EARLY LATERAL PREFERENCES AND MENTAL PROCESSING TRENDS IN BLACK PRESCHOOLERS

Carmel Patricia Jansen

A Thesis submitted to the Faculty of Arts,

University of the Witwatersrand

in fulfilment of the requirements

for the Degree of Doctor of Philosophy

March, 1998

FOR STEVE

DECLARATION BY CANDIDATE:

I hereby declare that this thesis is my own work and has not been submitted to any other University.

ACKNOWLEDGEMENTS

I would like to express my gratitude to the following people:

-Professor J.A. Fisher, my supervisor,for his encouragement,advice and trust.

-Ms Thea de Wet,project manager,Mrs Eileen Skuy,secretary and Ms April Anderson from the Birth to Ten Project for their excellent support over the two data collection periods.

-Mr Matthews Makgamatha and Ms Almarie Pierson for their invaluable assistance with test administration.

-Ms Barbara Moneypenny and Ms Thabile Sibuja for their help with interviews, organising taxis and contacting caregivers and without whom the research would not have been possible.

-Matthew Hurly and Ann Jansen for their considerable help with sorting questionnaires, data input problems and computer programme problems. I am particularly grateful to Matthew for his computer expertise and time, both of which he generously made available.

-Maggie Gifford, for patiently typing tables and questionnaires so cheerfully, Averil Barker for facilitating the administrative minefields so effectively,Mike Greyling and Peter Fridjhon for their willingness to answer statistical queries.

-Colleagues and friends for words of encouragement

-My family, Steve, Mike and Ann for their wonderful support.

-Finally to the children and their families without whom this study would not have been possible.

ABSTRACT

The current study adopts a developmental neuropsychological perspective, an approach which does not imply brain dysfunction but rather the principle of understanding the general relationship between brain growth and behavioural changes and the effect of environmental factors in children. A neuropsychology of normal development would seem to be an appropriate initial prerequisite if we are to understand the effects of brain insult or disease in the developing child. A modest aim was to acquire a fundamental understanding of emerging skills in black preschool children, starting with the most basic, the development of lateral preferences. This area was selected (a) as a departure point because of its location within the broad area of cerebral lateralization and (b) the opportunity it provided to explore the children's mental processing skills within the same theoretical perspective.

The purpose of the present study was the longitudinal investigation of lateral preferences in a sample of Soweto children at three and five years, and information processing skills in the same sample at five years. Three hundred and thirty-five children, 170 girls and 165 boys, were sampled with the assistance of the Birth to Ten project, a longitudinal study of growth, health and development of children living in the Johannesburg Metropolitan area over a ten year period, 1990 to 2000. The children were assessed prior to starting school in January, 1996. A descriptive approach was adopted in explaining the patterns of handedness, footedness and eyeness. The findings showed that the patterns for handedness reflected the expected rightward direction at both ages although the degree to which preference has been established was weaker at five years than that reported in other studies with children of similar ages. Thirty-nine percent of the sample were mixed-handed at five years, only 3% were mixed-footed and 5% showed mixed-eyeness.

At five years,Si ultaneous and Sequential information processing skills were assessed with the Kaufman Assessment Battery for Children (K-ABC). Factor analysis revealed a two factor solution broadly supporting the presence of the two processing styles. However the two coding processes were differentially distributed throug out the sample showing significant differences. More specifically,it was found that 34% of the children presented profiles of both processing styles that were below the group mean;31% showed profiles where one or other coding style was below the group mean;23% of the children portrayed processing profiles above the group mean. Thirty-nine children (12%) presented patterns of processing that were above the group mean but were highly developed in one or other processing stvle. Each of the profiles that emerged were grouped and considered separately.

Cognitive tasks involving verbal fluency,naming skills,draw-a person,basic perceptual knowledge,basic literacy,plus lateral preference information such as handedness direction, handedness consistency and handedness skills were appended to all the groups. Low scores in processing styles were found to be associated with poor verbal skills, low mental age,poor perceptual and basic literacy knowledge,poor hand skill performance,and greater (but non-significant) numbers of mixed-handers. The lowest scoring group also contained the majority of male left-handers. One of the highest scoring groups showed the strongest lateralizing patterns although the numbers were small ($n=11$). Girls with above average sequential skills also scored highly on verbal fluency ($p<.05$) and hand skills ($p<.05$). Boys in this group showed the strongest degree of right-handedness ($p<.05$). In the four lower performance groups,background variables such as type of preschool experience ($p<.001$),the presence of books in the home ($p<.05$) and mothers level of education ($p<.001$) were found to be significant. A regression model which incorporated environmental, epigenetic,cognitive and motoric factors was found to be the most viable in predicting processing skills.

TABLE OF CONTENTS

(CONT)

CHAPTER PAGE

(CONT)

CHAPTER PAGE

(CONT)

CHAPTER PAGE

LIST OF TABLES

CHAPTER 4

TABLE PAGE

TABLE PAGE

CHAPTER 7

TABLE PAGE

LIST OF FIGURES

FIGURE PAGE

CHAPTER 6

CHAPTER 7

FIGURE PAGE

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION AND BACKGROUND

Reliable knowledge regarding child development and the factors affecting physical growth and cognition have become the focus of research in recent years. In particular, interest has been directed towards developing countries in the southern African region and the developmental risk factors involved. For example, in a country such as South Africa more than 40% of the population live below the poverty line (World Bank, 1994). The conditions of poverty are compounded by factors of high population growth and overcrowding which are brought about by the influx of rural people to urban areas and exacerbated by the large numbers of illegal immigrants from neighbouring countries (Barbarin & Khomo, 1997). Such an increase in population places enormous strains on already scarce food and labour resources and increases the cycle of poverty and deprivation. More than half of South Africa's population live in urban areas and at least 40% of the black majority are unemployed (World Bank, 1994). Children living in these environments are at risk for numerous adverse effects including hunger and disease with ultimate implications for cognitive development and schooling. In these circumstances the opportunities for studying and monitoring the development of children growing up in at risk environments in ongoing longitudinal research are hugely advantageous. Until recently the knowledge and understanding of development in large samples and the manner in which environmental factors impinge has been difficult to acquire. This is because of the constant shifting of the populations which creates difficulties in tracking and following samples in long term studies. A longitudinal study, Birth to Ten, was initiated in 1989 through the efforts of a collaborative group of researchers from a number of universities and institutions. The general aim of the project was the study of the growth, health and development of children living in the Johannesburg Metropolitan area over the 10 year period, 1990 to 2000. The area of the study includes Soweto which is one of the largest black urban residential areas in South Africa. It is situated to the south of Johannesburg and it is estimated that at the current rate of influx from rural areas there will be an increase of the urban African population from the 6.5 million count in 1985 to 20 million by the year 2000 (Yach,Richter,Cameron,Von Schirnding & de Wet,1993a). Thus the aim of the Birth to Ten project is to ensure that future policies regarding child healthcare are based on sound epidemiological evidence (Yach et al., 1993a).

Data for the current study were collected in collaboration with the Birth to Ten project. A study such as the present one would not have been possible without a data base and follow-up information mechanisms. Longitudinal research of this nature does not take place within a vacuum and political events co-occurring in the year 1990 also saw the beginning of dramatic changes in South Africa. It was at this point in time that the mechanisms for change from a white minority to a black majority government were initiated. Thus the Birth to Ten project began in a period of political instability and violence in South Africa. The effects of the violence, especially in local black suburbs where the majority of Birth to Ten participants were domiciled,are difficult to evaluate. Yet the effect on data collection and sampling cannot be ignored. "*In addition to urbanization, high levels of social and political instability have had profound effects on health service utilisation (including preventive services for children) and on the conduct of the study.*" (Yach et al., 1993a,p.5)

Despite the background factors,the participation in a longitudinal study offers a unique opportunity for a researcher. Practically, such studies are beset by a number of difficulties including cost and methodological problems which may account for their limited use, especially in the area of developmental issues of childhood and adolescence (Wierson & Forehand, 1994). The advantages over cross-sectional research can be observed in terms of the unambiguous boundaries of the sample, which clearly accounts for the occurrence of missing cases;the provision of multiple points of measurement over time which reduces bias and increases reliability; and the ability to detect unexpected outcomes from early and sometimes risky experiences (Rutter, 1994). Nonetheless,it must also be acknowledged that longitudinal research involving shifting populations also presents formidable logistical organisation as a considerable amount of time can be expended on simply tracking and following-up individuals.

The approach to child development within the project has been multifaceted. The medical issues of nutrition in pregnancy, antenatal care,delivery and birth, early physical growth and development have been examined. Research has also focused on the child participants' language; emotional and intellectual growth; the home environment and household density. The current study adopts a different perspective in that development is examined from a neuropsychological,that is a brain and behaviour, perspective. Developmental neuropsychology is not a new field, indeed, developmental psychology and developmental linguistics have resulted in a core of knowledge which emphasizes a developmental psychobiological thrust in which the emergence of developmental neuropsychology as a framework has been a natural outcome. Such an approach does not imply maldevelopment but rather a knowledge of the neuropsychology of normal development, a position strongly advocated by Segalowitz and Hiscock (1992).

Research information regarding cultural differences of performance on neuropsychological and cognitive tasks has not been readily available. Researchers are often faced with the difficulty of choosing suitable areas of brain and behaviour for study based on the availability of appropriate measuring instruments. Despite the fact that children manifest rapid growth of brain in the early days and weeks after birth the ongoing behaviours that can usefully be assessed during this period are mainly motor movements which are poor sole predictors of later cognitive development (Bagnato & Neisworth, 1991). The principle of understanding the general relationship between brain growth and behavioural changes is the ultimate goal in developmental neuropsychology, however, the chances of achieving this laudable aim are pessimistic. Segalowitz & Hiscock (1992) explain the dilemma faced by researchers.

> *Describing the relationship between brain development and behavioural development, even in the most general terms, is a difficult undertaking. Specifying this relationship in detail is an overwhelming task. The multidimensional character of growth in both spheres is an obvious challenge. We must specify which aspects of neural development are related to which facets of behavioural development. For example, we must explore what the behavioural implications are of neuronal proliferation and migration, of synaptic attrition and axonal myelination. We must detail what the neuronal underpinnings of attention, language, or memory are. p.46.*

A major problem is the non-linearity of brain development and behavioural development over time. An understanding of the process of overproduction and selective attrition of neurons and synapses that takes place would be required. This is because the surviving neurons may in part be determined by the stimulation which the organism is subjected to during some sensitive or critical period. Thus early experience and neural development would seem to interact,although nature does not guarantee that neural substrates and associated behaviours will emerge simultaneously (Segalowitz and Hiscock, 1992, p.46). However, the differential effects of environmental experience cannot be ignored. For example,early experiences affect the visual system and the organization of the occipital cortex demonstrating permanent effects as shown by Hubel and Wiessel's (1962) animal experiments. When environmental factors are applied to human subjects,individuals who grow up in city environments show greater receptivity to horizontal and vertical patterns but less sensitivity to diagonals;on the other hand individuals growing up in rural environments do not show this effect (Annis & Frost,1973). The challenges facing developmental neuropsychologists to document these areas of developmental differences are many.

In terms of the current study a basic plan was to look at brain/behaviour correlates from a perspective that might lead to a more fundamental understanding of emerging skills. Moreover the area selected for such a study would have to incorporate non-invasive techniques. The major problem is that little is known about some of the most basic neurodevelopmental issues such as manual and lateral preferences in African children. The question is whether common and differential modes of neurodevelopment in different cultural contexts can be documented. The notion of culture and background of children living in Soweto cannot be disregarded. As Rogoff and Chavajay (1995) explain"*Sociocultural perspectives assert that individual cognitive developmental processes are inherently involved with the actual activities in which children engage with others in cultural practices and institutions and that variation is inherent to human functioning*" (p.871). Establishing lateral preference patterns in the preschool years was selected as a point of departure as it is located within a theoretical framework associated with the notion of cerebral lateralization of the hemispheres of the brain. Indeed, neuropsychologists,both developmental and experimental, have over the years maintained an intense interest in handedness as an indirect measure of cerebral organisation. Lateral specialisation or human sidedness, can be demonstrated with reasonable ease. The two hemispheres of the brain are thought of as dissimilar in terms of structure and function. The weight of evidence suggests that the right and left halves of the brain are sp...sed differentially from birth and even before (Selagowitz & Chapman, 1980; Segalowitz and Hiscock, 1992). Overall it would seem useful to track motor asymmetries in the very young at several points in time. There are many advantages in considering lateralization in developmental neuropsychology and many indicators of brain lateralization in infancy and young preschoolers are non-intrusive. These include head turning (e.g. Liederman & Kinsbourne, 1980; Saling, 1983), grasping, other manual and behavioural asymmetries such as footedness and eyeness (Ramsay,1980). The usefulness of this approach can be observed in similar work by researchers such as Michel (1981, 1983) and Molfese and Molfese (1985, 1986) who found links to subsequent motor and language asymmetries in follow-up studies. A further motivation for adopting this perspective was the relative scarcity of information of a longitudinal nature on motor or behavioural asymmetries in the preschool years (e.g.Bishop,1990). Harris (1992),for example, has pointed out that such studies might add to the fund of knowledge on issues of left-handedness and pathology.

A third issue in selecting an area of developmental neuropsychology that could be managed efficiently,was the manner in which the data could be collected over a reasonable period of time, and fourthly,the opportunity for continuity. The lack of trained psychologists proficient in a number of African languages was an important factor. This deterred the researcher from embarking on complex assessment procedures at the three and a half year stage which would have required specialists with skills and experience in the area of neuropsychology. However, natural occurring behaviours, such as handedness, footedness and eyeness could be assessed following intensive coaching with trained research assistants. These issues will be discussed more fully in the course of the following chapters.

In exploring behavioural asymmetries at two stages of development it was considered more meaningful if these two time stages should be placed in the preschool period. This was mainly because of the lack of data available in this area of developmental neuropsychology for this period of growth and also because of the dearth of information of developing behavioural asymmetries in the majority of South African children. However, patterns of motor asymmetry are not in themselves useful information unless they can be linked to other areas of developmental neuropsychological function. From a conceptual level,the ideal instrument would be an assessment procedure which evaluates mental function but at the same time can be anchored within a neuropsychological framework in which hypothesized brain and behavioural development could be examined. Assessment with the mainstream procedures of intellectual and mental efficiency have been unsuccessful from a cultural perspective. On the other hand,the use of neuropsychologically based measures have not been well validated within black populations of preschoolers. These issues will be addressed more fully in the following chapters. The central purpose of the current study is to study the children's developing behavioural asymmetries and processing skills which, when observed from several perspectives, could be linked to a theoretical neurodevelopmental framework. Thus the present study focuses on a delineated area of interest in developmental neuropsychology, the growth and development of lateral preferences and mental abilities. A general question posed is related to the overall development of these two areas. A more complex question is the relationship between the two areas.

Having explained the background and purpose of the current study, the content, method and form of presentation will be outlined. Chapters 2 and 3 contain a theoretical overview on lateral preferences and mental processing theories. In Chapter 2 the phenomenon of human sidedness is considered. The emphasis is on manual preference as this aspect comprises the bulk of the research carried out over the years. The major genetic, biological and environmental theories are discussed. A developmental perspective is emphasized. In Chapter 3 the review of the literature initially considers the absence of developmental models in which an understanding of emerging brain and behaviour relationships can take place. It is emphasized that a neuropsychological -neurodevelopmental model does not imply brain damage but rather a framework in which normal brain structure /function development can be understood. A number of assumptions have been made regarding brain and behaviour relationships in children and these have been largely based on studies with adult samples. Although it must be conceded that research with adults has been useful in that a number of hypotheses concerning neurodevelopment have been generated, these assumptions have obscured primary differences not least of which is the process of change in children (Hynd & Willis,1988). In particular the three most influential sources of theory are highlighted, Luria's hierarchial theory of functional systems, Information Processing theory (which has as a basis the Luria-Das brain anterior-posterior processing hypothesis) and Cerebral Lateralization theory. It is the latter two frameworks that will form the focus of theoretical discussion in this research. Although both theories are based in neuropsychological theory,the assessment tools and approaches emanating from both perspectives differ. The discussion focuses on the major differences, the strengths and weaknesses and the appropriateness of each instrument for the area explored in the current study.

Chapter 4 is concerned with the methods and design of the study. The tasks employed,the categories of lateral and mental behaviours and the proposed analysis of the data are explained. Chapters 5 and 6 describe the results of the lateral preferences and mental processing tasks. Each of these chapters contains separate discussions related to the respective findings.

