

		N	Mean	Stdev	T	DF	Sig of T
Finger Tapping (dominant)	G1	25	50.8457	17.887	.11	34	.458
	G2	10	50.1548	17.959			
Finger Tapping (nondominant)	G1	25	48.1628	14.453	-.98	34	.167
	G2	10	53.1104	12.737			
Pegs (dominant)	G1	25	-2.0560	50.225	-2.49	33.47	.009**
	G2	10	29.0249	24.533			
Pegs (nondominant)	G1	24	-20.0696	80.982	-2.40	29.54	.011*
	G2	10	22.9308	22.646			
Trails A Time	G1	25	28.7042	24.404	-1.78	29.91	.043*
	G2	10	40.0471	13.024			
Trails A Error	G1	25	48.0800	20.933	-1.70	33	.049*
	G2	10	60.0333	1[illegible].479			
Trails B Time	G1	25	28.2260	23.580	-1.66	33	.053
	G2	10	41.7899	16.410			
Trails B Error	G1	25	51.8550	16.319	.21	33	.419
	G2	10	50.7250	8.944			

G1 - Ocular Abnormalities
G2 - No Ocular Abnormalities

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE H-9

Tactile-Perceptual Ability: Descriptive Statistics and T-Test Results for Ocular Variable

		N	Mean	Stdev	T	DF	Sig of T
Agnosia (dominant)	G1	25	27.3800	53.000	-2.39	30.98	.011*
	G2	11	54.9091	14.869			
Agnosia (nondominant)	G1	25	43.9200	21.525	-2.32	31.67	.013*
	G2	11	54.9091	6.472			
Dysgraphethesia (dominant)	G1	25	11.2073	66.245	-.46	33.24	.325
	G2	11	18.7905	33.182			
Dysgraphethesia (nondominant)	G1	25	-5.0503	81.612	-1.35	33.31	.093
	G2	11	19.9769	29.462			
Astereognosis (dominant)	G1	25	57.4837	9.962	-1.81	24.99	.041*
	G2	11	61.1325	.955			
Astereognosis (nondominant)	G1	25	52.5000	16.715	-3.05	26.21	.002**
	G2	11	62.9365	2.427			

G1 = Ocular Abnormalities
G2 = No Ocular Abnormalities

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE H-10

Academic Ability: Descriptive Statistics
and T-Test Results for Ocular Variable

		N	Mean	Stdev	T	DF	Sig of T
WRAT-T	G1	25	42.4800	11.267	-.87	34	.195
Spelling	G2	11	46.1212	12.212			
WRAT-K	G1	25	32.8800	10.126	-1.21	34	.117
Arithmetic	G2	11	37.2121	9.285			
PIAT-Reading	G1	25	52.8267	11.869	.32	33	.375
Recognition	G2	10	51.2667	15.765			
PIAT-Reading	G1	25	46.1067	9.925	1.28	34	.104
Comprehension	G2	11	40.6061	15.542			

G1 - Ocular Abnormalities
G2 - No Ocular Abnormalities

Note: No significant differences at .05 one-tailed level of significance

TABLE H-11

Vineland Adaptie Behaviour Scale: Descriptive Statistics and T-Test Results for Ocular Variable

		N	Mean	Stdev	T	DF	Sig of T
Communication	G1	25	35.2267	9.880	.00	34	.498
	G2	11	35.2121	11.965			
Daily Living Skills	G1	25	31.0133	14.092	-1.07	34	.146
	G2	11	36.3030	12.520			
Socialization	G1	25	41.4400	9.846	-.89	34	.189
	G2	11	44.6061	9.645			
Motor (estimated)	G1	25	16.6400	9.919	-3.10	13.15	.004**
	G2	11	33.5758	16.856			
Maladaptive	G1	25	51.3108	7.229	1.47	34	.075
	G2	11	47.7774	5.009			

G1 - Ocular Abnormalities
G2 - No Ocular Abnormalities

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE H-12

Vineland Adaptive Scale: Descriptive Statistics
and T-test Results for Ocular Variable

		N	Mean	Stdev	T	DF	Sig of T
<u>Communication</u>							
Receptive	G1	25	38.8810	34.170	-1.68	25.37	.052
	G2	11	50.5411	3.871			
Expressive	G1	25	40.8908	10.140	-1.66	34	.053
	G2	11	46.9091	9.731			
Written	G1	25	35.5782	11.168	.80	34	.214
	G2	11	31.7712	16.986			
<u>Daily Living Skills</u>							
Personal	G1	25	34.6731	27.675	-1.12	34	.135
	G2	11	45.4018	23.205			
Domestic	G1	25	30.2161	11.397	-1.39	34	.087
	G2	11	35.3344	5.391			
Community	G1	25	32.1813	13.970	-.22	34	.413
	G2	11	33.4311	18.821			

G1 = Ocular Abnormalities
G2 = No Ocular Abnormalities

<u>Note</u>: All values represent one-tailed tests
* p<.05 ** p<.01 *** p<.001

TABLE H-13

Vineland Adaptive Scale: Descriptive Statistics and T-Test Results for Ocular Variables

		N	Mean	Stdev	T	DF	Sig of T
<u>Socialization</u>							
Interest	G1	25	44.0801	19.352	-1.42	33.55	.081
	G2	11	50.9048	9.361			
Play	G1	25	41.1651	12.195	-.15	34	.439
	G2	11	41.8268	10.807			
Coping Skills	G1	25	43.3143	11.998	-.82	34	.209
	G2	11	46.6168	8.782			

G1 - Ocular Abnormalities
G2 - No Ocular Abnormalities

<u>Note</u>: No significant differences at .05 one-tailed level of significance

TABLE H-14

Behaviour and Social Competence: Descriptive Statistics and T-Test Results for Ocular Variable

		N	Mean	Stdev	T	DF	Sig of T
<u>Parent Achenbach</u>							
Social Competence	G1	18	30.5112	11.877	-2.14	24	.021*
	G2	8	41.1264	11.101			
Internalization	G1	24	56.0241	12.535	.92	30.45	.183
	G2	10	53.0416	6.370			
Externalizing	G1	24	51.6695	10.477	1.19	31.56	.122
	G2	10	48.5630	4.790			
Total Problems	G1	24	56.2077	12.375	1.42	31.93	.083
	G2	10	52.0464	4.737			

G1 - Ocular Abnormalities
G2 - No Ocular Abnormalities

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE H-15

Behaviour and Social Competence: Descriptive Statistics and T-Test Result for Ocular Variable

		N	Mean	Stdev	T	DF	Sig of T
<u>Teacher Achenbach</u>							
Social Competence	G1	18	39.7924	6.869	-1.90	24	.034*
	G2	8	44.8935	4.711			
Internalizing	G1	20	58.2022	14.584	1.21	26	.118
	G2	8	51.4630	9.053			
Externalizing	G2	20	52.9082	11.386	.88	26	.194
	G2	8	49.1565	5.942			
Total Problems	G1	20	55.4363	14.307	1.21	26	.119
	G2	8	48.9740	7.179			

G1 - Ocular Abnormalities
G2 - No Ocular Abnormalities

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

APPENDIX I

TABLE I-1

Intellectual Ability: Descriptive Statistics and T-Test Results
For Lesion Variable L2 or Above vs S1 or Below

		N	Mean	Stdev	T	DF	Sig of T
VIQ	G1	9	39.4815	7.278	-1.64	19	.059
	G2	12	46.6667	11.512			
PIQ	G1	9	31.8519	6.026	-3.48	19	.001**
	G2	12	43.1667	8.205			
FSIQ	G1	9	34.5926	5.642	-2.66	19	.007**
	G2	12	44.3333	9.800			
Verbal Subtests							
Information	G1	9	38.5185	9.590	-1.41	19	.087
	G2	12	46.1111	13.841			
Similarities	G1	9	44.8148	9.590	-1.49	19	.076
	G2	12	50.0000	6.356			

G1 = L2 or above
G2 = S1 or below

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE I-2

Intellectual Ability: Descriptive Statistics and T-Test Results
for Lesion Variables L2 or Above vs S1 or Below