There is also the need to identify and understand the effects of background issues and environmental factors which may contribute to risks in neurodevelopment. Indeed as Goldstein (1981) has pointed out where problems arise the benefits of intervention are highest where identification has been swift and early. With this aspect in mind, Chapter 7 explores these factors. The chapter contains a literature review and includes detailed background information. This information is linked to and highly pertinent to the findings in Chapters 5 and 6.

In Chapter 8, the results are considered and reflected on. The discussion reviews the findings within the conceptual framework adopted. In addition the integration of cognitive and socioeconomic findings are discussed in the light of the children's performance and developmental trends.

Longitudinal studies of developmental processes generate large amounts of data. Manageability of such a project can only be achieved by staying within the stated areas. It is thus tempting for any researcher to increase the amount of information contained in a project such as the current one by,for example, following up peripheral aspects of the data collected or even by increasing the period of follow-up. In the case of the current sample the first year of schooling might have elicited more information. Nevertheless, it is hoped that the focus on the period before school may provide a glimpse into an important slice of development within a crucial period. The collection of data is ongoing and will continue after the children's first years at school.

CHAPTER 2

LATERAL PREFERENCES: A THEORETICAL OVERVIEW

The cerebral hemispheres, the two halves of the brain, appear symmetrical, however, the nineteenth century discovery by Broca and Dax revealed differences in functional properties (McManus & Bryden, 1993;Kolb & Whishaw, 1996). More specifically, it was noted that damage to the left hemisphere affected the ability to speak while damage to the right hemisphere did not affect speech (Iaccino, 1993). Further support for language capacity in the left hemisphere emerged from Karl Wernicke's work which showed that other types of language disorders could be associated with left hemisphere damage (Kolb & Whishaw, 1996). In the majority of right-handed individuals the left hemisphere is also credited with the superior ability to organise `subtle, fine motor sequential activity even in the first months of life" (Young,Segalowitz, Corter & Trehub, 1983 p.9). The role of manual preference introduced an important moderating variable in the Broca-Dax speech discovery as several years elapsed before it was reported that left-handers did not conform to the left hemisphere speech location paradigm (McManus & Bryden, 1992;Harris, 1992). As McManus and Bryden (1992) point out *'Handedness is however, not only important as a secondary variable for interpreting other processes, but also is a major neuropsychological phenomemon in its own right which requires explanation and study'* (p.115). The notion that an understanding of developmental patterns of lateralized behaviour, such as handedness, could predict cerebral specialisation of function has significant appeal and possible general and applied applications (Young, Bowman, Method, Finlayson, Quintal & Boissonneault, 1983). For example, Young and his colleagues propose that environmental factors can play a crucial role in specifically left hemisphere stimulation in the infant. This can be effected through parent-infant interactions such as speaking and right-handed . t-directed activity(p.128). Harris (1992) agrees with this perspective suggesting that more precise knowledge regarding the effectiveness of early parental influence and social training require further clarification. The stated goal by Boivin, Chounramany, Gordioni, Xaisida, Choulamountry, Pholsena Crist and Olness (1996) of seeking out universal features of brain and behavioural developmental trends has appeal within the cerebral lateralization perspective, both from the cognitive dimension and also from the cultural context of social custom, interaction and adaptation (p.88). In this chapter theories regarding lateral preferences will be explored with a special emphasis on developmental issues.

Hemispheric Differences

Hemispheric asymmetry in the brain, the fact that the two halves of the brain differ, has been the subject of provocative discussion for decades. The specialisation of the two halves of the brain may be influenced by genetics or biological issues or factors related to society or by environmental experiences such as socioeconomic status (Witelson & Kigar, 1988; Young, Bowman, Methot, Finlayson, Quintal & Boissonneault, 1983). Each hemisphere of the brain exercises primary motoric and sensory control over the contralateral side of the body. This means that hand and foot movements of the right side of the body are controlled by the left cerebral hemisphere. The left hemisphere also contains the primary mechanisms for speech in the majority of individuals and attempts to link these two factors and other forms of cognitive functions have influenced research in this area (Porac & Coren, 1981). In the first instance, the notion that speech resided in the left hemisphere suggested a superior role, in fact the term cerebral dominance portrays the idea that one hemisphere directs behaviour (Springer & Deutsch, 1993). In the second instance this assertion gave direction to specific kinds of research while neglecting other types. As Porac and Coren (1981) point out, handedness was the main focus of empirical investigation giving rise to the assumption that forms of lateral preferences, such as eyeness, arm folding or hand-clasping and footedness have the same original or are caused by the same processes as handedness. These lateralities have their own separate genetic control and should not be confused with handedness, however, neither should they be precluded from investigation in conjunction with handedness (McManus & Bryden, 1992, p.135).

Structural Asymmetries Of The Hemispheres

There is sound support for anatomical asymmetries in human brains with differences in structures associated with language in the left hemisphere in the majority of human subjects (Helligle, 1993). The investigation of structural differences began in 1877 with Broca's presentation of evidence that the left hemisphere had greater complexity of convolutions than the right (Porac & Coren, 1981). Contemporary studies followed the same kind of investigation with Geschwind 1968) who noted that the left planum temporale, posterior to the left temporal lobe, a known language area, was larger. Evidence to support the notion that anatomical asymmetry is present in early life was found in the brains of fetuses and infants at 10 to 44 weeks. In these studies once again the planum temporale area was found to be larger on the left in 54% of the cases, with a reversal of the differences in 18% (Chi, Dooling & Giles, 1977). Bishop (1990) noted that the presence of asymmetries in the planum temporale has been cited as evidence of hemispheric specialisation at birth however,there is a danger in making an assumption that *"physical measurements indicate the amount of brain power available for a given function"* (p.29). There is considerable difficulty in understanding the nature of the relationship regarding the physical asymmetry and the functional asymmetry of the hemispheres (Springer & Deutsch,1993). There is also a paucity of information in interpreting these structural asymmetries in infants in terms of understanding whether lateralization of function is present at birth. An example of this dilemma is the work on language lateralization in neonates (Molfese & Molfese, 1986;Wada & Davis, 1977) using electro- encephalographic (EEG) procedures. The findings have been interpreted as supporting the presence of fundamental asymmetry which exists prior to language acquisition. However,the possibility has been raised that such responses are the result of brainstem or diencephalic systems activations and do not reflect the presence of specialised brain processors (Kinsbourne & Hiscock,1983a). Thus,specific responses will only occur when the relevant matured systems, language, for example,have developed. Currently there are opposing views on the functional development of the cerebral hemispheres.

Two views of developing cerebral lateralization have been postulated. The equipotential model (Lenneberg, 1967) suggests that lateralization of function co-occurs with the process of language acquisition and continues until the onset of puberty. However, Lenneberg's (1967) approach was largely based on studies of infants who had sustained lesions to the left hemisphere but who subsequently suffered no apparent language deficiencies. The opposing perspective suggests that cerebral dominance is established closer to the time of birth before language is acquired (Iaccino,1993), a view that is endorsed by Turkewitz (1988). Dean (1988) cautions that the equipotential view does not necessarily rule out the possibility that functional lateralization is an ongoing developmental process. This approach is implicit in the view that children's brains are less lateralized than adult brains (Hynd & Willis, 1988). However, Segalowitz and Hiscock (1992)) raise the question of how the process of brain maturation could be related to developmental competencies in the child and suggest that a model such as Best's (1988) is an important example of how this may occur. Catherine Best (1988) proposes a model in which brain maturation could be related to the maturation of behavioural competencies. Within this model a growth gradient is suggested that involves *"the main axes of embryologic development"*(p.16). The growth of hemispheres takes place on a right-left dimension, a frontal-occipital dimension which is complicated by a growth gradient that moves from primary and secondary motor and sensory zones to secondary and tertiary association zones. Finally the fourth aspect is the ventral-dorsal growth gradient that moves from basal to superior regions (p.17). Further, Best suggests:

> *With concurrent developmental shifts along all gradients, the advancing wave of the growth vector would then precede toward earlier emergence of the left side for tertiary associations (including Wernicke's area) that lie more dorsal and posterior (e.g.superior parietal), again at least initially (but recall the the late and presumed leftward bias in protrusion of prefrontal regions). At some point midway between these extremes, growth should reach equilibrium between the two sides (possibly in secondary association areas).*(p.17).

Although broadly speculative in terms of functional zone development such as association areas, Best's model accounts for the volumetric differences in left frontal and right occipital areas that have been noted in adult brains. The growth vector model of maturation suggests that the order in which the hemispheres mature is clearly more complex than previously proposed. Segalowitz and Hiscock (1992) note that there is support for Best's (1988) model in terms of predictions of size and asymmetry from previous evidence of structural asymmetry measurements (e.g.LeMay, 1976). Best's description of a maturational gradient is useful in increasing our understanding of the phenomenon of hemispheric specialisation. However, morphological asymmetries are not synonymous with hemispheric functional differences and currently there is a lack of empirical support for any association between behavioural and morphological differences within the model. Iaccino (1993) suggests that the two models of developmental lateralization, the progressive model and the invariant model, may be integrated to account for development. Hemispheric differences for speech may be the earliest to appear although environment plays an important role in initial language acquisition in that the linguistic structures require basic stimulation (p.201). Other changes in hemispheric function could depend on environmental input such as exposure to one or more languages, or to skilled motor or spatial movements (Iaccino, 1993). The current research offers a unique opportunity to explore the role of environment in the development of lateral preferences in a high risk sample. In the following section the most accessible aspects of hemispheric asymmetry will be explored,the most popular being handedness.

Handedness

Some overt behavioural responses appear to be controlled primarily or exclusively by only one hemisphere (Helligle, 1993). Handedness is a typical example of overt behaviour and in humans it is thought to reflect hemispheric asymmetry for manual activity and may be related to hemispheric asymmetries for other functions of a more cognitive nature (Helligle, 1993). In this chapter, hand, foot,and eye preferences are discussed with the view to establishing background factors for understanding their functional and behavioural significance. The majority of individuals are right-handed and both genetic (e.g Annett,1985) biological (Geschwind & Galaburda, 1987), environmental factors, such as pre-, peri- or post-natal insult (e.g. Bakan,Dibb & Reed, 1973) or culture (e.g. Dawson, 1972) are thought to contribute to this preferential pattern.

Genetic factors. The first simple genetic model of hand preference was initially suggested by Ramaley (1913) and later by Marion Annett (1964). This view posited that handedness was determined by either a right dominant gene (D) or by a left recessive gene (R). However, the rationale for assigning dominant and recessive gene patterns was flawed in that the hypothesized expectation of 100% of children with left-handed relatives did not materialise from analyses of research (Iaccino,1993). Further studies of familial sinistrality and monozygotic twins concordance rates did not reject outright the notion of a genetic mechanism but suggested that there was greater complexity in the genetic processes involved (Iaccino,1993).

More complex genetic models of handedness emerged. A genetic theory by Levy and Nagylaki (1972) proposed two genes. One gene would determine the lateralization of language with the inherited L dominant gene responsible for left hemisphere speech; the recessive gene would determine right hemisphere speech. The second gene determines the role of the speech hemisphere in control of the writing hand, either ipsilateral (I) or contralateral (C). A left speech and right-handed combination would be coded LrCi. Research by Levy and Reid (1978) suggests that handwriting posture might reflect the hemisphere controlling the speech functions. The hooked or inverted posture adopted by some sinistrals is thought to reflect ipsilateral localization while the non-inverted posture suggests a contralateral focus. Iaccino (1993) points out that environmental influences or educational experience (Bishop, 1990) may dictate an inverted style in many sinistrals. However, support for the two gene model has not been shown empirically (Annett, 1978;Bishop, 1990;Peters & McGrory, 1987).

In a revision of her theory, Annett (1985) proposed that instead of a dominant

gene for right-handedness rathe. a strong right-sided genetic component, a right shift factor (RS+) was responsible for handedness. The presence of RS+ would account for a strong right-handed bias. According to Annett (1985) the presence of RS+ was also characterized by the lateralization of la in the left hemisphere. The explanation for non-right-handedness was attributed to the absence of the right shift factor, RS-, resulting in neutral hand preference and less cortical laterality for language. Annett (1985) proposed that about half of the RS- group would be right-handed and right language lateralized while the other half would become left-handed and left language orientated, in other words, chance factors would operate independently for speech and handedness (Iaccino,1993;Springer & Deutsch, 1993). Thus, in this model similar factors in the left hemisphere influence both dextral bias and language systems development. Some support for this approach has been sought in twin and singleton studies. More specifically ,the high rate of perinatal risk in twin births could produce a greater rate of pathological left-handedness so that genetic factors become obscured. Annett (1985) reported a high rate of left-handedness in twins in comparison to singletons when pathological left-handers were excluded by their performance on tasks of manual dexterity. Annett suggested that crowding of twins in the uterus slowed development of the cerebral hemispheres and affected handedness. Annett also proposed that the immaturity of the hemispheres could further give rise to other areas of delayed development such as language. McManus (1980)) was critical of Annett's findings for twin and singletons suggesting that the approach was methodologically flawed. More specifically. McManus (1980) suggested that both twins and singletons must be assessed in the same study with the same researchers using identical criteria. A more recent study was carried out by Davis and Annett (1994) in which data collected included information on handedness and twinnedness. From a sample of 33,401, 2.7% reported that they were born a twin. In terms of handedness,a greater percentage of left-handedness was reported for twins than for singletons. Davis and Annett

(1994) propose that gene expression is dependent on factors which affect and influence cerebral maturation in utero. The findings appear to support Annett's view that the right shift factor *"facilitates language development and might depend for its expression on factors associated with relative maturity at birth"* (Davis & Annett, 1994,p.109). Orlebeke, Koopmans, Boomsma and Bleker (1996) dispute Davis and Annett's (1994) findings in support of the RS+ model. Left-handedness in twins can also be accounted for by the presence of a left-handed relative apart from the effect of twin birth (p.480). However, the findings of Orlebeke et al's.(1996) study show increased left-handedness in first born twins, a factor that in itself may be genetically based,and which may be associated with low-birth-weight and birth stress. The genetic factors could act in concert so that the combination of left-handedness in mothers or fathers combined with birth-risk factors may create the condition for left-handedness in twin births (Orlebeke et al., 1986). Bishop (1990) also cautions that the flexibility of the right shift model is such that if the parameters are realigned a large number of data sets could be accommodated (p.45). According to Bishop,the model could be more rigorously tested by exploring family relationships in the distribution of hand skills, an issue that Annett regards as crucial to hand preference. However, obvious practical considerations emerge such as the assessment of hand skills in previous generations (p.45), which prevent further empirical investigation in this direction.

McManus and Bryden (1993) suggest that the understanding of how a gene for handedness evolved would be of enormous interest in understanding human evolution. However, biological genes are extremely rare, the only known and well-understood instance being that of the gene for the placement of the heart on the left side of the body (McManus & Bryden, 1993, p.693). Although the role of genetics in determining hand preference is widely acknowledged (McManus & Bryden, 1993). biological factors in handedness has gained increasing prominence in recent years.

Biological theories. One of the most important biological theories of handedness was introduced by Geschwind and Behan in 1982. The paper produced an immediate impact on the medical and scientific communities because of its radical proposals and its ability to account for male predominance in neurodevelopmental disorders such as autism and dyslexia. These researchers explain cerebral lateralization as a linkage with levels of fetal testosterone '*and with the functioning of the fetal and adult immune systems, and hence could explain a surprising range of putative associations between left-handedness and various diseases*' (Bryden, McManus & Bulman-Fleming, 1994, p.104). By 1987, Geschwind and Galaburda had published their findings and the theory later became known as the Geschwind-Behan-Galaburda (or GBG) theory. The theory is a wide ranging explanation encompassing a enormous array of neuropsychological and biological phenomena.

The GBG theory stated that alterations in the fetal levels of testosterone were seen as having many ramifications. Firstly, the higher levels of testosterone produce alterations in growth of the left cerebral hemisphere. From this a number of consequences flowed; language development would be affected which could produce impaired language, developmental dyslexia,stuttering or autism. The changes in left hemisphere function also resulted in, what Geschwind and Galaburda (1987) referred to, as anomalous dominance or a pattern of atypical handedness in combination with language lateralization and visual lateralization. At the same time the development of the right hemisphere is affected and a number of consequences are proposed. Cognitive abilities involving spatial ability, mathematics and music are modified by the changes (Bryden et al.,1994). In addition it is proposed that elevated levels of testosterone affect the thymus and this can result in disorders of the immune system. Thus, a four-way association between male gender,left handedness, developmental disorders such as dyslexia, and strong visuospatial ability is suggested within a single framework (Bishop, 1990).

The central concept of anomalous dominance is crucial to the GBG theory as it describes a pattern of handedness that differs from the standard form. The standard pattern of dominance proposed in the GBG theory is described as a strong left hemisphere dominance for handedness (strong right-hand preference) and language and a strong right hemisphere dominance for other abilities especially those of a spatial nature that are associated with males (Bryden et al.,1994, p.108). However, the pivotal role of the term anomalous dominance raised a number of difficulties. The most important is the definition of the term AD which has been loosely applied to left-handed, ambidextrous or individuals who show cross-lateral preferences for hand, foot and eye (e.g.Casey & Nutall, 1990; Chengappa, Ganguli, Yang, Schurin, Cochran, Brar & Rabin,1992; Schachter,Ransil & Geschwind,1987). Geschwind and Behan (1982;1984) succeeded in collecting data to substantiate their hypothesis although their results differ from other findings in the literature. There are controversial methodological issues surrounding Geschwind and Behan's findings (Bishop, 1990; Bryden et al., 1994). For example, a sample of 652 right-handed controls and 440 left-handed subjects responded to a questionnaire in which medical and personal details were required (Geschwind and Galaburda, 1984). Left-handers were recruited both in Scotland and from customers attending a shop, situated in London, which catered exclusively for left-handed people; right-handers were recruited in Scotland. Handedness was assessed with the Edinburgh Handedness Inventory and questionnaires were sent to shops for left-handers. Significant differences were found,with left-handers showing higher incidences of migraine,thyroid disorders and allergies. However, the method of sampling, largely self-selection, and differences in populations for right- and left-handers weaken the findings. A further study (Geschwind & Behan, 1984) consisting of a sample of clinic patients is methodologically more convincing. A significant difference was found for left-handers who showed a greater incidence of Crohn's disease, thyroid disorders, coeliac disease, ulcerative colitis and myasthenia gravis. However, studies attempting to replicate these findings have not been successful (e.g. McManus, Naylor & Booker, 1991; Salcedo, Spiegler, Gibson & Magilavy, 1985; Satz, Miller, Selnes, Van Gorp, D'Elia & Visscher, 1991; Schur, 1986; Van Strien, Bouma & Bakker, 1987). An exception is Smith's (1987) study which reported raised incidences of allergic disease in left-handed clinic patients, whose diagnosis had been confirmed, in comparison to controls who were recruited at railway stations. Overall, empirical evidence in support of immune functioning and incidences of left-handedness as suggested in the GBG theory has not been strongly supportive (Bryden et al., 1994).

The Geschwind and Galaburda (1987) perspective emphasises the male vulnerability of left hemisphere areas of language and reading, however, their theory also explains the contradictory evidence of male left-handers who show clearly superior skills. The factors that retard left hemisphere growth also accelerate the right hemisphere, boosting visuospatial skills (Bishop, 1990, p.156). Martino and Winner (1995) point out that the Pathology of Superiority, as the association has been termed (Geschwind & Galaburda, 1987) also extends to poorer verbal skills relative to higher spatial skills. Martino and Winner (1995) reported a greater spatial ability in left-handed males together with poor spelling skills. There are several weakness in this study that require mention. First, it is disputable whether global comments on verbal skills can be based on a spelling test. The support found for the GBG theory is slight, in addition, numbers are small (28 left handed males). Finally, subject selection was based on enrolment in college majors that emphasized either spatial skills or non-spatial skills, that is more language oriented work. As the authors point out, the spatial skills may have been enhanced through practice in the same way as their verbal capacity was less challenged. Is there evidence of left-handed male superiority in sports ? Wood and Aggleton (1989) examined left-hander's performance in sport. An analysis of highly ranked cricketers (bowlers and batsmen), tennis players and soccer players was computed. Only highly ranked cricketers, bowlers,showed a significant proportion of left-handers in their ranks. A practical perspective is that left-handers would have a greater advantage facing a right-hander. "*Because right-handers are more common than left-handers,the typical opponent will have had many years of practice against right-handed players and will have learnt to place the ball in positions they find difficult"(Bishop, 1990,p.156).* Thus, visuospatial superiority is not the major advantage but rather the knowledge and ability to place and anticipate the ball in a way that would outmanoeuvre the opponent. Porac and Coren (1981) analysed data from a number of studies and showed that in non-ball playing sport such as boxing,left-handers again appear to have a significant advantage over right-handers. Comparisons of left- and right-handers and their performance in sports such as archery or rifle shooting, which both require sighting skills, do not reflect any significant differences in performance (p.185). However, in sports such as basket ball, bowling and gymnastics, eye preference rather than hand preference would appear to raise the efficiency of the performance. Porac and Coren's careful analysis draws attention to the dominant skill requirement, which in some cases would be visual and in others hand-eye coordination. Voyer (1994) remarks that although the GBG theory proposes that AD in males is likely to produce increased spatial talents it does not account for the general trend in many males, regardless of hand preferences, for greater spatial skills. While it is true that all males may be exposed to higher levels of fetal testosterone the GBG theory cannot account for the mechanisms that bring about anomalous dominance in some but not all males (Voyer, 1994).

There are other aspects of the GBG theory that are also open for debate. For example, the notion of fetal testosterone levels as a variable is difficult to measure and monitor in humans. However, Clark, Robertson and Galef (1996) reported effects of perinatal exposure to testosterone propionate (TP) on 'handedness' in gerbils. The findings partially support the GBG hypothesis, in that forelimb use in treated gerbils differed from that of untreated controls. Nevertheless,Clark and colleagues (1996) report that it would be simplistic to suggest that increased exposure to testosterone results in increased expression of lateralized forelimb use in treated animals. In their view the effects of TP on lateralization are not as straightforward as proposed by Geschwind and Galaburda (1987,p.417). Best's (1988) model (see p.14) also implicitly supports the GBG theory in that she suggests that the effects of hormonal and genetic influences on the growth vector may give rise to biases in handedness and gender. The fact that these biases can be observed in specific populations such as the learning disabled, may be understood from the perspective of the GBG testosterone hypothesis (p.30). Thus,the question is whether the GBG theory can be viewed in a serious light. One particular area which does seem to have a high incidence of AD is autism. As Bryden and his associates point out, this may be taken as an indication of support of the GBG theory, however, Satz, Soper and Orsini (1988) hypothesize that severe early bilateral brain damage may prevent the establishment of manual dominance (usually right-handedness) and bring about the phenomenon of ambiguous handedness. Bishop (1990) and more recently Parlow, Kinsbourne and Spencer (1996) also support findings of elevated AD in mentally retarded populations. The increased incidence of AD is more than likely a reflection of mental impairment than any of the causal factors within the GBG model. Parlow and her colleagues reported that anomalous peripheral laterality (handedness) was not a predictor of IQ but did predict language ability. Such findings contribute further to the debate and although difficulties in validating this theory are apparent,it remains one of the most influential and pervasive theories of lateralization. - The only possibility for refuting the GBG model would be its replacement with a stronger model (Bryden et al. 1994).

Environmental factors in handedness. Several environmental factors are thought to contribute to handedness,for example,pre- and peri-natal trauma. In the Birth Stress Model of handedness,Bakan et al.(1973) argue that left-handers report a higher rate of peri-natal hazards than right-handers. This is because birth trauma, but specifically anoxia, can damage the giant Betz cells of the motor cortex,especially the left pyramidal area, resulting in contralateral dysfunction of the right hand. This raises several questions,not least is the assumption that all left-handedness is the result of brain damage (Bishop, 1990). Bakan and his co-workers's (1973) views would seem to support this approach as they suggested that the presence of left-handedness in groups might be seen as a sign or index of neurological insult at birth. One of the problematic issues with the Birth Stress Model is the lack of empirical support. Birth stressors such as anoxia have not been shown to have convincing associations with elevated left-handedness (Previc, 1996). However, links between left-handedness and birth stress have been observed in several studies of very low-birthweight infants (e.g. O'Callaghan, Burns, Mohay, Rogers & Tudehope, 1993; O'Callaghan, Tudehope, Dugdale, Mohay, Burns & Cook,1987; Ross, Lipper & Auld,1987). Ross et al.(1987) found that 47% of very low birthweight babies were left-handed at aged three to four years, in comparison to the 80% right-handed full-term babies studied. The non-right-handers in this study were also reported to have significantly lower IQs and impaired language when compared to the right-handed children. Ross, Lipper and Auld (1992) reported on the same group at aged seven- to eight-years and found decreased differences in handedness, in that mixed-handers had become more right-handed, but the incidence of left- and mixed-handedness was higher than the normal control group. Ross and her co-worker's findings showed that in the high risk group left- and mixed-handedness was associated with cognitive (full scale IQ) and behavioural (attention deficit with hyperactivity) deficits. These researchers suggest that the lack of right-hand preference in high risk samples of young children may be a marker of early left brain insult (p.493). In the current study the population, which is domiciled in Soweto and its close environs,are likely to come from circumstances in which low-birthweight deliveries, either full-term or premature, are prevalent (Cameron, 1993; Cooper, 1993). Previc (1996) has noted that the causal links between LBW and handedness are difficult to establish although he notes that prematurity, which is generally associated with LBW, may bring about left-handedness by *"preventing the establishment of vestibular asymmetry in the final trimester"* (p.450). A pragmatic influence highlighted in a recent paper by Ellison, Richter, de Wet, Harris, Griesel and McIntyre (1997) relates to inaccuracies in birthweight data which may decrease reliability and create difficulties in comparing findings. Birthweight data is a continuous variable and particularly susceptible to errors in transcription. Ellison and associates (1997) reported that the majority of errors resulted in the tendency to report birthweight to the nearest 5 or 10 grams although some errors for 50 gram discrepancies were recorded. On the other hand methodological issues require consideration. For example, a retrospective survey of previous research, which includes boys and girls, clearly demonstrates that birth stressors, such as prematurity or Caesarian section, show surprising small correlational values with handedness and account for less than 1% of the variance (Young, 1990). When the same research findings on the sexes are examined separately, only boys are shown to produce significant associations with birth stressors and handedness and almost always with one-tailed tests(p.91). Results reported by Ross et al.(1992) show that a history of prematurity and hand preference were significantly related to Full Scale IQ score and the presence of Attention Deficit Disorder at seven-years. Such children were also more likely to change their hand preference over time. Research by Nativ, Pratt, Allerd and Frank (1992) reveal that adult left-handers demonstrate a stronger reliance on subcortical processing in contrast to right handers who show greater cortical involvement. This would imply greater bilateral integration at lower levels of the central nervous system than previously thought and perhaps greater vulnerability of these areas in premature infants. However, further research is required in order to clarify the implications of these findings (Nativ et al.,(1992).

Coren (1995) points out that the connection between all left-handedness and pathology is misleading. Satz, Soper and Orsini (1988) have sought to clarify the issue by identifying three subtypes of left handedness:

1.The first subtype is that of pathological left-handedness (PLH). This group contain natural right-handers who,through factors such as injury or pathological growth affecting the left hemisphere suffer "hypofunction of the contralateral hand which in turn causes a shift in manual preference to the left"(p.282). The PLH type is usually found in epileptics who suffer early unilateral lesions although PLH can also appear in individuals who appear asymptomatic.

2.The second subtype suggested by Satz et al. (1988) are those with ambiguous handedness (AH). The AH group are usually found in a subset of the autistic population who have failed to establish manual preference. The term ambiguous suggests inconsistency within items presented for testing. The source is thought to be severe bilateral brain damage in natural right-handers which prevents or even arrests the development of manual preference. The AH subtype represents a subgroup that are more cognitively impaired than autistic children who have established manual dominance (p.283). Satz and his associates raise the possibility that the AH subgroup may also contain severely mentally retarded individuals.

3.The third subgroup represents the normal left-handers (NLH) in the population whose manual preferences are non-pathological but probably stem from genetic,or/and cultural sources (Satz et al. 1988,p.284). The NLH subtype seems to occur in about 8% to 12% of the population. In this latter group, there is little evidence to suggest a neuropathological substrate and there would be no prediction of either cognitive or developmental anomalies.

It would seem likely that links between left-handedness and pathological developmental trends might be associated only with the first two subgroups. Satz and his colleagues have amended the previous PLH model (Satz, 1972; Orsini & Satz, 1986) in that etiology of the NLH group (either genetic or environmental) is not specified (Previc, 1996). In addition, the concept of ambiguous handedness proposed by Satz and his co-workers has been widely accepted.

A slightly different perspective has been reported by Wassing, Siebelink and Luyendijk (1993) concerning the malfunction or maldevelopment of the corpus callosum and manual lateralization in spina bifida. Patients with callosal agenesis and spina bifida show patterns that would suggest interference with the normal course of hand lateralization. Spina bifida, in particular, may affect or delay the process of myelination of the callosal fibres. This in turn might result in a later more rapid catch-up by increasing the connections between the hemispheres. This could lead to greater bi-hemispheric representations thus accounting for the high proportion of non-righthandedness found in this group (p.795). It would be inappropriate to move away from a discussion on environmental factors without referring to the role of social pressures and handedness.

Social custom, social pressure and handedness. Other environmental pressures such as those based on social or religious factors are also relevant in considering manual preferences. As Harris (1992) explains "*The environment thus can be seen as providing the context and opportunity for the bias to be expressed and to develop into handedness*" (p.193). In some societies, social pressures may be more important contributing factors in determining handedness although the level of tolerance varies from one society to another (Bishop, 1990). African studies reveal a very low incidence of left-hand use although it has been hypothesised that urbanization would increase the incidence of non-right-handedness because of modifications in childrearing practices (Dawson, 1974). In his study of a Temne sample from Sierra Leone, Dawson (1972) reported 3.8% of the boys as left-handed and 0.00% of the girls, thus, raising the possibility that in this sample social pressures on girls to conform to right-handedness are greater. A similar pattern appears in the Verhagan and Ntumba (1964) study with Katangan school children. In this survey 2.13 % of the boys and 1.97% of the girls were left-handers. These researchers suggest that surveys of preschool children might be informative regarding early patterns of handedness in males and females. Early research on South African customs and traditions (e.g. Kidd,1906 in Bishop, 1990) report drastic measures such as the scalding of the hand of a child who showed strong left manual preferences. Current research in South Africa has not focused on handedness patterns neurodevelopmentally. From an anthropological perspective it is acknowledged that the implicit use of right-handedness takes place in a social/cultural context, that is the use of the right-hand only is acceptable when offering or receiving food, objects etc.from older members of the family or relatives (Hammond-Tooke, 1996,Personal Communication; Reynolds, 1996, Personal Communication). Differences in groups or tribes may vary in terms of strictness in adherence to etiquette and tribal custom. For example, Brain (1977) noted an higher rate of left-handedness amongst the Tanzanian Meru in comparison to other groups sampled in his study. In studies carried out in the Transkei,South Africa, Chierian (1994) and Elliot (1970) have commented on the strictness of Xhosa parents (a tribal group who are part of the Nguni speaking people of South Africa (Van Warmelo, 1974) in the administration of discipline both in encouraging academic achievement and in adhering to etiquette and social custom. In the current study the differences between groups living in an urban environment such as Soweto, in the maintenance of social custom or the etiquette of manual activities is worthy of consideration.

As previously observed,socially, some manual activities may be singled out particularly for censure against left-hand use, for example, eating, greeting, giving or accepting gifts (Payne, 1981 p.234). Bakare (1974) found that in Nigerian society, the offering of a gift with the left hand, even from a child, is unacceptable. Payne (1987) reported that in societies with rigid taboos against left-hand use there was an insistence on the use of the right-hand by specific groups. The Nigerian Muslim community, for example, appear to enforce strict rules regarding left-hand use generally, whereas non-Muslim adult participants in a survey showed greater variety of hand choice depending on the task. Payne's findings confirmed a range of tasks relating to manual preferences in eating and receiving objects from another person, demonstrating a strong right-hand bias for both Nigerian Muslim and non-Muslim participants. It would seen that most Nigerian adult participants believe that these activities should be performed with the right hand only (p.255). In a study of Nigerian children ranging from the first year to the seventh year of schooling, boys generally showed a greater incidence of left-handedness, 5.4%, in comparison to girls, 2.96%, although these figures are considerably less than those reported in Western societies (Payne, 1981). Brain (1977) reported a substantial right-handed bias in Tanzanian 12- to 17-year-old school children. In a sample of 2124 children only 31 left-handers were present, 23 males and eight females. At least 10.3% (219) of the sample reported being forced to adopt the right-hand. A 1964 study by Verhagen and Ntumba with Katangan children also supported the notion of enforced right-handedness. The rareness of left-handedness in the samples could stem from strict social pressures. This view is supported by Ardila, Ardia, Bryden, Ostrosky, Rosselli and Steenhuis's (1989) findings. In this study a rural 'permissive' indigenous hunting and fishing group was shown to be more mixed and right-handed but not left-handed. Contrary findings were reported by Dawson (1977) showing higher incidences of left-handedness in highly permissive hunting and fishing societies. It is also possible that environmental and genetic factors may integrate to determine the rate of left-handedness in a society although the way in which these mechanisms interact is not well understood (Bishop, 1990; Helligle, 1993). It is difficult to make predictions regarding the role of handedness, social conformity and developmental disorders, however, the developmental patterns in preferred handedness would be a useful area to explore.