<u>Verbal Subtests</u>	N	Mean	Stdev	T	DF	Sig of T
Arithmetic	9	41.1111	6.236	-1.65	19	.058
	12	46.6667	8.528			
Vocabulary	9	42.2222	9.574	-.77	19	.225
	12	46.3889	13.887			
Comprehension	9	41.4815	8.352	-1.44	19	.083
	12	47.7778	10.948			
Digit Span	9	44.4444	11.055	-.36	19	.362
	12	46.1111	10.134			

G1 = L2 or above
G2 = S1 or below

<u>Note</u>: No significant differences at .05 one-tailed level of significance

TABLE I-3

Intellectual Ability: Descriptive Statistics and T-Test Results
for Lesion Variable L2 or Above vs S1 or Below

<u>Performance Subtests</u>		N	Mean	Stdev	T	DF	Sig of T
Picture Completion	G1	9	38.1481	7.286	-3.36	19	.001**
	G2	12	48.6111	6.884			
Picture Arrangement	G1	9	37.4074	6.620	-4.55	19	.000***
	G2	12	51.6667	7.454			
Block Design	G1	9	36.2963	8.571	-2.19	19	.020*
	G2	12	44.4444	8.328			
Object Assembly	G1	9	33.7037	8.571	-1.80	19	.044*
	G2	12	42.2222	12.088			
Coding	G1	9	35.5556	7.817	-.28	19	.389
	G2	12	36.6667	9.535			

G1 – L2 or above
G2 – S1 or below

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE I-4

Language Ability: Descriptive Statistics and T-Tests for Lesion Variable
L2 or Above vs S1 or Below

		N	Mean	Stdev	T	DF	Sig of T
Peabody Picture	G1	9	43.4815	12.192	-1.21	19	.120
Vocabulary	G2	12	49.9444	12.049			
Expressive	G1	9	37.0370	9.581	-1.70	19	.052
One-Word Test	G2	12	44.8333	10.918			
Fluency	G1	9	40.8095	8.939	.50	19	.310
	G2	12	38.1696	13.622			
Token	G1	9	49.5396	17.669	-.93	18	.183
	G2	11	55.7175	12.121			

G1 = L2 or above
G2 = S1 or below

Note: No significant differences at .05 one-tailed level of significance

TABLE I-5

Memory Ability: Descriptive Statistics and T-Test Results for Lesion Variable L2 or Above vs S1 or Below

		N	Mean	Stdev	T	DF	Sig of T
<u>Verbal Memory</u>							
VSRT[1] - Recall	G1	3	7.4576	19.983	-.77	6	.235
	G2	5	21.4133	26.946			
VSRT - Long Term Storage	G1	9	16.0494	24.584	-.36	19	.361
	G2	12	19.9322	24.172			
VSRT-Consistent Retrieval	G1	9	30.3235	12.776	-.66	19	.260
	G2	12	34.6536	16.379			
Sentence Memory	G1	9	37.1071	12.185	-1.32	19	.100
	G2	12	44.7858	13.827			

G1 = L2 or above
G2 = S1 or below

<u>Note</u>: No significant differences at .05 one-tailed level of significance

[1]VSRT = Verbal Selective Reminding Test

TABLE I-6

Memory Ability: Descriptive Statistics and T-Test Results for Lesion Variable L2 or Above or S1 and Below

Nonverbal Memory		N	Mean	Stdev	T	DF	Sig of T
NVSRT[1] - Recall	G1	9	32.1430	13.515	-.51	19	.308
	G2	12	34.7568	10.098			
NVSRT - Long Term Storage	G1	9	32.4496	12.376	-.11	19	.456
	G2	12	33.0614	12.365			
NVSRT-Consistent Retrieval	G1	9	32.7866	7.247	.02	19	.492
	G2	12	32.7297	6.373			
Rey-Figure Recall	G1	9	28.0437	9.909	-.33	19	.374
	G2	12	29.6877	12.408			
Rey-Figure Reorganization	G1	9	31.7815	4.906	-1.21	19	.121
	G2	12	35.0266	6.845			

G1 = L2 or above
G2 = S1 or below

Note: No significant differences at .05 one-tailed level of significance

[1]NVSRT = Nonverbal Selective Reminding Test

TABLE I-7

Construction and Problem-Solving Abilities: Descriptive Statistics and T-Test Results for Lesion Variables L2 or Above or S1 and Below

		N	Mean	Stdev	T	DF	Sig of T
<u>Construction</u>							
DTVMI[1]	G1	9	31.1111	9.718	-1.57	19	.067
	G2	12	38.3333	10.964			
Rey-Figure Copy	G1	9	44.2598	6.788	-.98	19	.168
	G2	12	47.9304	9.489			
Rey-Figure Organization	G1	9	35.1089	9.282	-.53	19	.302
	G2	12	37.1674	8.538			
<u>Problem-Solving</u>							
Halstead Category	G1	9	26.6676	10.729	-2.67	19	.007**
	G2	12	41.8307	14.210			

G1 = L2 or above
G2 = S1 or below

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

[1]DTVMI = Developmental Test of Visuomotor Integration

TABLE I-8

Attention: Descriptive Statistics and T-Test Results for Lesion variable L2 or Above or S1 and Below

		N	Mean	Stdev	T	DF	P
CPT[1] Omission Errors	G1	9	42.3913	17.568	-.10	18	.460
	G2	11	43.1581	16.380			
CPT Commission Errors	G1	9	46.0884	6.816	1.83	10.57	.047*
	G2	11	21.1807	44.453			
Underlining Subtest 1	G1	9	30.9875	9.323	.21	18	.419
	G2	11	30.1533	8.650			
Underlining Subtest 2	G1	9	25.1994	11.670	.02	18	.493
	G2	11	25.0983	14.627			
Underlining Subtest 4	G1	9	37.7726	8.504	-.78	18	.223
	G2	11	40.9516	9.519			
Underlining Subtest 5	G1	9	33.5297	4.433	-.06	14.05	.477
	G2	11	33.7351	10.424			

G1 = L2 or above
G2 = S1 or below

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

[1]CPT = Continuous Performance Test

TABLE I-9

Motor Ability: Descriptive Statistics and T-Test Results
for Lesion Variable L2 or Above or S1 and Below

		N	Mean	Stdev	T	DF	Sig of T
Finger-Tapping	G1	9	45.2565	19.497	-1.51	19	.074
(dominant)	G2	12	56.3449	14.242			
Finger-Tapping	G1	9	47.8641	13.773	-.94	19	.180
(nondominant)	G2	12	53.5144	13.646			
Pegs	G1	9	-.1090	30.884	-1.04	19	.155
(dominant)	G2	12	13.7875	29.754			
Pegs	G1	9	6.8370	26.872	.39	19	.349
(nondominant)	G2	12	.2785	43.954			

G1 = L2 or above
G2 = S1 or below

<u>Note</u>: No significant differences at .05 one-tailed level of significance

TABLE I-10

Motor Ability: Descriptive Statistics and T-Test Results for Lesion Variables L2 or Above or S1 and Below

	N	Mean	Stdev	T	DF	Sig of T
Trails A	9	30.4426	7.243	-1.59	19	.064
(time)	12	36.7477	10.102			
Trails A	9	60.7778	11.918	1.45	19	.081
(error)	12	54.8056	6.886			
Trails B	9	32.0942	13.142	-.91	19	.187
(time)	12	37.5014	13.703			
Trails B	9	51.1574	16.936	.41	10.44	.344
(error)	12	48.6597	7.624			

G1 - L2 or above
G2 - S1 or below

Note: No significant differences at .05 one-tailed level of significance

TABLE I-11

Tactile-Perceptual Ability: Descriptive Statistics and T-Test Results for Lesion Levels L2 or Above vs S1 or Below

	N	Mean	Stdev	T	DF	Sig of T
Agnosia	9	16.5556	83.846	-1.20	8.45	.130
(dominant)	12	50.6667	16.143			
Agnosia	9	43.5556	27.097	-.77	11.36	.229
(nondominant)	12	51.1667	14.358			
Dysgraphethesia	9	5.3405	106.014	-.14	9.31	.445
(dominant)	12	10.5687	34.946			
Dysgraphethesia	9	-6.7940	110.214	-.22	19	.414
(nondominant)	12	1.5388	64.047			
Astereognosis	9	60.3191	3.237	-.72	8.71	.244
(dominant)	12	61.1151	.788			
Astereognosis	9	62.4272	3.713	1.48	12.05	.082
(nondominant)	12	53.8690	19.540			

G1 = L2 or above
G2 = S1 or below

Note: No significant differences at .05 one-tailed level of significance

TABLE I-12

Academic Ability: Descriptive Statistics and T-Test Results for Lesion Variable L2 or Above vs S1 or Below

		N	Mean	Stdev	T	DF	Sig of T
WRAT-R Spelling	G1	9	44.4444	11.935	-.69	19	.250
	G2	12	47.9444	11.315			
WRAT-R Arithmetic	G1	9	35.8519	7.787	-.42	19	.341
	G2	12	37.5556	10.270			
PIAT-Reading Recognition	G1	9	52.1481	14.556	.15	18	.442
	G2	11	51.1515	15.547			
PIAT-Reading Comprehension	G1	9	43.2593	6.267	.17	14.65	.432
	G2	12	42.3333	17.102			

G1 = L2 or above
G2 = S1 or below

Note: No significant differences at .05 one-tailed level of significance

TABLE I-13

Behaviour and Social Competence Domain: Descriptive Statistics and T-Test Results for Lesion Variable L2 or Above vs S1 or Below

Vineland Domains		N	Mean	Stdev	T	DF	Sig of T
Communication	G1	9	33.7037	11.762	-.80	19	.217
	G2	12	37.7222	11.128			
Daily Living Skills	G1	9	29.1852	17.571	-1.79	19	.045*
	G2	12	40.1111	10.335			
Socialization	G1	9	38.8889	8.048	-2.22	19	.019*
	G2	12	47.3889	9.107			
Motor	G1	9	14.5185	6.216	-3.67	14.88	.001**
	G2	12	33.4444	16.376			
Maladaptive	G1	9	52.6842	6.706	.87	19	.198
	G2	12	49.8945	7.700			

G1 = L2 or above
G2 = S1 or below

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE I-14

Behaviour and Social Competence Domain: Descriptive Statistics
and T-Test Results for lesion Variable L2 or Above vs S1 or Below

Vineland Subdomains		N	Mean	Stdev	T	DF	Sig of T
Communication							
Receptive	G1	9	48.4259	10.860	-.80	9.60	.220
	G2	12	51.4782	3.958			
Expressive	G1	9	43.4015	13.996	-.24	19	.405
	G2	12	44.7123	10.807			
Written	G1	9	35.1364	11.600	-.25	19	.403
	G2	12	36.4640	12.489			
Daily Living Skills							
Personal	G1	9	29.3255	33.105	-2.07	8.69	.035*
	G2	12	52.6067	7.893			
Domestic	G1	9	24.2975	12.163	-3.36	10.22	.003**
	G2	12	38.8097	5.214			

G1 = L2 or above
G2 = S1 or below

Note: All values represent one-tailed tests
* p<.05 ** p<.01 *** p<.001

TABLE I-15

Behavior and Social Competence Domain: Descriptive Statistics and T-Test Results for Lesion Variable L2 or Above vs S1 or Below

Vineland Subdomains		N	Mean	Stdev	T	DF	Sig of T
Daily Living Skills							
Community	G1	9	26.8963	13.645	-1.18	19	.125
	G2	12	35.5491	18.420			
Socialization							
Interests	G1	9	44.5347	11.563	-1.76	19	.047*
	G2	12	52.3341	8.813			
Play	G1	9	38.2673	8.039	-1.97	19	.031*
	G2	12	46.1836	9.815			
Coping Skills	G1	9	40.6614	12.638	-1.21	19	.121
	G2	12	46.8720	10.944			

G1 = L2 or above
G2 = S1 or below

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE I-16

Behaviour and Social Competence Domain: Descriptive Statistics and T-Test Results for Lesion Variable L1 or Above vs S1 or Below

Parent Achenbach		N	Mean	Stdev	T	DF	Sig of T
Social Competence	G1	7	30.3958	3.197	-3.82	8.21	.002**
	G2	8	46.6886	11.558			
Internalization	G1	7	58.8657	11.994	.59	17	.280
	G2	12	55.7725	10.363			
Externalizing	G1	7	49.4847	6.955	-.50	17	.310
	G2	12	51.9333	11.636			
Total Problems	G1	7	55.4313	7.220	-.26	17	.397
	G2	12	56.7918	12.326			

G1 = L2 or above
G2 = S1 or below

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE I-17

Behaviour and Social Competence Domain: Descriptive Statistics and T-Test Results for Lesion Variable L2 or Above vs S1 or Below

Teacher Achenbach		N	Mean	Stdev	T	DF	Sig of T
Social Competence	G1	5	38.8759	5.815	-1.03	14	.160
	G2	11	43.0672	8.136			
Internalization	G1	6	52.6433	12.304	-.80	15	.218
	G2	11	58.9713	17.010			
Externalizing	G1	6	50.3154	6.595	-.48	15	.320
	G2	11	53.0829	13.237			
Total Problems	G1	6	51.6544	9.013	-.52	15	.307
	G2	11	55.5393	17.046			

G1 = L2 or above
G2 = S1 or below

Note: No significant differences at .05 one-tailed level of significance

APPENDIX J

TABLE J-1

Intellectual Ability: Descriptive Statistics and T-Test Results for Lesion Variables L3-L5 vs S1 or Below

		N	Mean	Stdev	T	DF	Sig of T
VIQ	G1	15	38.8444	6.903	-2.19	25	.019*
	G2	12	46.6667	11.512			
PIQ	G1	15	39.7333	14.529	-.73	25	.236
	G2	12	43.1667	8.205			
FSIQ	G1	15	38.2667	9.650	-1.61	25	.059
	G2	12	44.3333	9.800			
<u>Verbal Subtests</u>							
Information	G1	15	40.6667	7.888	-1.21	16.58	.121
	G2	12	46.1111	13.841			
Similarities	G1	15	43.7778	7.650	-2.26	25	.016*
	G2	12	50.0000	6.356			

G1 = L3-L5
G2 = S1 or below

<u>Note</u>: All values represent one-tailed tests
* p<.05 ** p<.01 *** p<.001

TABLE J-2

Intellectual Ability: Descriptive Statistics and T-Test Results for Lesion Variables L3-L5 vs S1 or Below

<u>Verbal Subtests</u>		N	Mean	Stdev	T	DF	Sig of T
Arithmetic	G1	15	40.8889	6.839	-1.96	25	.031*
	G2	12	46.6667	8.528			
Vocabulary	G1	15	38.8889	7.418	-1.69	15.94	.055
	G2	12	46.3889	13.887			
Comprehension	G1	15	41.5556	5.616	-1.79	15.58	.046*
	G2	12	47.7778	10.948			
Digit Span	G1	15	42.4444	8.588	-1.02	25	.159
	G2	12	46.1111	10.134			

G1 = L3-L5
G2 = S1 or below

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE J-3

Intellectual Ability: Descriptive Statistics and T-Tests
for Lesion Levels L3-L5 vs S1 or Below

Performance Subtests		N	Mean	Stdev	T	DF	Sig of T
Picture	G1	15	46.6667	14.086	-.47	21.20	.322
Completion	G2	12	48.6111	6.884			
Picture	G1	15	40.2222	11.017	-3.07	25	.002**
Arrangement	G2	12	51.6667	7.454			
Block Design	G1	15	42.8889	13.206	-.35	25	.363
	G2	12	44.4444	8.328			
Object	G1	15	44.8889	16.944	.46	25	.325
Assembly	G2	12	42.2222	12.088			
Coding	G1	15	36.0000	12.097	-.16	25	.438
	G2	12	36.6667	9.535			

G1 = L3-L5
G2 = S1 or below

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE J-4

Language Ability: Descriptive Statistics and T-Tests for
Lesion Variables L3-L5 vs S1 or Below

		N	Mean	Stdev	T	DF	Sig of T
Peabody Picture	G1	15	42.3556	10.260	-1.77	25	.044*
Vocabulary Test	G2	12	49.9444	12.049			
Expressive	G1	15	39.8222	9.890	-1.25	25	.111
One-Word Test	G2	12	44.8333	10.918			
Fluency	G1	15	34.5500	9.557	-.81	25	.212
	G2	12	38.1696	13.622			
Token	G1	15	54.3601	11.391	-.29	24	.386
	G2	12	55.7175	12.121			