Developmental Patterns in Handedness

Early signs of motoric asymmetry in neonates have focused on head turning and hand preference

(Saling, 1983;Young, 1990). The earliest lateral trends have been noted in neonates within the first 24 hours of life. The postural asymmetry, known as the tonic neck reflex,is characterized by head turning to either left or right, that is the preferred side, with concomitant ipsilateral extensions of the arm and leg (Turkewitz, 1977). The majority of children demonstrate a right-sided reflex which may be a biased movement and part of an innate postural neural response mechanism (Iaccino, 1993;Liederman & Kinsbourne, 1980). Early lateral biases of the tonic neck reflex may be the precursor of hand preferences as reported by Gesell and Ames (1947). Research reports on developmental trends in hand preference have been largely based on cross-sectional studies and report increasing right-hand preference with age (De Agostini,Pare, Goudot & Dellatolas, 1992) with greater stabi. t three years (Bishop, 1990;Tan, 1985). Bishop (1990) notes that early right biases in infanc, re a good predictor of later right-handedness although the implications of early left or neutral preferences are less clear and require further research of a longitudinal nature to extend the observations. A longitudinal study by Gesell and Ames (1947) tracked a small group of children from 8 weeks to 16 years and demonstrated that the pattern of preferred handedness "*does not take a straight line course*"(p.155). Although these researchers claim that their data reflect systematic shifts during the course of development. Bishop (1990) refutes these findings suggesting that the observations merely demonstrate a progression from random to more stable hand preferences. Liederman (1983) suggests that changes in handedness reflects fluctuations in the maturational rates of cortical and subcortical subsystems that control movement. A number of studies support a decreasing trend in mixed-handedness with an increase in age (Rice,Plomin & DeFries,1984;Coren,Porac & Duncan,1981;Longoni and Orsini,1988; McManus,Sik,Cole,Mellon,Wong & Kloss,1988). In a wide ranging study of the literature Young, Segalowitz, Misek, Alp and Boulet (1983) showed that the general developmental trend was towards right-handedness. De Agostini et al.(1992) reported that in a sample of preschoolers (mean age 4.35 for girls and 4.29 for boys) ambidextrous trends were more prevalent in boys,raising the possibility of weaker lateralization in males of this age group. Similar arguments were put forward by Orton in 1925 regarding mixed handedness and lack of cerebral dominance as the core problem in poor male readers. Although Orton did not offer any hard data to substantiate his claims, his theory has been influential and still continues to receive substantial support despite the lack of empirical evidence. Thus,the course of development of the hemispheres and the causes of mixed-handedness or leftward manual preferences are probably more complex than previously imagined (Young, 1990). It has been argued that a substantial proportion of debate stems from the approaches and measures used to infer lateral preferences (Dean, 1988).

The degree and stability of handedness in children are frequently overlooked,but the kind of task or tasks used to elicit responses is an important aspect (Bishop, 1990;Salmaso & Longoni,1985). Usually,questionnaires are given to children whose mental age is ten years and above. Younger children may have difficulty in reading instructions and instead are usually requested to perform or mime the tasks (Bishop, 1990). In considering the range of activities used for establishing handedness in children several factors need to be taken into account. The child must have practice in some of the complex activities (e.g. dealing cards or lighting a match) used to assess preferences as handedness consistency is largely the result of neuromotor maturation and familiarity (Bishop, 1990; Brito, Lins,Paumgartten & Brito,1992;Salmaso & Longoni,1985). Bishop (1990) also points out the inaccuracies in measuring hand preference that can occur by grading across activities. For example,three out of four activities carried out with the left hand will be graded as mixed whereas temporary labile shifts in handedness may well be graded as dominance established. Instead, Bishop(1990) suggests that developmental patterns may involve a gradual stabilization for a given activity with greater consistency of hand preference across a range of activities (p.64). This could be established by a longitudinal study in which hand preference consistency can be assessed by presenting the same activities. What will change with age becomes the focus of preference (Bishop, 1990). Gesell and Ames' findings have not been replicated and the small number of participants in the study tends to weaken their arguments as more factors influencing development become evident. As an example, Liederman (1983) suggests that early infant hand preference may simply reflect the relative maturity of medial and lateral motor areas. These systems control arm and fine motor movements respectively and require consideration when exploring lateral preferences especially handedness in infants. The role of developmental motor maturity and handedness has yet to be examined in other cultural environments although developmental differences have been acknowleuged. Mwamwenda (1995) for example, draws attention to the precocity of African infants' physical developm ent for grasping objects and locomotion in comparison to their Western counterparts. The implication of such early maturation processes are as yet unclear. More useful information regarding handedness may be extracted from children who are at least three years-old (Bishop, 1990). Research supports the trend of less lateralization at this age so that findings associated with handedness should be regarded with caution (Curt, Maccario & Dellatolas, 1992). For instance, Tan (1985) established that immature (or ambiguous) hand preference in preschoolers was linked to lower levels of motor skills. Such children may require early identification so that early motoric skills training can be implemented (p.124). In addition, Tierney and her colleagues (1984) reported a link between unestablished hand preferences and low scores on the Cognitive Index of the McCarthy Scales in four-year-old preschoolers. From this evidence, young children who show consistent hand preference seem to be superior, cognitively and motorically, to their less consistently handed peers (Gabbard, Hart & Kanipe, 1993).

Gesell and Ames' (1947) paper suggests that varying patterns of unilaterality and bilaterality are hallmarks of development in the preschool years. At three years "*unilaterality of one sort or another predominates in all cases,but there is a good deal of bilateral behavior in at least half the cases*" (p.165). At five years"*the right [hand] definitelv predominates and the left is almost completely passive*". *(p.166)*. This pattern suggests that a child who is consistently left handed at three years could become right-handed at a later age,with increased incidence for boys (De Agostini et al. 1992).

Developmental handedness patterns for boys and girls have been reported to differ. Brito and his coworkers (1992) reported distinctly different patterns in children aged between four and seven years. More specifically boys were more likely to demonstrate more mixed and less right-handed bias than girls,a finding which has been observed in other studies (Bryden, 1977;Chapman & Chapman, 1987;Lansky, Feinstein & Peterson,1988;Plato, Fox & Garruto, 1984). Harris and Carlson (1988) suggest that the "*developmental pathway for handedness appears to be more 'canalized' in females (p.312)*. This again confirms the notion that males are more likely to show diverse patterns of handedness and would seem to show support for the Geschwind and Galaburda (1985) theory as discussed above.

Laterality Patterns

The development of patterns of lateral preference in addition to handedness has received attention. Other overt behaviours such as footedness and eyeness may also reflect characteristic trends in the development of lateral preferences. According to Iteya and Gabbard (1996) preference for foot and eye can also be described either in terms of congruence, that is a preference for right-hand,right-foot and right eye, or cross-lateral patterns when eye-hand or eye-foot preference are different. Iteya and Gabbard state further "*The underlying premise is that those who are* *strongly lateralized (to the right) exhibit more pronounced functional asymmetries than their peers with inconsistent lateralization" (p.31).*

Foot preference seems to show a high stability, it can be associated with handedness and may be an example of motor laterality that is relatively uncontaminated by practice or training (Peters, 1988). Footedness refers to the preferred foot for kicking a ball, or stepping on a small object. Although footedness has not been researched as extensively as handedness it has been shown to correlate highly with handedness and eyeness (Porac & Coren,1981). At least two studies have reported the establishment of right-footedness in preschoolers aged 4-and 5- years (Belmont & Birch, 1963;Sinclair, 1971). Researchers such as Peters (1988) argue for the inclusion of foot laterality measures in neuropsychological assessment although the type of tasks selected, especially for young children, would require thoughtful consideration and observation. This is best illustrated by Freide's (1978) study of footedness in children. Specific differences in children's foot skills,for instance, skill in hopping on the right or dominant foot may co-occur with extremely weak performance on this task with the left foot. Invariably a child who demonstrates this pattern will use the left foot to kick a ball and can be incorrectly assigned dominant status to the same foot. As Freides observed "..*what was happening was that the intact side was given the prior task of maintaining the body upright so that only the side with the lesser capacity was available for kicking* " (p.134). In this instance dominance can be a demonstration of other underlying motoric problems. Freides' observations cast some doubt on the validity of foot preference measures in preschoolers although the documentation of foot preference at several points in time, as occurring in the current study, may provide further developmental information. Bishop (1990) advocates the inclusion of footedness measures,as the lower limbs seem to be more affected by neurological insult and may therefore be a sensitive index of neurological impairment.

The use of eye dominance measures has been a source of debate as the visual system is structured in such as way that each ey .iformation to both hemispheres. In their discussion on eye preference, Porac and Coren (1981) point out that the measures for establishing eyeness probably reflect acuity dominance. Thus, the dominant eye is the one that usually shows better performance on a visual task. Bryden (1977) distinguishes between acuity and sighting dominance although acuity dominance is positively but non-significantly related to sighting dominance, the latter is significantly correlated with handedness (p.430). Bryden's distinction is task related in that the stimuli presented to his subjects necessitated both acuity and sighting responses to letters and dots. The majority of tasks, especially for younger children, determine eye preference by observing the eye used for sighting through a telescope or looking through a keyhole. Porac,Coren,Steiger and Duncan (1980) caution that sensory laterality processes,such as eyeness and earness, and motoric processes,such as hand and foot,should not be regarded as common indices of laterality. Nevertheless,Bryden (1977) reported a clear effect for laterality of eyeness (sighting) and handedness in a letter recognition task. Although no relatic ship could be established with other lateral effects,specifically in the auditory modality, Bryden suggests that both visual and auditory lateral signs may be related to 'general lateral linguistic mechanisms'(p.433). This is especially pertinent for visual processing of tachistoscopically presented verbal material, which may be tapping into the functioning of the left occipital and posterior parietal areas but are more suitable for studies with older children and adult subjects.

Friedlander (1971) found strong correlations between eyeness and handedness in right-handed adult subjects. Dawson (1972) reported that fixed dominance or congruence (right hand/right eye) is more common than mixed dominance. Hebben,Benjamins and Milberg (1981) found that right-handers were more likely to be right-sighted,while left-handers were ei her right- or left-sighted. These researchers argue that although handedness and eyeness are not related in a 'straightforward manner' (p.445) further efforts are required to determine how these measures may be related to cortical dominance. The notion of crossed hand/eye pattern, although arguably emanating from different motor systems,has been found to be extensive and stable enough to warrant consideration in terms of children's learning processes and development (Whittington & Richards, 1987). Bishop (1990) indicates that eye-hand coordination plays an important ro... in skilled tasks so that the developmental status may be an interesting aspect to observe in preschool children hence its inclusion in the current study.

Hand Skills

Hand skills are usually assessed in terms of speed and dexterity. Bishop (1990) reported that hand precision skills were the best predictor of consistent hand preference. Annett (1992) cautions that some measures of hand skill do not always correlate with hand preference. However, a specific task such as peg-moving has been found to correlate strongly with hand pre... and can provide useful distinctions in the degree of handedness skill and handedness direction. Other tasks which have been found useful in exploring hand skills are writing and drawing although these tasks can only be used with children whose handedness is sufficiently differentially developed (Harris & Carlson, 1988). Annett (1970) found a marked right-hand superiority for ...ng preschoolers on a peg-board task although skill and speed continue to improve with age. Tests of handedness dexterity and skill have been used to compare different clinical populations. Badian and Wolff (1977), for example, investigated motor sequencing skills in learning disabled boys. Specific problems in maintaining stability for alternating movements were found which were attributed to developmental delays in interhemispheric cooperation (p.348). As observed in the preceding discussion,the relationship of hand dominance to other cognitive asymmetries is complex,far from perfect and somewhat controversial (Helligie, 1993). Berman (1977) reported that a strong positive relationship was found between cerebral dominance and intelligence (p.381). Workers such as Wassing and his associates (1993) believe *"hand preference has been known to show some relationship with the pattern of specialisation. In particular left and mixed-handedness would seen to indicate greater bi-hemispheric representation of cognitive function"* (p.795). Annett (1992) maintains that intellectual ability is not independent of laterality. Certainly there is a higher than normal incidence of non-right-handedness, but also mixed laterality (handedness, footedness and eyeness) in dyslexics,autistics and epileptics (Bishop, 1990; Curtiss, 1985). - Even in normal children the presence of mixed or cross-laterality patterns produce poor intersensory integration (Dean & Rothlisberg, 1983). Some researchers believe that lateral preference may simply be a `soft sign' and have little relevance for understanding cerebral specialisation and development (Hynd,1995,Personal Commu..cation). Nevertheless, lateral preferences but specifically handedness, is regarded by some workers in the field as an important influencing factor, together with age and sex, in the pattern of developing cerebral specialisation (Curtiss,1985:Shapiro & Dotan,1986). More specifically, right-handed children appear to show greater lateral specialisation and left hemisphere dominance than left-handers who may have greater bilateral representation of function (Shankweiler & Studdert-Kennedy, 1975; Shapiro & Dotan, 1986).

Thus,it is apparent that lateral preferences remain an area of focus in motor and skills development. Handedness specifically has been studied, firstly, in terms of the relationship with cerebral or nization, secondly exploring the hypothesized relationship with cognitive deficits and finally, the patterns of development and environmental factors, such as social influences,in various populations. The signs associated with aberrant patterns of lateral preferences but especially handedness are becoming increasingly important in clinical populations. As Harris and Carlson

(1992) point out "*...what is needed now is to assess these signs with cognitive tests that have been validated as measures of left- and right-hemisphere functions.*" (p.359). In the following chapter discussion will focus on such tasks and the theories surrounding them.

Summary. The main points in this chapter are summarized. Handedness has been recognised as an important neuropsychological phenomenon in its own right. Manual preference has engendered much controversy over the years. Biases in handedness, towards sinistrality, have occurred over the years so that many developmental disorders have been associated with non-righthandedness. However, many of the controversies and confusion could stem from methodological errors. Research findings support the notion that in the majority of children,manual preference develops in an increasingly rightward direction. On the other hand, the course of development of foot and eye preferences has not been well documented. The development of handedness may be affected by genetic,biological, environmental and perhaps relevant for the current sample, social pressure and etiquette. Handedness has been associated with a variety of phenomena but especially cerebral organization and cognitive abilities. The measurement of handedness in preschoolers requires careful selection of age appropriate measures. Hand skills have been cited as influencing the direction of handedness, the greater the skills the greater handedness consistency. In the following chapter the discussion will focus on cognitive tasks that could be linked to neuropsychologyical theories of brain and behaviour.

CHAPTER 3

INFORMATION PROCESSING:THEORETICAL BACKGROUND AND APPROACHES TO BEHAVIOURAL ASSESSMENT

In this chapter three issues are addressed (1) the theoretical background from which the origins of information processing theories in neuropsychology have been drawn; (2) Luria's theoretical perspective on information processing which is emphasised in Das and Naglieri's (1997) assessment of children's cognitive abilities; and (3) an assessment battery by Kaufman and Kaufman (1983), the Kaufman Assessment Battery for Children (K-ABC),which draws on several theoretical models but specifically the cerebral specialisation information processing approach. In the first instance,the aim of this chapter is to provide theoretical debate and to explore the origins of the information processing approach as a background for understanding mental ability from a neurodevelopmental perspective. A further aim is to examine the two specific models of information processing and the respective measuring instruments available in terms of (a) the extent to which they can incorporate the dynamic interaction between brain structure-function and (b) the extent to which the role of prerequisite experiential factors of the testing instruments prejudice performance.