G1 - L3-L5
G2 - S1 or below

Note: All values represent one-tailed tests
* p<.05 ** p<.01 *** p<.001

TABLE J-5

Memory Ability: Descriptive Statistics and T-Test Results for Lesion Variable L3-L5 vs S1 or Below

Verbal Memory		N	Mean	Stdev	T	DF	Sig of T
VSRT - Recall	G1	9	19.7080	24.264	-.12	12	.452
	G2	5	21.4133	26.946			
VSRT - Long Term Storage	G1	15	17.1058	24.565	-.30	25	.383
	G2	12	19.9322	24.172			
VSRT - Consistent Retrieval	G1	15	31.6766	11.576	-.55	25	.292
	G2	12	34.6536	16.379			
Sentence Memory	G1	15	42.4972	9.053	-.52	25	.304
	G2	12	44.7858	13.827			

G1 = L3-L5
G2 = S1 or below

Note: No significant differences at .05 one-tailed level of significance

[1]VSRT = Verbal Selective Reminding Test

TABLE J-6

Memory Ability: Descriptive Statistics and T-Test Results for Lesion Levels L3-L5 vs S1 or Below

Nonverbal Memory		N	Mean	Stdev	T	DF	Sig of T
NVSRT[1] - Recall	G1	15	30.1780	11.152	-1.11	25	.138
	G2	12	34.7568	10.058			
NVSRT - Long Term Storage	G1	15	30.4439	10.967	-.58	25	.282
	G2	12	33.0614	12.365			
NVSRT-Consistent Retrieval	G1	15	32.4282	6.856	-.12	25	.454
	G2	12	32.7297	6 373			
Rey-Figure Recall	G1	15	27.7892	11 678	-.41	25	.343
	G2	12	29.6877	12.408			
Rey-Figure Reorganization	G1	15	33.3520	5.691	-.69	25	.247
	G2	12	35.0266	6 845			

G1 = L3-L5
G2 = S1 or below

Note: No significant differences at .05 one-tailed level of significance

[1]NVSRT = Nonverbal Selective Reminding Test

TABLE J-7

Construction and Problem-Solving Abilities: Descriptive Statistics and T-Tests for Lesion Variable L3-L5 vs S1 or below

		N	Mean	Stdev	T	DF	Sig of T
<u>Construction</u>							
DTVMI[1]	G1	15	30.6667	10.998	-1.80	25	.042*
	G2	12	38.3333	10.964			
Rey-Figure Copy	G1	15	46.6655	9.579	-.34	25	.367
	G2	12	47.9304	9.489			
Rey-Figure Organizations	G1	15	32.6305	8.990	-1.33	25	.097
	G2	12	37.1674	8.538			
<u>Problem-Solving</u>							
Halstead Category	G1	15	33.1715	14.978	-1.53	25	.069
	G2	12	41.8307	14.210			

G1 = L3-L5
G2 = S1 or below

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

[1]DTVMI = Developmental Test of Visuomotor Integration

TABLE J-8

Attention: Descriptive Statistics and T-Test Results
for Lesion Variables L3-L5 vs S1 or below

		N	Mean	Stdev	T	DF	Sig of T
CPT Omission	G1	14	9.2238	57.033	-2.12	15.65	.025*
Errors[1]	G2	11	43.1581	16.380			
CPT Commission	G1	14	17.2114	44.680	-.22	23	.413
Errors	G2	11	21.1807	44.453			
Underlining	G1	14	30.5291	13.874	.08	23	.469
Subtest 1	G2	11	30.1533	8.650			
Underlining	G1	13	28.0571	14.737	.49	22	.314
Subtest 2	G2	11	25.0983	14.627			
Underlining	G1	13	45.9580	5.391	1.62	22	.060
Subtest 4	G2	11	40.9516	9.519			
Underlining	G1	13	36.7084	10.941	.68	22	.252
Subtest 5	G2	11	33.7351	10.424			

G1 = L3-L5
G2 = S1 or below

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

[1]CPT = Continuous Performance Test

TABLE J-9

Motor Ability: Descriptive Statistics and T-Test Results
for Lesion Levels L3-L5 vs S1 or below

		N	Mean	Stdev	T	DF	Sig of T
Finger-Tapping	G1	15	49.2933	18.817	-1.07	25	.146
(dominant)	G2	12	56.3449	14.242			
Finger-Tapping	G1	15	47.6889	14.618	-1.06	25	.150
(nondominant)	G2	12	53.5144	13.646			
Pegs	G1	15	6.8936	63.002	-.37	20.83	.356
(dominant)	G2	12	13.7875	29.754			
Pegs	G1	14	-21.0218	102.949	-.70	18.15	.245
(nondominant)	G2	12	.2785	43.954			

G1 = L3-L5
G2 = S1 or below

<u>Note</u>: No significant differences at .05 one-tailed level of significance

TABLE J-10

Motor Ability: Descriptive Statistics and T-Test Results
for Lesion Levels L3-L5 vs S1 or below

		N	Mean	Stdev	T	DF	Sig of T
Trails A (time)	G1	14	28.7944	33.696	-.84	15.67	.206
	G2	12	36.7477	10.102			
Trails A (error)	G1	14	42.6905	26.418	-1.65	15.03	.059
	G2	12	54.8056	6.886			
Trails B (time)	G1	14	27.4774	31.606	-1.07	18.29	.148
	G2	12	37.5014	13.703			
Trails B (error)	G1	14	54.2351	17.506	1.08	18.33	.147
	G2	12	48.6597	7.624			

G1 = L3-L5
G2 = S1 or below

Note: No significant differences at .05 one-tailed level of significance

TABLE J-11

Tactile-Perceptual Ability: Descriptive Statistics and T-Test Results for Lesion Variables L3-L5 vs S1 or below

		N	Mean	Stdev	T	DF	Sig of T
Agnosia	G1	15	35.4333	27.150	-1.71	25	.049*
(dominant)	G2	12	50.6667	16.143			
Agnosia	G1	15	46.4000	16.906	-.78	25	.222
(nondominant)	G2	12	51.1667	14.358			
Dysgraphethesia	G1	15	20.7993	29.185	.83	25	.207
(dominant)	G2	12	10.5678	34.946			
Dysgraphethesia	G1	15	9.0779	45.968	.36	25	.362
(nondominant)	G2	12	1.5388	64.047			
Astereognosis	G1	15	55.5531	12.422	-1.73	14.14	.052
(dominant)	G2	12	61.1151	.788			
Astereognosis	G1	15	53.1019	13.982	-.12	25	.453
(nondominant)	G2	12	53.8690	19.540			

G1 = L3-L5
G2 = S1 or below

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE J-12

Academic Ability: Descriptive Statistics and T-Test Results for Lesion Levels L3-L5 vs S1 or below

		N	mean	Stdev	T	DF	P
WRAT-R Spelling	G1	15	39.6000	10.752	-1.96	25	.030*
	G2	12	47.9444	11.315			
WRAT-R Arithmetic	G1	15	30.5333	10.211	-1.77	25	.044*
	G2	12	37.5556	10.270			
PIAT-Reading Recognition	G1	15	53.4222	10.315	.45	24	.329
	G2	11	51.1515	15.547			
PIAT-Reading Comprehension	G1	15	46.8000	9.747	.86	25	.200
	G2	12	42.3333	17.102			

G1 = L3-L5
G2 = S1 or below

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE J-13

Behaviour and Social Competence: Descriptive
Statistics and T-Tests for Lesion Variables L3-L5 vs S1 or below

Vineland Domains		N	Mean	Stdev	T	DF	Sig of T
Communication	G1	15	34.1333	9.228	-.92	25	.184
	G2	12	37.7222	11.128			
Daily Living	G1	15	28.7111	11.630	-2.66	25	.007**
Skills	G2	12	40.1111	10.335			
Socialization	G1	15	40.5333	10.146	-1.82	25	.040*
	G2	12	47.3889	9.107			
Motor	G1	15	16.8886	10.916	-3.15	25	.002**
	G2	12	33.4444	10.376			
Maladaptive	G1	15	49.0286	6.044	-.33	25	.373
	G2	12	49.8945	7.700			

G1 - L3-L5
G2 - S1 or below

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE J-14

Behaviour and Social Competence: Descriptive Statistics and T-Tests for Lesion Variables L3-L5 vs S1 or below

Vineland Subdomains		N	Mean	Stdev	T	DF	Sig of T
Communication							
Receptive	G1	15	31.6270	42.288	-1.81	14.31	.046*
	G2	12	51.4782	3.958			
Expressive	G1	15	40.7405	7.215	-1.14	25	.132
	G2	12	44.7123	10.807			
Written	G1	15	32.3429	14.827	-.77	25	.224
	G2	12	36.4640	12.489			
Daily Living Skills							
Personal	G1	15	31.4024	28.413	-2.76	16.63	.007**
	G2	12	52.6067	7.893			

G1 = L3-L5
G2 = S1 or below

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE J-15

Behaviour and Social Competence: Descriptive Statistics and T-Tests for Lesion Variables L3-L5 vs S1 or below

Vineland Subdomains		N	Mean	Stdev	T	DF	Sig of T
Daily Living Skills							
Domestic	G1	15	30.6457	8.974	-2.79	25	.005**
	G2	12	38.8097	5.214			
Community	G1	15	33.5747	13.642	-.32	25	.375
	G2	12	35.5491	18.420			
Socialization							
Interests	G1	15	42.2089	23.269	-1.55	18.71	.068
	G2	12	52.3341	8.813			
Play	G1	15	39.3742	13.988	-1.43	25	.083
	G2	12	46.1836	9.815			
Coping Skills	G1	15	44.4818	10.403	-.58	25	.283
	G2	12	46.8720	10.944			

G1 = L3-L5
G2 = S1 or below

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE J-16

Behaviour and Social Competence: Descriptive Statistics and T-Tests for Lesion Variables Le-L5 vs S1 or below

<u>Parent Achenbach</u>		N	Mean	Stdev	T	DF	Sig of T
Social Competence	G1	11	26.5395	9.482	-4.18	17	.000***
	G2	8	46.6886	11.553			
Internalization	G1	15	52.9109	11.404	-.67	25	.253
	G2	12	55.7725	10.363			
Externalizing	G1	15	50.4069	8.408	-.40	25	.348
	G2	12	51.9333	11.636			
Total Problems	G1	15	53.3285	11.278	-.76	25	.227
	G2	12	56.7918	12.326			

G1 = L3-L5
G2 = S1 or below

<u>Note</u>: All values represent one-tailed tests
* *p*<.05 ** *p*<.01 *** *p*<.001

TABLE J-17

Behaviour and Social Competence: Descriptive Statistics and T-Tests for Lesion Variables L3-L5 vs S1 or below

Teacher Achenbach		N	Mean	Stdev	T	DF	Sig of T
Social Competence	G1	10	40.7331	5.142	-.78	19	.223
	G2	11	43.0672	8.136			
Internalization	G1	11	55.5640	10.293	-.57	20	.288
	G2	11	58.9713	17.010			
Externalizing	G1	11	51.4192	8.876	-.35	20	.366
	G2	11	53.0829	13.237			
Total Problems	G1	11	52.6963	10.504	-.47	20	.321
	G2	11	55.5393	17.046			

G1 = L3-L5
G2 = S1 or below

Note: No significant differences at .05 one-tailed level of significance

APPENDIX K

TABLE K-1

Intellectual Ability: Descriptive Statistics and T-Test Results
for Lesion Variables L2 or Above vs L3-L5

		N	Mean	Stdev	T	DF	Sig of T
VIQ	G1	9	39.4815	7.278	.21	22	.416
	G2	15	38.8444	6.903			
PIQ	G1	9	31.8519	6.026	-1.85	20.26	.039*
	G2	15	39.7333	14.529			
FSIQ	G1	9	34.5926	5.642	-1.04	22	.156
	G2	15	38.2667	9.650			
<u>Verbal Subtests</u>							
Information	G1	9	38.5185	9.590	-.60	22	.278
	G2	15	40.6667	7.888			
Similarities	G1	9	44.8148	9.590	.29	22	.386
	G2	15	43.7778	7.650			

G1 = L2 or above
G2 = L3-L5

<u>Note</u>: All values represent one-tailed tests
* *p*<.05 ** *p*<.01 *** *p*<.001

TABLE K-2

Intellectual Ability: Descriptive Statistics and T-Test Results for Lesion Variable L2 or Above vs L3-L5

		N	Mean	Stdev	T	DF	Sig of T
<u>Verbal Subtests</u>							
Arithmetic	G1	9	41.1111	6.236	.08	22	.468
	G2	15	40.8889	6.839			
Vocabulary	G1	9	42.2222	9.574	.96	22	.174
	G2	15	38.8889	7.418			
Comprehension	G1	9	41.4815	8.352	-.03	22	.489
	G2	15	41.5556	5.616			
Digit Span	G1	9	44.4444	11.055	.50	22	.312
	G2	15	42.4444	8.588			

G1 = L2 or above
G2 = L3-L5

<u>Note</u>: No significant differences at .05 one-tailed level of significance

TABLE K-3

Intellectual Ability: Descriptive Statistics and T-Test Results for Lesion Variables L2 or above vs L3-L5

		N	Mean	Stdev	T	DF	Sig of T
<u>Performance Subtests</u>							
Picture	G1	9	38.1481	7.286	-1.67	22	.054
Completion	G2	15	46.6667	14.086			
Picture	G1	9	37.4074	6.620	-.69	22	.248
Arrangement	G2	15	40.2222	11.017			
Block Design	G1	9	36.2963	8.571	-1.33	22	.098
	G2	15	42.8889	13.206			
Object Assembly	G1	9	33.7037	8.571	-1.83	22	.040*
	G2	15	44.8889	16.944			
Coding	G1	9	35.5556	7.817	-.10	22	.461
	G2	15	36.0000	12.097			

G1 = L2 or above
G2 = L3-L5

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE K-4

Language Ability: Descriptive Statistics and T-Tests for
Lesion Variables L2 or above vs L3-L5

		N	Mean	Stdev	T	DF	Sig of T
Peabody Picture	G1	9	43.4815	12.192	.24	22	.405
Vocabulary Test	G2	15	42.3556	10.260			
Expressive	G1	9	37.0370	9.581	-.68	22	.253
One-Word Test	G2	15	39.8222	9.890			
Fluency	G1	9	40.8095	8.939	1.59	22	.063
	G2	15	34.5500	9.557			
Token	G1	9	49.5396	17.669	-.82	22	.211
	G2	15	54.3601	11.391			

G1 = L2 or above
G2 = L3-L5

<u>Note</u>: No significant differences at .05 one-tailed level of significance

TABLE K-5

Memory Ability: Descriptive Statistics and T-Test Results for Lesion Variables L2 or above vs L3-L5

		N	Mean	Stdev	T	DF	Sig of T
<u>Verbal Memory</u>							
VSRT[1] - Recall	G1	3	7.4576	19.983	-.78	10	.226
	G2	9	19.7080	24.264			
VSRT - Long Term Storage	G1	9	16.0494	24.584	-.10	22	.460
	G2	15	17.1058	24.565			
VSRT - Consistent Retrieval	G1	9	30.3235	12.776	-.27	22	.396
	G2	15	31.6766	11.576			
Sentence Memory	G1	9	37.1071	12.185	-1.24	22	.114
	G2	15	42.4972	9.053			

G1 = L2 or above
G2 = L3-L5

<u>Note</u>: No significant differences at .05 one-tailed level of significance

[1]VSRT = Verbal Selective Reminding Test

TABLE K-6

Memory Ability: Descriptive Statistics and T-Test
Results for Lesion Variables L2 or above vs L3-L5

		N	Mean	Stdev	T	DF	Sig of T
<u>Nonverbal Memory</u>							
NVSRT[1] - Recall	G1	9	32.1430	13.515	.39	22	.351
	G2	15	30.1780	11.152			
NVSRT - Long Term Storage	G1	9	32.4496	12.376	.41	22	.341
	G2	15	30.4439	10.967			
NVSRT-Consistent Retrieval	G1	9	32.7866	7.247	.12	22	.452
	G2	15	32.4282	6.856			
Rey-Figure Recall	G1	9	28.0437	9.909	.05	22	.478
	G2	15	27.7892	11.678			
Rey-Figure Reorganization	G1	9	31.7815	4.906	-.69	22	.249
	G2	15	33.3520	5.691			