Because brain organisation of developing children differs from adults,an understanding of neuropsychological organisation in childhood requires a prerequisite knowledge of the dynamics of neurological functional and structural systems (Hynd & Willis, 1988). Developing children are in the process of ongoing acquisition of a variety of skilled behaviours, both for daily functioning and for educational purposes. In addition, consideration of social and environmental influences in the development of brain organization are important factors (Segalowitz & Hiscock, 1992). However, a large proportion of child neuropsychological research has addressed pragmatic problems such as the consequences of brain damage at an early age on later development. For example, a classic study is that of Teuber and Rudel (1962) in which brain injured children were followed-up, assessed and observed over a ten-year period to determine the effects of the brain insult on cognitive functioning. At the end of the ten-year period the researchers reported a variety of outcome patterns of either slow recovery or consistent impairment or behavioural deficits. A perplexing finding was that many children showed all three patterns of behaviour depending on the task involved (Horton & Puente, 1990). These observations illustrate the complexity of developmental factors in neuropsychology, and while such studies are worthwhile they appear fragmented and incomprehensible without a neurodevelopmental framework to unify them. Linked to this notion is the need for assessment techniques for all children that are not only culturally valid but sensitive to the environmental factors that influence development (Boivan, Chounramany, Giordani, Xaisida, Pholsena, Crist & Olness, 1996). As Adelman (1978) points out the absence of valid indicators of early developmental problems can either prevent practitioners from making meaningful interventions or result in mislabelling or stigmatizing outcomes.

Information Processing

Information processing models have been used in cognitive psychology for the past three decades as a means of challenging the fixed and static nature of abilities as elicited via intelligence testing, with a more flexible and dynamic approach (Aysto, 1988). From an information processing perspective, the decoding, encoding, combining, storage and retrieval of information is the focus. From a developmental perspective, the question raised is how these processes change with age, that is if they do change, and if so what would cause such changes? (Sternberg, 1994). Several approaches to information processing have emerged over the years, in that theorists adopt either a broad information processing approach or a domain specific focus. For example, a domain specific cognitive information processing model focuses on analyses of reading and its disorders. Frith (1985) proposed a three stage information processing model for reading development. However, its usefulness is limited in the current study, as its focus is narrowed to a domain specific kind of behavioural output, reading and reading aberrations in children. The implicit requirement is an understanding of the brain prerequisites for reading skills.

Attempts to understand general information processing from a cognitive developmental perspective have focused on variations in performance task times between adults and children (Hale, 1990: Kail, 1986). Developmental differences observed have been attributed to variations in speed of a cognitive (such as word retrieval) rather than a peripheral nature (such as motoric speed). Hale (1990) suggests that apart from theoretical considerations, mathematical differences in speed can be precisely computed as a means of understanding developmental differences in processing speed. Response latencies can then serve as cognitive benchmarks for different age groups (p.662). Researchers such as Davis (1997) assert that a general speed component is a vague benchmark. Although speed of processing is related to IQ, it does not change with age. Instead, specific factors such as motor and attention components improve with age and enhance performance (Davis, 1997). Clearly the nature of the tasks are also important in attempting to link specific aspects of performance to development. Kail (1986) used two distinct tasks, mental rotation and name retrieval to estimate age differences in the range 8 years to 21 years in males and females. Kail reported that growth function for both tasks is `*...better characterized by an exponential function than by the hyperbolic function that typically characterizes practice or learning '(p.984)*. Comparisons between adult and child performances on the same tasks elicited a central limiting developmental mechanism in younger children, linked more to the mental resources available, possibly attention or memory storage capacity, for the execution of cognit' processes (Kail, 1986). This suggests that the quantity of information processing would seem to increase with age. However, Kail's data were based on a cross-sectional sample which is limiting in terms of the individual developmental differences that might be observed in longitudinal research.

The current chapter focuses on mental processing abilities from a brain-behaviour perspective. The discussion will initially review theory and models with the aim of tapping information processing along two axes in the developing brain, that is the left/right axis and the a rior/posterior axis. The left/right or lateral axis represents the two cerebral hemispheres and their hypothesized contra ing information processing systems. Within this model it is posited that each hemispheric system possesses its own efficient way of dealing with information (Holmes, 1988). The posterior/ anterior brain axis contrasts two aspects of function and information processing. The executive, that is higher order cognitive functions and motor control or generally the output functions, are attributed to the anterior area (Holmes, 1988). The posterior area is thought to be a `storehouse of knowledge' (p. 122) as it is effective for input, that is the reception and storage of information

(Holmes, 1988). The origins and theoretical underpinnings of the anterior/posterior approach will first be explored in a functional systems theory. The most comprehensive theory of brain structure and function is that of Luria (1973). However, this theory might be more accurately described as a system, a broader structure "*in which theories are often couched*" (Moehle, Rasmussen & Fitzhugh-Bell, 1988 p.145). Information processing in terms of anterior/posterior brain divisions, and cerebral lateralization (right brain/left brain differences) theories are regarded as part of this system (Moehle et al. 1988). From a neuropsychological perspective, there is the lack of research linking brain structure and cognitive processes. Prather and Gardner (1992) point out, however, that brain and behaviour relationships imply more precisely *brain-cognitive* relations (p.419). Das, Kirby and Jarman (1975) have used neuropsychological theory as an anchor for their research in information processing theory and their approach is one of the main areas for discussion in this chapter. Das and colleagues (1975) suggest that it is appropriate to search for the physiological bases of cognitive function in the brain. However, they emphasize that such a physiological base must contain the capacity for flexibility and versatility in dealing with multiple aspects of cognitive content (p.88). Elaborating and exemplifying further on this view, Das and his associates (1975) single out the brain structures underlying speech and language areas. It is explained that the presence of these structures is crucial for speech and language ability however, their presence also provides and sustains a diversity of linguistic processes that will determine the manner in which a cognitive task is performed. Thus, cognitive processes, "*In a limited sense*" (p.88) can be broadly linked to cortical areas with information 'arriving' through receptors (eyes, ears or skin, for example) either over time (or serially) or concurrently (synchronously) (Das, Naglieri & Kirby, 1994, p.19). This gives rise to distinct modes of processing which can be associated with specific cortical areas, namely the anterior and posterior zones of the cortex. At the heart of the approach there is a close dependency on Alexander Luria's (1973) basic concepts related to functional systems in the brain. Luria's conceptualization of a three unit brain from which cognitive processes arise is not a developmental theory. Several researchers (Hooper & Boyd, 1986; Morgan,1988) have noted that developmental factors are implicit within the Lurian framework. This is largely because the hierarchial structures described by Luria (1973) suggest a sequence of development over time (Hooper & Boyd, 1986). In the absence of well-researched stage theories of development such as Piaget's, neuropsychology and especially child neuropsychology must retain existing frameworks as a point of departure.

Luria's Three Unit Theory of Brain Function

Luria (1973) proposed a three unit brain in which the functional systems involve components associated with each unit. The principal units comprise subcortical, posterior and anterior cortical divisions of the brain, with the incorporation of basic functions, which, while mutually interactive, remain basically distinct (Hynd & Willis, 1988). Thus function is not conceptualized in terms of end products of activity but rather as a complete system of coordinated and neurological activities.

The first unit, comprising subcortical structures but particularly the brainstem reticular formation, is functionally regarded as an arousal unit. In ontogenetic terms this unit functions from birth and controls wakefulness, attention and arousal from sleep. Disruptions in this unit would compromise the efficiency of information processing and regulation of behaviour. Luria (1973) described the functional specialisation of the unit as the maintenance of cortical tone, in addition to interaction with the cerebral cortex to also experience descending [fibres] regulatory influences. It has been suggested that this functional system is particularly vulnerable to damage in the prenatal period (Morgan, 1988) and can result in deficits of attention and hyperactivity (Douglas, 1983).

In the second unit the associated structural substrata include the cortex of the temporal, occipital and parietal lobes. These cortical regions have extensive connections with subcortical areas (via projection fibres) and with adjacent cortical areas, including the anterior cortical unit. There are also extensive interhemispheric connections via the corpus callosum. In this unit there is a hierarchy of primary, secondary and tertiary areas. The tertiary zone is associated with the integration of polymodal information. Functionally, this unit is specialised for the reception, analysis and storage of incoming stimuli, the processing of information. Disruptions here will affect or be affected by attention and arousal, functions associated with the first unit (Das & Vernhagen, 1986).

Ontogenetically, the primary cortical zones appear to be mature at birth (Luria, 1980). In the early developmental stages direct and associative sensory processes are dominant (Vygotsky, 1978). The maturation of the secondary areas corresponding to the primary areas takes place allowing a higher level of perception and integration of incoming stimuli and output to take place (Morgan, 1988). These secondary zones are posited as the initial sites of learning. Goldin (1981) suggests that the tertiary zones (largely located in the parietal lobe region) become active from the age of five to eight years, coinciding with the beginning of schooling. The crucial processes of cross-modal integration for reading, writing and mathematics skill acquisition, mature and educational problems in these areas now become apparent (Morgan, 1988).

The third unit comprises the frontal regions of the brain demarcated from the second unit by the central sulcus. The anterior unit three is morphologically distinguished from the posterior cortical unit two and is specialised for planning, programming and verifying overt and covert behaviours and the regulation of states of attention and activity (Hynd & Willis, 1988). The frontal brain region has extensive cortical and subcortical connections. The subcortical connections include the basal ganglia, thalamus, reticular formation, and cerebellum. The cortical areas are connected by fasciculi,bundles of nerves,to the parietal (Cingulum and Superior longitudinal),occipital (Inferior occipito-frontal and Superior Longitudinal) and temporal (Arcuate,Inferior Occipito-frontal,Uncinate) lobes. Together with the interconnecting commissures, chiefly the corpus callosum, there is strong evidence for the interconnectedness of Luria's three functional units (Hynd & Willis, 1988).

As observed in the second unit there is a hierarchial relationship comprising the primary, secondary and tertiary zones. However, unlike the second unit there is only one primary zone, an agranular cortex corresponding to Broadmann's area 4. The secondary areas of the third unit correspond to Broadmann's areas 6 and 8. The structural substrata of the tertiary zone are the prefrontal parts of the cerebral hemispheres. These areas are characterized by the absence of the giant pyramidal cells, which can be found in the motor and premotor areas of the primary and secondary zones. Thus the tertiary zone is often referred to as the granular frontal cortex (Luria, 1973). Functionally, it guides and influences the primary and secondary areas (Luria, 1980). Much of what is known about this third unit particularly, and functional systems generally, is largely based on Luria's clinical observations of brain damaged adult patients (Kolb & Whishaw, 1996). His explanation of brain function has been challenged on several issues, not least is the assumption based on a hierarchial organisation,that information is processed in a 'simple feed-forward' fashion (Kolb & Whishaw, 1996,p.171). The functional organisation of cortical areas into hierarchial order as posited by Luria has also been debated as it has been speculated that the number of specialised domains for vision,auditory or somatic, may be greater than originally suspected (Changeux & DeHaene, 1993). For example, Rakic and Singer (1988) reported that the primate brain contains at least a dozen representations of the visual world and about six representations were noted in auditory and somatic areas. Luria's theory has gained popularity because of its relatively simple presentation of brain function based on known anatomical organisation of cortical areas (Kolb & Whishaw, 1996). Advances in knowledge of physiological and anatomical brain structures will require further revision on how the complexity of cortical organisation is integrated.

Luria's Theory and Developmental Implications

Although it was previously noted that Luria's model of brain function is not a developmental theory, it has developmental implications. The formation of working secondary zones, especially in the second unit, could not take place without the integrity of the primary areas (Luria, 1973, p.74). Similarly the development and functioning of tertiary zones are dependent on the intact function of the secondary areas. Clearly, during development the process of maturation of cortical areas is reliant on physiological and functional changes (Hooper & Boyd, 1986). Thus, neurodevelopment would seem to take place in stages with the largest growth period in the six- to eight- year-old phase (Passler, Isaac & Hynd, 1985; Welsh, Pennington & Grossier, 1991). If Luria's theory is considered in developmental steps the following stages are proposed by Hooper and Boyd (1986, pp.19-23):

-Stage 1 would involve Unit 1 and the reticular activating system (RAS), which develops primarily in the prenatal stage and is fully operational at birth.

-Stage 2 would involve the three main sensory modality primary areas, visual, auditory and somaesthetic of Unit ll and the primary motor area of Unit lll. By birth all the primary areas are operational, and most reflexes, which require both sensory and motor functions, are present in the neurologically intact child at birth (Morgan, 1988).

-Stage 3 develops concurrently with stages 1 and 2 but continues into the child's fifth year. It is during this stage that the secondary cortical zones, corresponding to each primary zone, mature and becomes functional. Thus, more complex integration of sensory input and output replaces the more primitive sensori-motor activities of the previous stage (Morgan, 1988).

This is marked by the increase in verbal skills which,according to Goldin (1981) could be seen as an indication of the early phase of the lateralization process. It could be argued that language development is a process that starts early in the post-natal period beginning with auditory intake (or receptive skills) long before the expressive activities apparent.

-Stage 4 sees the development of the tertiary zones of Unit ll. These zones only become active when the child is in the five to eight-year-old range (Goldin, 1981). The role of environment may emerge as an important determinant within this stage. With tertiary integration skills active,abilities in cross-modal processing increase. As previously observed, this is crucial to the acquisition of reading, writing and mathematics and it is at this stage that difficulties in learning first appear in apparently `normal' children.

-Stage 5 is characterized by the development of the tertiary area of Unit lll located in the prefrontal areas. According to Luria (1980) this is the main integrative and regulatory unit of the brain and does not become active until the child is between the ages of four to seven years. This area continues to develop through to early adulthood. Although stages of prefrontal development have been proposed from six to eight years,measuring methods have relied largely on adult tasks (e.g. Welsh et al.,1991), and more appropriate and reliable assessment procedures for children have yet to be devised.

Attempts to link Luria's theory to developmental stages raise several concerns the most important of which is the lack of empirical evidence. For instance, Hartlage and Telzrow (1986) maintain that although Luria's theory implies a developmental hierarchy, there is no direct and unvarying relationship between the three brain units or the primary,secondary and tertiary zones. Consequently, it is not consistently possible to predict from one developmental stage what the behavioural status will be at the next. This is especially pertinent when those functions might be subserved in different ways by different functional systems. For example, attention deficits in preschoolers, which is subserved by the first functional unit, may diminish when the tertiary area of the third functional unit exerts inhibitory control. Milich (1984) reported a lengthening of attention span in children in comparison to previous developmental stages. On the other hand, language is an example of a hierarchial process in which early problems may impinge on later higher order skills (Hartlage & Telzrow, 1986).

With adults, the integrity of functional systems can be investigated by applying a series of tests e.g. Luria's Neuropsychological Investigation (Christensen,1975) in which the components or interconnections of symptoms can be identified using qualitative clinical methods. This detailed analysis or syndrome analysis approach is believed to demonstrate that the integrated activity of a functional system is intact (Luria, 1980). The question is whether Lurian techniques could be used in the assessment of children. Although a children's battery of Lurian tasks has been established (Luria-Nebraska-Neuropsychological Test Battery for Children (LNNB-C), Goldin,1981),it has generated criticism on several levels. In the first instance it has been suggested that the tasks are merely simplified versions of adult tasks, which casts doubt on the adherence to a developmental model (Hynd & Willis, 1988). Goldin's (1981) own view that children are simply less skilled than adults on some tasks, tends to support this critique. The second issue is the notion surrounding the development and maturation of the anterior tertiary zones by the test developers. Goldin (1981) asserted that this area does not make a functional difference until adolescence although more recent research does not support this view (e.g.Passler, et al.,1985;Welsh et al., 1991). The third issue that emerges with the use of LNNB-C (Goldin,1981) is that the psychometric measures do not reflect Luria's theory accurately. Finally,it is not possible to determine whether failure on a task is due to developmental delay or to deficits (Hynd & Willis, 1988). In this latter context,performance on tasks using the LNNB-C reflects no more than success or failure and little is understood about the cognitive processes employed. As Hynd and Willis (1988) have noted, the growing child has a rapidly developing nervous system which so far has confounded the study of neuropsychological functions. Although Lurian assessment techniques do not seem to lend themselves to assessing children from a developmental perspective, Luria's theory has provided the neuropsychological framework for developing a model in which cognitive processes are described and at the same time incorporating the principles of information processing (Das & Varnhagen, 1986).