G1 = L2 or above
G2 = L3-L5

<u>Note</u>: No significant differences at .05 one-tailed level of significance

[1]NVSRT = Nonverbal Selective Reminding Test

TABLE K-7

Construction and Problem-Solving Abilities: Descriptive Statistics
and T-Test Results for Lesion Variables L2 or above vs L3-L5

		N	Mean	Stdev	T	DF	Sig of T
<u>Construction</u>							
DTVMI[1]	G1	9	31.1111	9.718	.10	22	.460
	G2	15	30.6667	10.998			
Rey-Figure	G1	9	44.2598	6.788	-.66	22	.258
Copy	G2	15	46.6655	9.579			
Rey-Figure	G1	9	35.1089	9.282	.65	22	.262
Organization	G2	15	32.6305	8.990			
<u>Problem-Solving</u>							
Halstead	G1	9	26.6676	10.729	-1.14	22	.134
Category	G2	15	33.1715	14.978			

G1 = L2 or above
G2 = L3-L5

<u>Note</u>: No significant differences at .05 one-tailed level of significance

DTVMI = Developmental Test of Visuomotor Integration

TABLE K-8

Attention: Descriptive Statistics and T-Test Results
for Lesion Level L2 or above vs L3-L5

		N	Mean	Stdev	T	DF	Sig of T
CPT Omission Errors[1]	G1	9	42.3913	17.568	2.03	16.54	.029*
	G2	14	9.2238	57.033			
CPT Commission Errors	G1	9	46.0884	6.816	2.38	13.93	.016*
	G2	14	17.2114	44.680			
Underlining Subtest 1	G1	9	30.9875	9.323	.09	21	.466
	G2	14	30.5291	13.874			
Underlining Subtest 2	G1	9	25.1994	11.670	-.48	20	.316
	G2	13	28.0571	14.737			
Underlining Subtest 4	G1	9	37.7726	8.504	-2.77	20	.006**
	G2	13	45.9580	5.391			
Underlining Subtest 5	G1	9	33.5297	4.433	-.82	20	.210
	G2	13	36.7084	10.941			

G1 = L2 or above
G2 = L3-L5

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

[1]CPT = Continuous Performance Test

TABLE K-9

Motor Ability: Descriptive Statistics and T-Test Results for Lesion Variables L2 or above vs L3-L5

		N	Mean	Stdev	T	DF	Sig of T
Finger-Tapping (dominant)	G1	9	45.2565	19.497	-.50	22	.310
	G2	15	49.2933	18.817			
Finger-Tapping (nondominant)	G1	9	47.8641	13.773	.03	22	.488
	G2	15	47.6889	14.618			
Pegs (dominant)	G1	9	-.1090	30.884	-.36	21.44	.360
	G2	15	6.8936	63.002			
Pegs (nondominant)	G1	9	6.8370	26.872	.96	15.62	.175
	G2	14	-21.0218	102.949			

G1 - L2 or above
G2 - L3-L5

Note: No significant differences at .05 one-tailed level of significance

TABLE K-10

Motor Ability: Descriptive Statistics and T-Test Results for Lesion Variables L2 or above vs L3-L5

		N	Mean	Stdev	T	DF	Sig of T
Trails A	G1	9	30.4426	7.243	.18	14.81	.431
(time)	G2	14	28.7994	33.696			
Trails A	G1	9	60.7778	11.918	2 [illegible]3	19.38	.019*
(error)	G2	14	42.6905	26.418			
Trails B	G1	9	32.0942	13.142	.49	18.73	.316
(time)	G2	14	27.4774	31.606			
Trails B	G1	9	51.1574	16.936	-.42	21	.340
(error)	G2	14	54.2351	17.506			

G1 = L2 or above
G2 = L3-L5

<u>Note</u>: All values represent one-tailed tests
* *p*<.05 ** *p*<.01 *** *p*<.001

TABLE K-11

Tactile-Perceptual Ability: Descriptive Statistics and T-Test Results for Lesion Variables L2 or above vs L3-L5

		N	Mean	Stdev	T	DF	Sig of T
Agnosia	G1	9	16.5556	83.846	-.66	9.02	.264
(dominant)	G2	15	35.4333	27.150			
Agnosia	G1	9	43.5556	27.097	-.32	22	.376
(nondominant)	G2	15	46.4000	16.906			
Dysgraphethesia	G1	9	5.3405	106.014	-.43	8.73	.339
(dominant)	G2	15	20.7993	29.185			
Dysgraphethesia	G1	9	-6.7940	110.214	-.41	9.70	.345
(nondominant)	G2	15	9.0779	45.968			
Astereognosis	G1	9	60.3191	3.237	1.41	16.97	.088
(dominant)	G2	15	55.5531	12.422			
Astereognosis	G1	9	62.4272	3.713	2.44	17.07	.013**
(nondominant)	G2	15	53.1019	13.982			

G1 = L2 or above
G2 = L3-L5

Note: All values represent one-tailed tests
* p<.05 ** p<.01 *** p<.001

TABLE K-12

Academic Ability: Descriptive Statistics and T-Test
Results for Lesion Variables L2 or above vs L3-L5

		N	Mean	Stdev	T	DF	Sig of T
WRAT-R Spelling	G1	9	44.4444	11.935	1.03	22	.158
	G2	15	39.6000	10.752			
WRAT-R Arithmetic	G1	9	35.8519	7.787	1.34	22	.096
	G2	15	30.5333	10.211			
PIAT-Reading Recognition	G1	9	52.1481	14.556	-.25	22	.402
	G2	15	53.4222	10.315			
PIAT-Reading Comprehension	G1	9	43.2593	6.267	-.97	22	.171
	G2	15	46.8000	9.747			

G1 = L2 or above
G2 = L3-L5

Note: No significant differences at .05 one-tailed level of significance

TABLE K-13

Behaviour and Social Competence: Descriptive Statistics
and T-Test Results for Lesion Variables L2 or above and L3-L5

		N	Mean	Stdev	T	DF	Sig of T
<u>Vineland Domains</u>							
Communication	G1	9	33.7037	11.762	-.10	22	.461
	G2	15	34.1333	9.228			
Daily Living Skills	G1	9	29.1852	17.571	.08	22	.468
	G2	15	28.7111	11.630			
Socialization	G1	9	38.8889	8.048	-.41	22	.341
	G2	15	40.5333	10.146			
Motor	G1	9	14.5185	6.216	-.59	22	.279
	G2	15	16.8889	10.916			
Maladaptive	G1	9	52.6842	6.706	1.38	22	.091
	G2	15	49.0286	6.044			

G1 = L2 or above
G2 = L3-L5

<u>Note</u>: No significant differences at .05 one-tailed level of significance

TABLE K-14

Behaviour and Social Competence: Descriptive Statistics and T-Test Results for Lesion Level L2 or above vs L3-L5

		N	mean	Stdev	T	DF	Sig of T
<u>Vineland Subdomains</u>							
<u>Communication</u>							
Receptive	G1	9	48.4259	10.869	1.46	16.89	.081
	G2	15	31.6270	42.288			
Expressive	G1	9	43.4015	13.996	.53	10.60	.303
	G2	15	40.7405	7.215			
Written	G1	9	35.1364	11.600	.48	22	.317
	G2	15	32.3429	14.827			
<u>Daily Living Skills</u>							
Personal	G1	9	29.3255	33.105	-.16	22	.436
	G2	15	31.4024	28.413			

G1 = L2 or above
G2 = L3-L5

<u>Note</u>: No significant differences at .05 one-tailed level of significance

TABLE K-15

Behaviour and Social Competence: Descriptive Statistics and T-Test Results for Lesion Level L2 or above vs L3-L5

		N	Mean	Stdev	T	DF	Sig of T
<u>Vineland Subdomains</u>							
<u>Daily Living Skills</u>							
Domestic	G1	9	24.2978	12.163	-1.47	22	.078
	G2	15	30.6457	8.974			
Community	G1	9	26.8963	13.645	-1.16	22	.129
	G2	15	33.5747	13.642			
<u>Socialization</u>							
Interests	G1	9	44.5347	11.563	.28	22	.391
	G2	15	42.2089	23.269			
Play	G1	9	38 2673	8.039	-.22	22	.415
	G2	15	39.3742	13.988			
Coping Skills	G1	9	40.6614	12.638	-.80	22	.215
	G2	15	44.4818	10.403			

G1 = L2 or above
G2 = L3-L5

<u>Note</u>: No significant differences at .05 one-tailed level of significance

TABLE K-16

Behaviour and Social Competence: Descriptive Statistics and T-Tests for Lesion Variables L2 or above vs L3-L5

		N	Mean	Stdev	T	DF	Sig of T
<u>Parent Achenbach</u>							
Social	G1	7	30.3958	3.197	1.24	13.19	.118
Competence	G2	11	26.5395	9.482			
Internalization	G1	7	58.8657	11.994	1.12	20	.137
	G2	15	52.9109	11.404			
Externalizing	G1	7	49.4847	6.955	-.25	20	.402
	G2	15	50.4069	8.408			
Total Problems	G1	7	55.4313	7.220	.45	20	.329
	G2	15	53.3285	11.278			

G1 - L2 or above
G2 - L3-L5

<u>Note</u>: No significant differences at .05 one-tailed level of significance

TABLE K-17

Behaviour and Social Competence: Descriptive Statistics and T-Test for Lesion Variables L2 or above vs L3-L5

		N	Mean	Stdev	T	DF	Sig of T
<u>Teacher Achenbach</u>							
Social Competence	G1	5	38.8759	5.815	-.63	13	.269
	G2	10	40.7331	5.142			
Internalization	G1	6	52.6433	12.304	-.52	15	.304
	G2	11	55.5640	10.293			
Externalizing	G1	6	50.3154	6.596	-.27	15	.397
	G2	11	51.4192	8.876			
Total Problems	G1	6	51.6544	9.013	-.20	15	.420
	G2	11	52.6963	10.504			

G1 - L2 or above
G2 - L3-L5

<u>Note</u>: No significant differences at .05 one-tailed level of significance

APPENDIX L

TABLE L-1

Intellectual Ability: Descriptive Statistics and T-Test Results for Intrauterine Hydrocephalus

		N	Mean	Stdev	T	DF	Sig of T
VIQ	G1	14	37.9524	8.607	-1.96	34	.029*
	G2	22	43.9394	9.106			
PIQ	G1	14	33.8095	10.999	-2.23	34	.016*
	G2	22	42.1515	10.898			
FSIQ	G1	14	34.8095	8.689	-2.47	34	.009**
	G2	22	42.2727	8.934			
<u>Verbal Subtests</u>							
Information	G1	14	38.8095	10.750	-1.41	34	.083
	G2	22	43.9394	10.523			
Similarities	G1	14	44.7619	8.135	-.80	34	.215
	G2	22	46.9697	8.094			

G1 - Intrauterine Hydrocephalus
G2 - Intrauterine Hydrocephalus not present

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE L-2

Intellectual Ability: Descriptive Statistics and T-Test Results for Intrauterine Hydrocephalus Variable

		N	Mean	Stdev	T	DF	Sig of T
<u>Verbal Subtests</u>							
Arithmetic	G1	14	40.7143	6.690	-1.37	34	.089
	G2	22	44.2424	7.980			
Vocabulary	G1	14	38.0952	10.436	-1.92	34	.032*
	G2	22	44.8485	10.221			
Comprehension	G1	14	39.0476	6.192	-2.74	34	.005**
	G2	22	46.5152	8.878			
Digit Span	G1	14	43.5714	10.250	-.29	34	.386
	G2	22	44.5455	9.403			

G1 = Intrauterine Hydrocephalus
G2 = Intrauterine Hydrocephalus not present

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE L-3

Intellectual Ability: Descriptive Statistics and T-Tests Results for Intrauterine Hydrocephalus Variable

		N	Mean	Stdev	T	DF	Sig of T
<u>Performance Subtests</u>							
Picture Completion	G1	14	41.1905	10.590	-1.77	34	.043*
	G2	22	47.7273	10.954			
Picture Arrangement	G1	14	39.2857	10.716	-1.89	34	.034*
	G2	22	45.9091	9.970			
Block Design	G1	14	39.2857	12.484	-1.09	34	.142
	G2	22	43.3333	9.759			
Object Assembly	G1	14	37.6190	13.551	-1.23	34	.114
	G2	22	43.4848	14.235			
Coding	G1	14	31.4286	7.478	-2.37	34	.012*
	G2	22	39.0909	10.500			

G1 = Intrauterine Hydrocephalus
G2 = Intrauterine Hydrocephalus not present

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE L-4

Language Ability: Descriptive Statistics and T-Test Results for Intrauterine Hydrocephalus Variable

		N	Mean	Stdev	T	DF	Sig of T
Peabody Picture Vocabulary	G1	14	42.4286	12.865	-1.14	34	.131
	G2	22	46.9091	10.588			
Expressive One-Word Vocabulary	G1	14	36.8095	11.232	-1.91	34	.032*
	G2	22	43.3333	9.122			
Fluency	G1	12	34.9388	7.251	-1.17	33.74	.124
	G2	22	38.8377	12.684			
Token	G1	14	53.5956	11.358	.02	33	.493
	G2	21	53.5148	14.685			

G1 = Intrauterine Hydrocephalus
G2 = Intrauterine Hydrocephalus not present

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE L-5

Memory Ability: Descriptive Statistics and T-Test Results for Intrauterine Hydrocephalus Variable

		N	Mean	Stdev	T	DF	Sig of T
<u>Verbal Memory</u>							
VSRT[1] - Recall	G1	6	5.6640	25.343	-1.70	15	.055
	G2	11	24.8025	20.488			
VSRT - Long Term Storage	G1	14	5.0362	24.687	-2.81	34	.004**
	G2	22	25.8960	19.705			
VSRT-Consistent Retrieval	G1	14	27.3977	10.363	-1.83	34	.038*
	G2	22	35.4698	14.288			
Sentence Memory	G1	14	40.3014	9.434	-.66	34	.258
	G2	22	42.9379	12.972			

G1 = Intrauterine Hydrocephalus
G2 = Intrauterine Hydrocephalus not present

<u>Note</u>: All values represent one-tailed tests
* *p*<.05 ** *p*<.01 *** *p*<.001

[1]VSRT = Verbal Selective Reminding Test

TABLE L-6

Memory Ability: Descriptive Statistics and T-Test Results for Intrauterine Hydrocephalus Variable

Nonverbal Memory		N	Mean	Stdev	T	DF	Sig of T
NVSRT[1] - Recall	G1	14	31.1578	10.964	-.44	34	.333
	G2	22	32.8559	11.686			
NVSRT - Long Term Storage	G1	14	26.8939	9.612	-2.15	34	.019*
	G2	22	34.9513	11.721			
NVSRT-Consistent Retrieval	G1	14	30.3642	5.831	-1.68	34	.051
	G2	22	34.0527	6.787			
Rey-Figure Recall	G1	14	26.1733	10.943	-.99	34	.166
	G2	22	29.9572	11.413			
Rey-Figure Reorganization	G1	14	31.4508	5.955	-1.72	34	.047*
	G2	22	34.8328	5.595			

G1 - Intrauterine Hydrocephalus
G2 - Intrauterine Hydrocephalus not present

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

[1]NVSRT - Nonverbal Selective Reminding Test

TABLE L-7

Construction and Problem-Solving Abilities: Descriptive Statistics and T-Test Results for Intrauterine Hydrocephalus Variable

		N	Mean	Stdev	T	DF	Sig of T
<u>Construction</u>							
DTVMI[1]	G1	14	27.1429	9.595	-2.99	34	.002**
	G2	22	37.2727	10.112			
Rey-Figure Copy	G1	14	43.3263	8.891	-1.77	34	.043*
	G2	22	48.4962	8.331			
Rey-Figure Organization	G1	14	31.4225	8.124	-1.86	34	.035*
	G2	22	36.8878	8.858			
<u>Problem-Solving</u>							
Halstead Category	G1	14	31.1528	12.523	-1.07	34	.145
	G2	22	36.5186	15.768			

G1 - Intrauterine Hydrocephalus
G2 - Intrauterine Hydrocephalus not present

<u>Note</u>: All values represent one-tailed tests
* *p*<.05 ** *p*<.01 *** *p*<.001

[1]DTVMI - Developmental Test of Visuomotor Integration

TABLE L-8

Attention: Descriptive Statistics and T-Test Results for Intrauterine Hydrocephalus Variable