Information Processing:The Luria-Das Perspective

Based on Luria's theory, Das and Varnhagen (1986) suggest that all cognitive and motoric behaviours require the integration and coordination of the three functional units. Even a simple task such as drawing a circle requires integrated arousal of muscle and cortical tone which enable contraction of arm, wrist and finger grasping movement. While sufficient arousal is crucial for drawing a circle, over-arousal can diminish performance. This could be the result of an excessively tight grasp which could produce flawed performance and adversely influence behaviour (Das & Varnhagen, 1986). On the other hand underarousal may affect performance in other ways in that there is poor grip and control of the pencil and performance is again adversely affected. Das and Varnhagen maintain that both voluntary and involuntary movement "*cannot be accomplished merely by activation of efferent nerves in the cerebral cortex"p.123),* but require integrated input from many areas of the brain, a view that is based on work by Soviet physiological researchers (Luria, 1970). In addition, voluntary movement also integrates information comprising spatial analysis and sensory feedback which is required in the coordination of orchestrated movement. Sensory and spatial areas of the cortex, specifically those in the second unit will contribute to all spatial movements and impede the drawing attempt resulting in, for example, distorted shape. Finally, implicit in all voluntary movements is the element of a plan or intention. The formulation and regulation of movement of fingers,wrist and arm are the domain of the third functional unit of the brain. Lack of intentional planning will result in loss of voluntary movement, whereas lack of regulation will result in repetitive or aimless movements. Thus, even the most simple behaviours require the integration and coordination of all three functional units in the brain. Luria's theory of a concertedly working brain lays down the basis for a process approach for understanding the underlying neurological substrata which produce a variety of processes for cognitive and motoric behaviour (Das & Varnhagen, 1986). Two distinct modes of information processing accomplished by the second functional unit but also coordinated by the first (arousal) and third (planning) units, are proposed. The information processing approach, as proposed by Das, Kirby and Jarman, (1975) integrates the clinical neuropsychological findings of Luria (1966) with mental processing. Aysto (198?) notes that an information processing approach is well suited to Luria's theory where functional systems are seen as a working constellation of activities that are dynamic and changing due to environmental influences. Luria (1966) drew extensively on the original work on perception by I.M. Sechenov, a Moscow physician. In 1878,Sechenov proposed a physiological theory, based on animal experimentation,of how mental processes might operate within the individual. According to Sechenov, perceptual processes were guided by two principles:auditory perceptions,which require the combination of individual sounds into an integrated successive temporal series;visual and tactile sensations which are integrated into composites of stimuli that are of a spatial simultaneous combination (Das & Varnhagen, 1986). Luria's (1966) work extended that of Sechenov in that he explored two modes of synthesis,verbal and non-verbal, across processes such as memory and perception. According to Luria (1966) there is strong evidence for distinguishing two basic forms of coding information that are responsible for the acquisition, storage and retrieval of knowledge. The major differences in the two types of processing is the manner in which the information is organised. A simultaneous mode applies to information that is organised into gestalt or holistic schema. A successive mode refers to information that is processed in serial fashion,thus focusing on the processes by which stimuli are synthesized. Based on Luria's (1973) clinical investigations with brain injured adult patients, the neurological regions cited include areas of the parieto-occipital cortex for simultaneous processes and the fronto-temporal area for successive synthesis. However, other investigators (e.g.Gazzaniga, 1984) disagree with the neuroanatomical divisions applied to the two processing modes. Instead it has been suggested that the neurological substrata involved in the two modes of processing might be related to differential cerebral hemispheric functions (Hynd & Willis, 1988), a lateralizing process along a different axis. This approach will be explored later in this chapter, however, it is important to raise this debate as it challenges the cortical-axial division of successive and simultaneous processing modes, that is the coronal as opposed to the sagittal. As Hynd and Willis (1988) point out the position remains equivocal.

Das and his colleagues draw substantially on Luria's functional systems theory in documenting information processing and the developmental course of higher order cognitive functions (Hynd & Willis, 1988). Researchers have viewed information processing from a clinical neuropsychological dimension by careful analysis of stimulus material and the possible differential neurological substrata subserved, by factor analytical investigations (Das,Kirby & Jarman, 1975; Das & Varnhagen, 1986). Das and his colleagues believe that although their adapted model relies on the neuropsychological aspects as proposed by Luria's theory,there is a stronger emphasis the cognitive aspects of processing. Ongoing research of simultaneous and successive processing constructs in the Luria-Das model, suggest their robustness in withstanding tests and analytical techniques (Hynd & Willis,1988). The initial description was that of an information processing model adapted from Luria (Das et al., 1975);a later description was that of an information-integration model (Das et al.,1979) and recently the theory has been renamed as the Planning-Attention, Simultaneous,and Successive (PASS) model (Naglieri & Das, 1987;Naglieri & Das, 1988; Das, Naglieri & Kirby, 1994). The progress from the relatively simple dichotomy of Simultaneous-Successive to PASS has been a gradual one in which a model of intelligence has evolved. The effective employment of the two coding processes is bolstered by the involvement of the cognitive processes of attention and planning (Das et al., 1979; Naglieri & Das, 1987). The method of building the PASS model has been a careful and slow process based on systematic research and this empirical data is portrayed in a book in which the PASS model is presented (Das et al., 1994). It is, however, noteworthy that the bulk of this research has been performed by Das, his colleagues and his post-graduates students (Roodin, 1996).

Planning as a cognitive concept was included with Simultaneous and Successive tasks plus the construction of experimental tasks and validated through factor analysis (Naglieri & Das, 1987). A number of experimental tasks were included and a fourth factor, Attention, emerged as a separate process to Planning, Simultaneous and Successive skills (Naglieri, Prewett & Bardos, 1989). Das and his colleagues (1994) argue that their model is strongly based in theory and despite the emphasis on cognitive skills there is a serious attempt to link processes to cortical structures on a frontal-posterior axis. The linking of an assessment battery to a theoretical model although commendable,is weakened by the theoretical assumptions on which the PASS model is based. As previously noted, Luria'a theory has been challenged in terms of its assumptions and in the light of current knowledge of brain structure and cortical organisation (Kolb & Whishaw, 1996). However, Das and his co-workers urge professionals to restrain their criticism of the theoretical background and instead to focus on the benefits of working within a coherent theoretical framework (p.11).Professionals are encouraged to compare and examine cognitive measures from a theoretical perspective. The focus is placed instead on the major aim of the test battery which is to improve the diagnosis of learning problems and implement effective remediation strategies. Several concerns have been raised by researchers regarding task content and theoretical weaknesses (e.g. Cowart & McCallum, 1988; Kranzler & Weng, 1995a; Reschly & Wilson, 1990; Telzrow, 1990). In reply to these criticisms, Das and Naglieri (1990; 1995) have reiterated the 'firm theoretical basis' of their cognitive assessment battery (1995, p.159). Many of the concerns raised focus on the tests devised for the measurement of attention and planning and factor analytical interpretations by Naglieri, Das and co-workers (e.g. Kranzler & Weng, 1995b) and the intervention implications and treatment validity (Reschly & Wilson, 1990). There are considerable strengths in the Das and Naglieri (1997) approach which explores processes rather than products of cognition and can provide clear additional information for placement and treatment for learning impaired scholars. The issues and concerns will be addressed more fully in the following pages.

The following discussion examines the PASS model components, Das and his associates review of each part, how the cortical areas are involved and the techniques for assessment. Four basic components are proposed as essential for information integration: (1) Arousal/ Attention (2) Planning (3) Simultaneous and (4) Successive processing. The arousal function of the first unit is crucial as it provides for voluntary action of attention. Das and his colleagues maintain that arousal and attention although closely integrated are separate processes. The appropriate state of arousal sets the tone for the activities of two broad classes of attention, selective attention and divided attention (Das et al., 1994). Selective attention involves the suppression of one response in the face of conflicting stimuli while divided attention represents the degree to which the individual can carry out concurrent but different activities effectively (Das et al., 1994).

The location of the arousal/attention components in the brain is further explored by Das and his colleagues (1994). While conceding that the mechanisms of arousal are probably anchored in the Luria's first functional unit they refer to attention mechanisms that are housed in the more frontal areas of the brain. More specifically they suggest that the upper regions of the brain stem, thalamus and the neocortex combine to regulate attention. However, the neocortex plays the crucial role of guiding complex forms of attentional behaviour while the reticular formation in the brain stem is the principle component in maintaining suitable arousal levels, thus the process involves cortical and subcortical structures working in concerted interaction. This supports Luria'a (1973) view of a reciprocal relationship between Units I and III.

The characteristics of attentional processes as suggested by Geschwind (1982) leave no doubt that they are placed in the higher order of cognitive functions. These are :

1. Attention is selective.
2. Attention is coherent, as it is maintained for some time, once selection is made.
3. Attention necessitates shifting.
4. Attention focusing requires a pre-monitoring process.
5. Individuals may display specific kinds of sensitivity to certain stimuli (Adapted from Das et al., 1994 p.45).

Indeed many of the tasks selected by Das et al. (1994), such as the Stroop Test (1935) and visual search tests have been strongly associated with frontal lobe functions with little emphasis on the arousal dimension of behaviour. One possibility is that the mere participation in any activity will raise arousal levels, yet these researchers stress that the units are "*physiologically and functionally distinct*" (Naglieri, Das & Jarman, 1990, p.429). However, Das and his co-workers refer to measures employed in their research which implicate appropriate levels of arousal. For example, it is observed that vigilance task measures of sustained attention ideally have four characteristics: (a) Length and continuity, lasting for at least 30 minutes (b) Subtleness of the signal to be detected (c) Randomness of the signal to be detected (d) The probability of the signal's occurrence not being linked to the subject's responses. While acknowledging the usefulness of these strategies, Das and co-workers (1994) point out the difficulty in adhering to these requirements with special populations. Instead,it was considered offering as an alternative, a task for tapping vigilance in which the child is required to listen to lists of names and inform the examiner when certain names occur in sequence. Das et al. (1994) acknowledge the problems with measurement of attentional processes pointing out,for example,that while some tasks of selective attention require "*central processing capacity*" (p.49) vigilance tasks may not. Central processing capacity,a controlling attentional system,is involved when conscious effort is necessary for a cognitively demanding task,a view advanced by workers such as Badderly and Hitch (1974). The drain on central processing capacity has been found useful in distinguishing the learning disabled from the non-learning disabled (Das et al.,1994). On the other hand, vigilance tasks are less likely to establish these differences and therefore do not appear in the battery.

Other measures of attention used in research on the PASS model include selective attention-receptive. This task consists of matching pairs of letters,visually identical (AA) or identical in name (Aa) or matching pictures. Another task is selective attention-expressive. This task comprises word reading, colour naming and naming the ink colour, rather then the written colours. Versions of the above tasks appear in the 1997 test battery which is discussed later in this Chapter. However, there are other aspects of the Das task selection which require mention. The selection of tasks for tapping attention are aimed at children who have the capacity or require the capacity,to read letters of the alphabet and words (e.g. the Stroop task or the Expressive Attention Task (Das et al.,1994) and numbers (e.g.Number Finding,Das et al.,1994). An issue which influences results, specifically with the Stroop-like tasks,is the role of poor reading skills. Here the suppression mechanism for one source of information (ignoring the word but focusing on the colour) may be facilitated by poor reading skills resulting in a better score. It would be necessary to involve several alternative measures to overcome this problem and these would seem to have been introduced in the final version of the battery (Naglieri & Das, 1997). Several tasks can be geared towards younger school-going children (e.g. Auditory Selective Attention and Receptive Attention,Das et al.,1994).

Attentional deficits are prevalent in normal child populations and are often ignored in assessment procedures (Barkley, 1988). Although research findings (e.g. Milich, 1984) report a decrease of attentional deficits as maturation increases, further efforts are required to understand the developmental course of these processes, the effect on cognition,and the theoretical and clinical implications. Das and his associates have not expressed clear views on these issues. Thus, the group targeted by PASS theory is that of school-going children, which leaves a gap in our understanding of the processes,products and developmental implications for the preschooler. The importance of understanding this particular period was shown in recent work by Mariani and Barkley (1997). In this study it was noted that early signs of attention deficits could be detected in hyperactive preschool boys and may be related to fundamental deficiencies in core areas of working memory and goal-directed persistence (p.122), which are both associated with frontal function. Unfortunately methodological issues (small sample size, and variations in test administration) limit the usefulness of the findings although the groundwork has been laid for further research in this area. A further dilemma arises when attention tasks are administered to older children. In these instances there is the apparent problem in discerning between attention and planning factors (especially for children in Grades 5-12) when there is a hypothesized advancement in frontal lobe development (Kranzler & Weng, 1995a; Welsh et al. 1991). One possibility is that there is a more fundamental sharing of underlying neurological resources; alternatively, the tasks used simply fail to distinguish the two processes of attention and planning (Jensen,1987;Kranzler & Weng, 1995a). Naglieri and Das (1995) have refuted these particular arguments suggesting that the criticisms are invalid, as they are based on a redundant set of tasks which were used in experimental forms of the PASS model. However, the nature of the debate suggests that there is much to be done in defining and operationalizing attentional processes so that congruence can be enhanced between attentional tasks and the PASS theory. One difficulty is the role of arousal in first functional unit i.e. how should this be ascertained or is it sufficient to assume intactness as the child is wakeful although there would be a minimal intentional component (Whyte, 1994). Another problem that emerges lies with attentional processes located in the third functional unit. There is a lack of a precise definition for attention and perhaps more pertinent, there is a need for tasks that would exclude multiple non-attentional components. Currently, deficits on a task such as the Stroop-like procedure could be accounted for by cognitive deficits other than attention difficuities. Nonetheless,Das and his colleagues have raised awareness of this important aspect of functioning although the assessment of attention and the problems inherent remain with clinicians and educational psychologists (Barkley,1988).

The nature of the simultaneous and successive processes attributed to the second functional unit are further elaborated. Both coding processes are involved with the acquisition, storage and retrieval of knowledge. Luria (1973) proposed that processing takes place through a series of exteroceptive, proprioceptive,and interoceptive analyzers that collectively synthesize incoming stimuli into various forms, simultaneous and successive (Das et al.,1979). The core of simultaneous processing means that a numbers of elements are present in the sensory register simultaneously,however, their presence is such that a relationship exists between them. The relationships are used to construct a new entity which is the result of the integration of the previously existing and separate elements. Simultaneous skills are crucial to spatial skills and imagery. The assessment of skills of spatial abilities call for some mental holding of the nonverbal stimulus and some transformation of the mental representation. Thus the mental rotation and comparison of a stimulus is often part of a task requirement. The process requires input of the elements of the stimulus shape and the mental holistic formation into a unitary stimulus. These skills are enacted in daily activities such as recognising faces or route finding activities on a map,they are also crucial in school activities such as Geometry or Geography where the understanding of diagrams is important (Kirby & Williams,1991). Kirby and Williams (1991) point out that simultaneous skills are also required in the verbal domain. A list of words which can be categorised into items of furniture or foods requires a simultaneous synthesis for such categorization. Spatial or relation statements (e.g. Peter is taller than Fred. p.184) also involve semantic reasoning. In addition, simultaneous processing is involved in comparative,possessive, passive, spatial and temporal relationships (Kirby & Williams,1991).

Simultaneous coding is also used to integrate sets of information, for example letter parts into letters, letters into words, words into phases (Das et al.,1994). The view that both coding processes are complimentary, that is neither one is superior to the other,is frequently stated by Das and his colleagues (1994). An example of this complimentary relationship is shown in reading. The reading process is also seen as having decoding and comprehension stages. While successive strategies are involved in decoding, research has shown that both successive and simultaneous coding is essential for comprehension (Das et al., 1994).

The essence of successive processing is the keeping of processed information in correct temporal order. This would involve tasks of analytical reasoning in which steps must be followed in sequential order. Kirby and Williams (1991) note that language comprehension, although not entirely dependent on successive processing, does require some elements of this synthesis. These authors point out that '*successive*' appears in the literature under other names such as working memory. However, this could give rise to some confusion and the definition of successive processing requires distinction from the memory for the order of sequential events and succession in terms of a perceptual process which refers to "*the sequential occurrences of events*" (Nichelli, 1993,p.339). The former is associated with sequential representations that specify what word follows what word and what force follows what force (Nichelli, 1993, p.363). Das and Siu (1989) suggest that a span of items and a story recall item could be seen as instances of successive processing, however, a task involving the sequential reading of words was not found to correlate with the coding process and has as yet to be understood more fully. An issue raised by Das et al.(1994) might have some bearing on this dilemma in that the approach to the coding task might vary, cross-culturally and individually, resulting in the need for alteration of the classification of tasks. This means that theoretically the nature of the stimuli to be synthesized is not the issue but rather the mode of processing which appears to be influenced by experiential, sociocultural and genetic factors as well as the task requirements (Das & Varnhagen,1986). For example, Das and his colleagues suggest that a child who uses number tables to memorize addition facts may progress to verbally presented addition in simultaneous mode by examining the mnemonic number table. On the other hand the child who uses numbered flash cards for acquiring addition practice may process the same information successively by sorting through the serially ordered memory traces to obtain the correct number (Das & Varnhagen, 1986). There are some weaknesses in this argument in that task demands, which may indeed dictate processing mode, may also be influenced by modal specificity of contents and products (Hynd & Willis, 1988). Simultaneous and successive processes can be identified in tasks and can be measured across ages but the development of the neurological substrata involved remains unclear. For instance,the manner in which development or maturation can be tracked for these processes is as yet under researched.

The concept of planning was included with the two processing approaches (Ashman & Das, 1980; Naglieri & Das, 1988). Das and his colleagues (1994) focus on the third functional unit which allows the individual to '*form plans of action, carry them out, and verify the effectiveness of the plans.*' (p.17). This component of processing is based on mechanisms for regulating, judging and verifying activity. An important aspect is the capacity to generate new questions, solve problems and self-monitor, all of which are connected to frontal lobe functioning (Luria, 1973).Das et al. (1994) point out that planful behaviour is characterized by (1) formulation of the problems by '*searching through an abstract space using certain operators to move from one point in the space to another.*' (pp.82-83) (2) the searching for a means-end analysis and (3) the orderly seeking and pursuit of a single line of enquiry at a time, rather than tracking multiple solutions.

According to Das and his associates (1994) processing implies a plan '*even if the plan is a simple or habitual one of which we are not conscious.*' (p.54). A lack of overt awareness of planfulness, or automatic acts do not require effort or conscious monitoring by the individual. Controlled acts differ in that there is limited capacity and deliberate conscious effort, however, extensive practice can produce effortlessness and automaticity (Shriffrin & Schneider, 1977). Thus, some acts do not appear to engage central processing resources. It is unclear how to clearly separate out the factors involved in analysing the component neurological substrata for central processing in order to gain a clearer picture of patterns in preschool children (Hynd & Willis, 1988).

Das et al. (1994) concede the difficulty in approaching the selection of tasks that exemplify planning strategies. As previously observed, the problems lie in teasing out factors such as speed and attention and many of the tasks identified by Das and his associates (1994) incorporate these factors. Some examples of tasks which Ashman and Das (1980) identified as a planning factor, include Visual Search and Trail Making. Although it is argued that speed does not emerge as a unitary factor, clearly performance accuracy and speed of responses are distinguishing features of comparison between different groups. This is best illustrated in studies by Rudel, Denkla & Broman, (1978) and Mittelmeier, Rossi and Berman (1989). In the former study children showed marked task efficiency, speed and decreases in error scores with increased age as observed on Visual Search tasks. In the latter study the Trail Making Test performance time was used to discriminate between slow and normal learners. However, the children's grade level emerged as a significant factor with the lowest grade showing the slowest times (Mittelmeier et al., 1989). Das et al. (1993) believe that the speed differences between groups imply more efficient strategies and therefore effective planfulness. Yet Kail (1986) for example, suggested an underlying but as yet unidentifiable developmental factor which may explain this source. More complex tasks such as syllogistic reasoning have been employed but are clearly more suited to older children and adults, therefore the need for relatively simple tasks is essential for observing planning behaviour in younger children or mentally challenged adults. Das and Abbot (1993) note that tasks such as visual search and planned connections (Trails) are regarded as valid indicators of a planning construct,thus failure on these tasks suggest a planning deficit (p.175). Given the multifactorial nature of these tasks,lack of success may be due to other features such as poor visual scanning, attention problems or as observed above, slow psychomotor speed. It seems clear that reasons for failure may be more complex than Das and his associates suggest and further exploration is thus warranted.

Although the inclusion of planning as a construct is useful,as previously noted,it cannot be separated from the attention factor so that incorporation of planning remains a matter for debate (Kranzler & Weng,1995a). One explanation is that the tasks employed to operationalize the planning and attention factors '*fail to adequately distinguish them*'. (p.154). Another difficulty is the speed component built in to both attention and planning factors by the test developers. The reliance on speed of response as a scoring mechanism may obscure the more fundamental component (or components) which may be underpinning these processes.

The degree of support for the components of the PASS model varies. There would seem to be increasing support for simultaneous and successive coding processes and the view that such a paradigm is consistent with current understanding of Luria's conceptualization of brain structure and function (Telzrow,1990). The two modes of information processing, Simultaneous and Successive, have been studied in diverse populations, including the mentally retarded (Ashman, 1982), the learning disabled (Kirby & Robinson, 1987), high and low socioeconomic samples and different cultural and eth populations (Dash,Puhan & Mahatra,1985;Krywaniuk & Das,1976). The constructs of Planning and Attention are less clearly supported. The concept of attention may be crucial in understanding children's neuropsychological performance but may be difficult to conceive as measurable intellectual behaviour. On the other hand planning as an executive function, is consistent with Lurian theory and could be seen as an important addition in assessment protocols (Telzrow, 1990). Naglieri and Das (1987) assert that the planning factor can be correlated with achievement and is as important as the cognitive processes themselves. The process of standardising the test battery has been ongoing and has resulted in the publication of the Cognitive Assessment System by Naglieri and Das in 1997. The tasks in the new battery will be discussed further below. In the following section,empirical studies will be explored.

Empirical Studies

In the following section, early and later studies will be reviewed. Early work with mentally retarded and non-retarded children utilised tasks such as Ravens Progressive Matrices, Graham-Kendall Memory for designs,Cross Modal Coding,Serial recall, Free recall and Visual short-term memory (Das et al.,1975). Factor analytical results supported the two broad categories of cognitive abilities, that is simultaneous and successive coding,although variations for memory tasks distinguished the two groups (p.93). More specifically non-retarded children obtained a high loading on reasoning for a visual short-term memory task, whereas retarded children showed a high loading on memory.

Das and his colleagues (1975) attribute this difference to the predominate reasoning strategies used by the nonretarded group, suggesting a simultaneous factor. The reasons why the two groups differed in the tasks loading on the two processing factors may be related back to the nature of the processes involved. In a later discussion which reflected on the processes,Das and his associates (1994) suggest that while successive processing draws on ordered encoding of information,simultaneous coding involves higher level comprehension skills. Many successive skills are in fact lower order simultaneous codes, although as previously noted, Das and his associates believe that neither type of coding is superior to the other but rather both types are essential at different levels (p.59).

Das et al. (1979) observed cross-cultural differences in processing modes with children from a non-Western environment showing successive coding preference for Progressive Matrices, tasks associated with visual-spatial problem-solving. Das and his associates (1979) attribute the difference to the fact that "*the children from India are leaning on the successive mode for solving a task which invariably elicits simultaneous strategies in white children* "(p.94). Further differences were observed in a study of gifted and learning disabled indigenous American Navajos (Mishra,Lord & Sabers,1989). In this instance the Wechsler Intelligence Scale for Children-Revised (WISC-R) was the instrument employed. Once again factor loadings supported the presence of the two coding components. Of interest was the difference in loading on simultaneous and successive marker tasks. More specifically,Mishra et al. (1989) reported that Similarities,identified as a simultaneous factor,loaded on a successive factor for the learning disabled group. While the approach taken by Mishra and her colleagues seems to support the versatile nature of the coding components over a wide variety of tasks, Das and Abbot (1995) are cautious about the use of traditional measures of IQ for the extraction of the two coding factors,especially with regard to eliciting information on reading difficulties. They believe that the WISC-R contains limited opportunity for testing successive processing in a way that would highlight specific phonological decoding problems (Das & Abbot,1995). Overall,Das and his associates (1994) believe that PASS model tasks give '*a more accurate view*' (p.130) when exploring the problems experienced by learning disabled children.

Of particular interest to workers in the field of education and neuropsychology are age-related changes in cognition as a function of brain maturation. Naglieri and Das (1987) administered a battery of six different simultaneous (figure recognition, tokens and matrices) and successive tasks (word recall, successive ordering and serial repetition of hand movements) to three school-age groups. The results of the study showed that evidence of construct validity was again obtained with this group of tests. Comparison of the scores showed greater speed and accuracy with increasing age although,as previously discussed,researchers such as Davis (1997) suggest that the nature of the developmental changes may be the result of maturation of attention and motor skills.

With older college students,the tasks selected for younger children were unlikely to test the limits (Campbell-Wachs & Harris,1986). In a study of undergraduate students some of the tests used were selected from the Wechsler Adult Intelligence Scale-Revised (WAIS-R) and from the PASS model repertoire that could be shown to measure both coding processes (simultaneous and successive). Examples of the WAIS-R tests included Block Design which has been shown to load on a simultaneous factor (Das et al.,1979) and Digit Span. Ravens Advanced Progressive Matrices was adapted and included as a marker test for simultaneous processing together with Concrete Paired Associates. Successive tasks included Visual Short-Term Memory and Sound Blending. Factor analysis once again confirmed two factors,simultaneous and successive. Of interest was the correlation of simultaneous tasks with entrance examination scores on mathematical tests and the successive tasks with essay writing grades. It was noteworthy that the successive factor showed a distinct verbal/non-verbal dichotomy,indicating a left hemisphere/right hemisphere division, which warrants further investigation.

Aysto (1988) points out that despite being based on Luria's clinical findings no research on the neuropsychological correlates of the model has appeared. A study by Cowart and McCallum (1988) on the Simultaneous-Successive-Planning (SSP) model as proposed by Das, Kirby and Jarman (1979) and Naglieri and Das (1987) failed to find *"conclusive evidence of convergent or discriminant validity of the S-S-P constructs using an MTMM matrix"*(p.62). These authors also raise concerns similar to Hynd and Willis (1988) regarding the Simultaneous-Successive dichotomy which they suggest may be confounded by a verbal/visual influence. Naglieri and Das (1990) point to administration and methodological weaknesses that undermine Cowan and McCallum's findings. In the first instance Naglieri and Das (1990) point out that the S-S-P model is not amenable to group administration (as performed by Cowart and McCallum, 1988) and such a departure may have an impact on the processing requirement of the task (p.168). Cowan and McCallum (1988) are also criticised for including subtests from the Kaufman Assessment Battery for Children (K-ABC, 1983). According to Naglieri and Das (1990) K-ABC tasks do not correspond to the S-S-P model as they do not include all aspects of Luria's three units. Despite the criticism, Cowan and McCallum, (1988) included tasks similar to those of Naglieri and Das (1987), such as Trail Making,which the latter researchers claim loads on a planning factor, and Hand Movements, which loads on a successive factor. The findings are refuted by Naglieri and Das (1990) as a failure to *`select reasonable tasks with proven reliability and adopt the proven procedure'*. (p.168). Yet Teizrow, (1990)) in her critique of the later PASS model, also raises similar issues. For example her observations of the items selected by Das and his colleagues showed that simultaneous processes were characterized by spatial tasks and successive processes by verbal tasks suggesting a consistent linguistic demand rather than the

PASS with four other models of abilities. These models were (1) 'g' or general intelligence (2) memory versus reasoning, Jensen's distinction between Level I and Level II reasoning (3) verbal versus non-verbal as exemplified by the Wechsler intelligence scales (4) verbal-spatial-speed as elicited by the Differential Abilities Test (Elliot, 1990). The results showed that the PASS model provided the best conceptualization of the interrelationships underlying the set of tasks. Naglieri et al. (1991) interpret these results as providing support for operationalizing the assessment of human cognitive functioning (p.13). However, this particular study was strongly criticised on several levels. Firstly, the comparison of PASS with non-traditional models of intelligence, specifically 'g' and memory versus reasoning "*is neither unexpected nor convincing evidence of the superiority of the PASS model*". (Kranzler & Weng, 1995a, p.145). Secondly, the use of confirmatory factor analysis with two other models of mental ability showed that the original PASS model did not provide a good fit. An alternative was that of a (PA)SS model whereby a combined planning/attention factor was observed with the two coding factors. Further refinement of the PASS theory was suggested (Kranzler & Weng, 1995a). The response by Naglieri et al. (1994) (see above) was critical of these findings. Nevertheless, critics have again singled out the weakest components of the current model which are those involving attention and planning. Until such time as these important dimensions of behaviour can be validated, measured and explained in a developmental context, the continuing debate on a four part model will remain.

The Cognitive Assessment System (1997)

The current battery contains the four part model for Planning, Attention, Simultaneous and Successive processing. The Planning aspect contains three tasks, Matching Numbers, Planned Codes and Planned Connections. Much depends on accurate timing for each task and questioning the child regarding strategies. For example, on the Planned Connections task the child is expected to describe whether they used "scanning,memory, or rehearsal strategies"(Naglieri & Das, 1997,p.17). Thus, the examiner asks the child "Tell me how you did this" or "How did you find the numbers that were the same?"

The Attention area contains three tasks, Expressive Attention, where younger children (aged 5 to 7 years) are expected to identify size of a stimulus while older children are administered a Stroop-like task. In the Number Detection test,children are expected to underline certain numbers. Younger children (5 to 7 years) are expected to identify and underline the numbers 1, 2 or 3. In the Receptive Attention task the child is required to underline certain objects under certain conditions. All tests are timed. Once again the child is asked to report on the strategies adopted.

The Simultaneous Processing subtests are: Nonverbal Matrices, Verbal-Spatial Relations and Figure Memory. In the Nonverbal Matrices the children are required to select and identify those shapes and geometric elements that are related. In Verbal-Spatial relations the child must select a specific spatial configuration in response to a question read by the examiner and within a time limit. In the Figure Memory task,the child is required to remember a geometric figure after a five second exposure and to select the original design from an embedded configuration.

The Successive Processing subtests include Word Series,Sentence Repetition, Speech Rate (for ages 5-7) and Sentence Questions (for ages 8 and upwards). In Word Series, monosyllabic non-related words ranging from two to nine in a series, are read to the child. The score is based on accuracy of repetition. Sentence Repetition for younger children requires exact repetition of 20 sentences. In the Speech Rate timed task,the child is required to continuously repeat a 3-word series read by the examiner. The Sentence Questions task is based on the child's ability to listen and comprehend the sentence content. One of the requirements is to respond correctly to questions posed by the examiner on the sentence content.

A score total score of 130 on the scale places the child in the very superior range while 69 and below is designated well below average (Naglieri & Das,1997). In addition,norms for children across a range of cultures and populations have been supplied in the interpretive manual. These include traumatic brain injury,mental retardation, serious emotional problems and gifted children. Naglieri and Das (1997) suggest that the CAS is suitable and fair for all groups.

In her review of an earlier version of the CAS,Telzrow (1990) questioned whether the assessment tasks themselves as constructed by Das and his colleagues, are consistent with the aims of sampling across modalities and methods of presentation. Telzrow expresses some concerns on this issue and regards tasks for successive and planning factors as internally redundant with regard to content or mode of presentation (p.353). In addition, the procedures constructed by Das and his colleagues for the two coding processes at times reflect a verbal-nonverbal distinction suggesting right/left hemispheric differences (Telzrow,1990). It has also been noted previously that many of the CAS tasks are directed at school going children who have some basic skills (e.g. counting or alphabetic knowledge). With preschool children, especially those from impoverished backgrounds, who have not been exposed to number, colour or alphabetic knowledge, the battery would be less helpful and little could be learnt from a neurodevelopmental perspective.

From a practical perspective, the CAS is a welcome addition to a small group of new era information processing tests. It is directed at children with school-level skills so that deficiencies that emerge can be identified, perhaps more clearly than with the mainstream IQ measures. Naglieri, Das and Jarman (1990) argue that the strong need for the diagnosis of children's learning problems is a major incentive for researching other kinds of assessment instruments such as the CAS. Traditional tests of intelligence have changed little over the past 80 years, but continue to conceptualize ability in an excessively narrow way and fail to include process measures (Naglieri et al.1990). Nevertheless,the debate on the utility of traditional measures as opposed to cognitive processing measures in the school environment is ongoing (Reschly & Wilson, 1990). The CAS is an innovative step for both assessment and remediation in education as it is geared towards intervention strategies. It would also be helpful to include assessment tasks geared for younger children where early appraisal of preparedness for school-related activities,especially in the areas of planning and attention,would be extremely useful. Although Das, Naglieri and Kirby (1994) invite research and elaboration of the PASS and CAS, the criticisms raised by Kranzler and Weng (1995a) regarding attention tasks and Telzrow's (1990) observations regarding administration and construct issues seem to have been largely overlooked.