		N	Mean	Stdev	T	DF	Sig of T
CPT Omission Errors	G1	13	3.1077	57.233	-2.60	12.76	.011*
	G2	21	44.9998	12.912			
CPT Commission Errors	G1	13	16.7864	43.529	-1.09	32	.141
	G2	21	31.9295	36.382			
Underlining Subtest 1	G1	13	27.2751	10.129	-1.38	32	.088
	G2	21	32.5431	11.170			
Underlining Subtest 2	G1	12	19.0546	11.521	-2.50	31	.009**
	G2	21	30.4268	13.143			
Underlining Subtest 4	G1	12	41.6598	8.355	-.20	31	.419
	G2	21	42.2837	8.482			
Underlining Subtest 5	G1	12	31.6849	5.511	-1.78	30.86	.043*
	G2	21	36.6592	10.563			

G1 - Intrauterine Hydrocephalus
G2 - Intrauterine Hydrocephalus not present

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE L-9

Motor Ability: Descriptive Statistics and T-Test Results for Intrauterine Hydrocephalus Variable

		N	Mean	Stdev	T	DF	Sig of T
Finger Tapping (dominant)	G1	14	50.1058	20.291	-.14	34	.444
	G2	22	50.9711	16.255			
Finger Tapping (nondominant)	G1	14	43.1678	14.424	-2.37	34	.011*
	G2	22	53.8152	12.244			
Pegs (dominant)	G1	14	-9.8210	63.147	-1.58	16.06	.066
	G2	22	18.4258	26.970			
Pegs (nondominant)	G1	13	-37.8308	104.691	-1.68	13.13	.059
	G2	22	11.9259	29.406			
Trails A Time	G1	14	21.5744	29.253	-2.09	16.18	.026*
	G2	21	38.8588	12.459			
Trails A Error	G1	14	42.6190	26.388	-2.01	15.30	.031*
	G2	21	57.4127	9.571			
Trails B Time	G1	14	19.4914	26.356	-2.71	18.46	.007**
	G2	21	40.5080	14.734			
Trails B Error	G1	14	54.5060	17.355	.99	33	.164
	G2	21	49.5496	12 245			

G1 - Intrauterine Hydrocephalus
G2 - Intrauterine Hydrocephalus not present

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE L-10

Academic Ability: Descriptive Statistics and T-Test Results for Intrauterine Hydrocephalus Variable

		N	Mean	Stdev	T	DF	Sig of T
WRAT-R Spelling	G1	14	38.8095	10.606	-2.08	34	.022*
	G2	22	46.6364	11.240			
WRAT-R Arithmetic	G1	14	30.2857	9.470	-1.96	34	.029*
	G2	22	36.6970	9.633			
PIAT Reading Recognition	G1	14	51.6190	10.052	-.28	33	.390
	G2	21	52.8889	14.676			
PIAT Reading Comprehension	G1	14	45.1905	10.345	.30	34	.382
	G2	22	43.9394	13.104			

G1 = Intrauterine Hydrocephalus
G2 = Intrauterine Hydrocephalus not present

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE L-11

Tactile-Perceptual Ability: Descriptive Statistics and T-Test Results for Intrauterine Hydrocephalus Variable

		N	Mean	Stdev	T	DF	Sig of T
Agnosia (dominant)	G1	14	38:3571	26.096	.30	31.74	.382
	G2	22	34.1591	56.236			
Agnosia (nondominant)	G1	14	46.6667	16.997	-.15	34	.439
	G2	22	47.6667	20.350			
Dysgraphethesia (dominant)	G1	14	-1.8400	84.388	-1.07	15.10	.150
	G2	22	23.3018	29.910			
Dysgraphethesia (nondominant)	G1	14	-35.2829	97.622	-2.32	14.38	.018*
	G2	22	26.7022	28.079			
Astereognosis (dominant)	G1	14	55.3466	12.896	-1:53	13.42	.074
	G2	22	60.6680	2.050			
Astereognosis (nondominant)	G1	14	47.5028	20.197	-2.41	14.48	.015*
	G2	22	60.8983	6.009			

G1 - Intrauterine Hydrocephalus
G2 - Intrauterine Hydrocephalus not present

<u>Note</u>: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE L-12

Behaviour and Social Competence Domain: Descriptive Statistics and T-Test Results for Intrauterine Hydrocephalus Variable

		N	Mean	Stdev	T	DF	Sig of T
Vineland Subdomains							
Communications							
Receptive	G1	14	36.7942	32.288	-.93	34	.178
	G2	22	46.0390	26.661			
Expressive	G1	14	37.5658	9.505	-2.60	34	.007**
	G2	22	46.0159	9.526			
Written	G1	14	32.1216	10.977	-.84	34	.204
	G2	22	35.8744	14.313			
Daily Living Skills							
Personal	G1	14	27.3558	34.622	-1.74	17.33	.050*
	G2	22	44.6939	17.580			
Domestic	G1	14	26.2158	12.569	-2.49	17.87	.011*
	G2	22	35.3210	6.772			
Community	G1	14	27.2334	15.854	-1.71	34	.048*
	G2	22	35.9549	14.343			

G1 - Intrauterine Hydrocephalus
G2 - Intrauterine Hydrocephalus not present

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE L-13

Behaviour and Social Competence: Descriptive Statistics and T-Test Results

		N	Mean	Stdev	T	DF	Sig of T
Socialization							
Interests	G1	14	39.8149	24.767	-1.52	14.71	.074
	G2	22	50.2066	7.933			
Play	G1	14	38.3250	13.951	-1.26	34	.108
	G2	22	43.3033	9.754			
Coping Skills	G1	14	42.9312	13.877	-.59	34	.278
	G2	22	45.2093	9.159			

G1 = Intrauterine Hydrocephalus
G2 = Intrauterine Hydrocephalus not present

Note: No significant differences at .05 one-tailed level of significance

TABLE L-14

Behaviour and Social Competence Domain: Descriptive Statistics and T-Test Results for Intrauterine Hydrocephalus Variable

Vineland Domains		N	Mean	Stdev	T	DF	Sig of T
Communication	G1	14	32.4286	8.616	-1.30	34	.101
	G2	22	37.0000	11.193			
Daily Living Skills	G1	14	26.2381	15.476	-2.38	34	.011*
	G2	22	36.6970	10.907			
Socialization	G1	14	39.4762	11.329	-1.46	34	.076
	G2	22	44.2727	8.361			
Motor	G1	14	12.1429	3.959	-4.56	25.10	.000***
	G2	22	27.9697	15.502			
Maladaptive	G1	14	50.3821	7.092	.11	34	.458
	G2	22	50.1351	6.712			

G1 = Intrauterine Hydrocephalus
G2 = Intrauterine Hydrocephalus not present

Note: All values represent one-tailed tests
* $p<.05$ ** $p<.01$ *** $p<.001$

TABLE L-15

Behaviour and Social Competence Domain: Descriptive Statistics and T-Test Results for Intrauterine Hydrocephalus Variable

Parent Achenbach		N	Mean	Stdev	T	DF	Sig of T
Social Competence	G1	10	29.3595	12.919	-1.46	24	.078
	G2	16	36.5387	11.734			
Internalization	G1	13	52.4248	11.666	-1.13	32	.133
	G2	21	56.8320	10.613			
Externalizing	G1	13	48.2122	7.664	-1.28	32	.105
	G2	21	52.3304	9.895			
Total Problems	G1	13	52.1045	9.956	-1.23	32	.113
	G2	21	56.7662	11.141			

G1 = Intrauterine Hydrocephalus
G2 = Intrauterine Hydrocephalus not present

Note: No significant differences at .05 one-tailed level of significance

TABLE L-16

Behaviour and Social Competence Domain: Descriptive Statistics and T-Tests Results for Intrauterine Hydrocephalus Variable

Teacher's Achenbach		N	Mean	Stdev	T	DF	Sig of T
Social	G1	10	41.0652	6.185	-.18	24	.430
Competence	G2	16	41.5499	7.100			
Internalization	G1	10	54.1572	10.416	-.61	26	.272
	G2	18	57.4542	15.006			
Externalizing	G1	10	50.0688	8.641	-.68	26	.251
	G2	18	52.8182	11.035			
Total Problems	G1	10	51.2953	10.126	-.70	26	.246
	G2	18	54.8647	14.315			

G1 = Intrauterine Hydrocephalus
G2 = Intrauterine Hydrocephalus not present

Note: No significant differences at .05 one-tailed level of significance