From a conceptual perspective, the PASS information processing model is a concerted effort to merge principles from both neuropsychology and cognitive theory. Luria's three unit brain might be conceived as a type of "software" in explaining the "hardware" of brain structures and the output of human behaviours (Telzrow, 1990,p.346). As Majovski (1989) points out the structure-function correlation is an important approach in furthering our understanding of neuropsychological development in children. Luria's model also emphasizes the integrative and dynamic nature of brain organization and argues for the bidirectionality of structure-function effects,the experiences of the organism, that may affect and influence the organization of the central nervous system and vice versa (Telzrow,1990). However, the blue print for the PASS model,as laid down by Lurian theory,is difficult to operationalize in children, especially the anterior/posterior processing dimensions. In addition, some doubt must be raised about applying and understanding Luria's paradigm in terms of human intelligence. As Telzrow (1990) points out,Luria's assessment approach incorporates a broader perspective,including sensation and motor abilities, than that traditionally associated with intelligence. Although current scales of intellectual measurement are criticized in terms of their limited sampling of human abilities (Das,1992),the intactness of some skills, for example motor skills,do not necessarily reflect intelligence but may be useful in assessing school related tasks such as hand-writing capacities. Further use of the CAS by researchers and psychologists will verify or refute many of the issues raised in this discussion. In terms of the current study the CAS is not a practical choice because of the language and literacy .equirements so that failure on a task could be either the result of deficit or task difficulty. The extent to which alternative instruments developed within the same paradigm can examine coding processes in young preschool children is now explored.

Kaufman Assessment Battery (K-ABC)

A particular battery which measures the two main coding processes,Simultaneous and Successive, has emerged in recent years. The Kaufman Assessment Battery for Children (K-ABC, 1983) is a device which is purportedly similar to the Das model of processing (the terms simultaneous and sequential are used), although it has been noted that the neurological underpinnings remain hypothetical (Shapiro & Dotan, 1986). Das (1984) is critical of the K-ABC suggesting that the instrument focuses on only one of Luria's divisions, the second unit or the posterior cortical area. Reynolds and Kamphaus (1986) have noted this criticism and respond by pointing out that the intactness of the arousal and attentional unit would be to some degree, implicit in any cognitive assessment. On the other hand, assessment of frontal functioning (unit three or the anterior cortical area) in a developing brain, especially in preschoolers,is limited by our current restricted knowledge and speculation regarding this area. Indeed, concerted efforts by Naglieri and Das (1995) to validate planning and attention factors lend support to this view. Further criticism of the K-ABC and its proposed similarity to the PASS model have been suggested (Das et al. 1994). In the first instance, it is asserted that the K-ABC is a conglomeration of divergent theories of intelligence woven into a simultaneous-sequential dichotomy. It is further suggested that although the early work of Das et al. (1979) may have been influential, the

K-ABC does not reflect any particular model or theory. This latter view is neither supported nor refuted by the K-ABC test constructors (Alan Kaufman,Personal Communication,1996).

Several studies have been undertaken in order to demonstrate the differences between the K-ABC and the Das battery. A study by Das and Mensink (1989) examined simultaneous and sequential coding scores and achievement in maths and reading. These researchers used the K-ABC but included a new simultaneous task, Tokens,devised by Naglieri and Das (1987) as part of the CAS battery. According to Das and Mensink (1989) Tokens taps into knowledge of shape and colour, plus simultaneous relationships involving verbal components, such as above as opposed to underneath,left as opposed to right (p.106). Das and Mensink elaborate further *'An example of a test item is "Put,under the round one, all the squares that are not blue"' (p.106)*. Such a task would seem to be multifactorial involving skills in verbal comprehension (for complex instructions),working memory (for holding the complex information/instruction), recognition memory plus visual perceptual skills (for shape and colour), and sustained attention for task performance. The Tokens task was found to be the strongest predictor of reading, decoding and comprehension achievement in comparison to the K-ABC tasks. It seems likely that the multifaceted nature of the task requirements, which would be a feasible blend with the requirements for reading,involve more than simultaneous processes. For example,elements of attention and successive skills (serial processing of the verbal command and serial completion of instructions), even problem solving/planning factors, are viable task requirements for Tokens.

A further study which examined the K-ABC plus four tasks from the 1986 version of the CAS was undertaken by Das, Mensink and Janzen (1990). The four CAS tasks included Tokens (Simultaneous Processing),Planned connections or Trails (Planning Processing), Visual Search (Planning Processing) and Crack-the -Code (Planning Processing). Confirmatory factor analyses showed that planning emerged as a separate cognitive process from simultaneous and sequential processing. Tokens, however, loaded on a planning and a simultaneous factor as suggested above. An interesting finding showed K-ABC Simultaneous subtests, Spatial Memory and Triangles also loaded on both simultaneous and planning factors. The possibility that attention processes may have intermingled with planning processes is raised although the K-ABC constructors do not claim to measure anything other than the two mental processing types plus an overall assessment of achievement. The K-ABC has also been standardized across ages ranging from 2 and one half years to 12 years,thus,it is possible to track development over time longitudinally or on a cross-sectional basis (e.g.Smith, Bolin & Stovell,1988). The validity of the two mental coding factors, Simultaneous and Sequential, has been confirmed in studies including those by Das and his associates (Das and Mensink, 1989;Das et al, 1990; Kaufman et al., 1982) although Keith (1986) cautions that the factor structure of the K-ABC requires greater attention and wider study. In terms of the current study,of considerable importance is the fact that it has been used more recently in the assessment of childrens' developing mental abilities in diverse cultures such as Zairian children (Giordani,Boivan,Opel,Nseyila & Lauer,1996) and Lao scholars (Boivan et al., 1996).

There is clear evidence for the two modes of information processing,simultaneous and sequential, as documented by factor analytic investigations, raising the possibility of the involvement of differential neurological substrata (Hynd & Willis, 1988). The task content together with the putative cortical organization associated with the differential modes of processing,must be seen as important although interaction between content and neurological substrata has,in some instances, already been demonstrated. For example, visuo-motor stimuli as opposed to auditory-oral stimuli and the associated neurological substrata have been well documented on a lateral axis (Gazzaniga, 1970; Segalowitz, 1983). It is the kind of interaction between content and the mode of processing that may have implications for understanding neuropsychological organization in children and in adults (Hynd & Willis, 1988). In the Das-Luria perspective, several problematic issues have been highlighted. For example, the difficulties in measuring behaviours attributed to the anterior portions of the brain, such as attention and planning, have been discussed (see above) and are evident in Das and his associates applications. On the other hand, the two coding processes, simultaneous and successive, have been repeatedly shown to be present as separate constructs relying on different behaviours.

A small number of studies using the K-ABC have noted a trend towards hemispheric localizing signs, in fact a shift towards a theory of hemispheric specialisation (e.g. Shapiro & Dotan, 1986; Morris & Bigler, 1987). Research by others (e.g. Bogen, 1969; Kaufman, Kaufman, Kamphaus & Naglieri, 1982; Morris & Bigler, 1987) has shown that the neurological substrata associated with the two modes of processing supports the notion of right and left hemispheric functions. It has been suggested that these signs may be restricted to specific pediatric populations with clearly lateralized brains. Currently the two contradictory propositions (Luria-Das anterior-posterior axis and hemispheric asymmetry) have yet to be resolved. In recent years there has been an increasing emphasis on understanding the processes of hemispheric specialisation and the implications for development. This offers an alternative conceptual framework for discussion.

Hemispheric Functioning and Information Processing

In this section simultaneous and sequential (or successive) processes are discussed from the cerebral lateralization perspective. Before focusing on these two processing behaviours it is necessary to examine the theoretical background factors that underpin cerebral specialisation. In cognitive and information processing, dichotomized modes of thought have been identified and labelled. For example dichotomized concepts such as parallel-serial (Neisser, 1967);

appositional-propositional (Bogen,1977); simultaneous-successive (Luria,1973;Das et al.,1975) and holistic-analytical (Bradshaw & Nettleton,1983) all refer to polar types of cognition. The existence of two hemispheres in the brain has provided a useful point of departure for testing hypotheses about different dichotomies of thought and cognition. Galin's (1974) paper, which reviews research in this area, highlights four major areas in which the hemispheres of the brain may differ in their specialisation;

1.The right hemisphere seems to make use of non-verbal images in thinking (Levy,Trevarthen & Sperry,1972; Seamon & Gazzaniga, 1972).

2.The right hemisphere uses a less analytical approach (than the left hemisphere) to thinking and problem solving (Levy,Trevarthen & Sperry,1972).

3.Timing and serial ordering appear to be the properties of the left hemisphere (Swisher & Hirsch, 1972).

4.Although verbal language is predominantly located in the left hemisphere,the right hemisphere also contains language elements such as poems and idioms (Gazzaniga & Hillyard, 1971; Kimura, 1973).

The split brain surgical procedures, which will be discussed later in this Chapter,have further enhanced the notion of differing processes in the right and left brain plus experimental evidence supports the verbal-nonverbal dichotomy (Wada & Rasmussen,1960). Less well understood are the hemispheric lateralization changes that may vary with developmental age (Bryden & Saxby, 1986). The following designations have been ascribed to the right and left sides of the brain:

Left Hemisphere	Right Hemisphere
Verbal	Non-verbal, visuospatial
sequential, temporal,	simultaneous, spatial
digital	analogical
Logical, analytical	Gestalt, synthetic
Rational	Intuitive
Western thought	Eastern thought

(Adapted from Springer & Deutsch, 1993, p272).

Individuals are thought to use a specific cognitive mode, which may be in keeping with right or left hemispheric function (Arndt & Berger, 1978; Springer & Deutsch, 1993). Studies exploring cognitive modes compare performance on tasks which reflect right hemisphere as opposed to left hemisphere function (Bogen, DeZure, TenHouten, & Marsh, 1972; Casey, Winner, Benbow, Hayes & Da Silva, 1993; Galin & Ornstein, 1974; Gordon & Kravetz, 1991). For example, Similarities, a verbal scale subtest of the Wechsler Adult Intelligence Scale (WAIS), is regarded as a task that engages logical analytical thought, signifying left hemisphere thinking (Arndt & Berger, 1978). Alternatively, the Street Gestalt Completion Test (Street, 1931) may involve largely right hemisphere processes. When comparisons were made between diverse groups on these tasks it was found that middle-class white males excelled on the Similarities task (Bogen et al., 1972). Groups who showed superior performance on the right hemisphere task included Hopi Indians, urban black women and urban black males. However, an argument raised against these findings criticizes the measuring instruments and points to poor verbal skills in diverse cultures rather than right hemisphere cognitive mode superiority. Thus preferred mode and cognitive asymmetry has not been o... ... demonstrated by such studies (Arndt & Berger,1978). Further experimental work on eliciting specific kinds of asymmetries has led the way to understanding aspects of specialisation of the hemispheres (Gazzaniga, Bogen & Sperry, 1965; Sperry, ...niga & Bogen, 1969; Kimura,1974).

The notion that the two hemispheres of the brain may have different capacities gained support from work with epileptic patients whose hemispheres had been surgically disconnected in order to alleviate seizure activity. The corpus callosum is the main commissural connection between the two cortical hemisphere fields in the human brain and when it serves as a major pathway for propagation of epileptiform discharges,the sectioning serves to decrease or abolish the seizure activity (Crandall, 1985, p.281). Thus,the ensuing disconnection syndrome provided crucial information which,hopefully,could be extrapolated to hemispheric function in the normal brain. Despite the fact that the information obtained from the split-brain studies was based on 'pathological 'brains,Bogen (1985) maintained that it provided researchers with valuable insight into hemispheric function. In his work with split-brain patients, Sperry (1985) noted that

> *....each of the two hemispheres is found to process concurrently its own separate perceptual-cognitive-mnemonic functions; these may be grossly incompatible or even mutually contradictory, without either hemisphere noticing that anything is wrong, so separate are the inner experiences of the disconnected hemispheres". p.15.*

Sperry's observations have been supported with findings from commissurotomy patients that show, for example, that stimuli presented to the right and left halves of the visual field are perceived separately by each hemisphere (Gazzaniga, Bogen & Sperry, 1965;Sperry, Gazzaniga & Bogen, 1969). A strong left dominance for language was also observed among these subjects so that objects felt with the left-hand, or seen with the left visual field or smelled with the left nostril could not be verbally reported (Sperry, 1985). The separated hemispheres seem to function concurrently and in parallel. Further experimental research has examined asymmetries in normal intact brains.

In auditory asymmetries, with normal subjects, paired materials are presented to each ear simultaneously. The material presented can include numbers (Kimura, 1961) or consonant vowel tasks (Berlin, Hughes,Lowe-Bell & Berlin,1973) or a verbal stream (Geffen & Caudrey, 1981). All the findings support a strong right ear/ left hemisphere advantage. Anatomically, the left hemisphere receives competing stimuli from both ears but the crossed contralateral pathway to the left hemisphere (or speech hemisphere) is stronger in the majority of individuals and there is suppression of the ipsilateral left pathway (Bishop,1990). Conversely, a left ear advantage has been found in response to non-speech stimuli such as music (Kimura, 1964). Kimura (1967) investigated the development of functional asymmetry in children. She reported a significant right ear (left hemisphere) advantage in four-year-olds with above average IQ from advantaged backgrounds. In five-year-olds from low to middle class environments a significant left hemisphere (right ear) superiority was found for girls but not for boys. These results have been supported by a number of studies showing similar findings (Geffner & Hochberg, 1971;Dorman & Geffner, 1974; Geffen,1976). Geffner and Dorman (1976) reported gender differences, with data for four-year-old girls from low to middle-class environments failing to show the expected right ear or left hemisphere advantage. The results also imply early lateralization of language which casts doubts on Lenneberg's (1967) developmental model (see Chapter 2).

Asymmetry has also been recorded for visual stimuli. Similar to the auditory pathways, the visual pathways also contain both contralateral and ipsilateral connections to both hemispheres of the brain so that the pathways for each eye projects to both hemispheres. Research has shown that there is a left visual field,or right hemisphere advantage for non-verbal stimuli such as dot detection (Davidoff,1977) and faces (Berlucchi,Brizzolara,Marzi,Rizzolatti & Umilta,1974; Hilliard, 1973). On the other hand, a right visual field or left hemisphere advantage has been observed for processing letters (Reynolds & Jeeves,1978). In addition, words presented bilaterally to both visual fields have been found to be more efficiently processed by the left hemisphere (McKeever,1971;McKeever & Hurling,1971).

The corpus callosum. Many of the split-brain patients made good recoveries after their operation so that the role of the corpus callosum in hemispheric function requires consideration. Unlike commissurotomy patients,normal individuals can respond verbally to stimuli flashed to the left visual field or right hemisphere because the intact corpus callosum can communicate with left hemisphere language centres (Iaccino, 1993). Kim (1996) reported differences in responses to letter versus non-letter stimuli which reflect a switch in hemispheric processing. The left hemisphere performance suggested a parallel mode whereas the right adopted a serial or sequential approach. However, Kim (1996) suggests that the nature of the tasks may have elicited differential responses from the two hemispheres. The effects described could be attributed to the manner in which divided field stimuli are processed in the intact brain as opposed to the split brain. More specifically, the role of the corpus callosum may not result in a unilateral processing of stimuli. Instead the switch in processing observed could reflect a callosal transfer mechanism opposite to the traditional hypothesised distinctions. Kim (1996) points out "*This provides an explanation for some discrepancies in literature in ascribing certain processing strategies (e.g.sequential vs parallel, analytic vs holistic) to the two hemispheres ..(p.213)*. Thus, current findings in cerebral specialisation imply more latitude in hemispheric processing, possibly involving the corpus callosum,than the rigid explanations imposed by the right-left dichotomy.

The fact that the corpus callosum, an intricate structure with its many connections, exists suggests that it must play an important role in hemispheric function. Cook (1984) hypothesized that the corpus callosum is involved in several important ways in hemispheric functioning,both in the inhibition and excitation of neural activity. Cook's model is based on the assumption that arousal and attentional mechanisms,located in the subcortical areas respond to stimuli in an undifferentiated manner and arouse both hemispheres. The inhibitory mechanisms in the corpus callosum act to suppress identical neuronal activity triggered in the opposite hemisphere. At the same time the excitation mechanisms allow activity to develop around the suppressed area that are complementary to the original stimulus. In this way both hemispheres hold different but complementary perspectives on the same stimulus or information(p.102). Woodward's (1988) model offers a slightly different variation on callosal function. He suggests that left hemisphere processing relies on vertically arranged non-overlapping connections in a dominant circuit. The right hemisphere may be seen as more recessive with horizontal intersecting circuits. The tendency is towards the suppression or inhibition of horizontal connections with the vertical connections dominating the cortical patterns. Callosal signals thus serve to suppress the dominant (vertical) circuit.

The role or capacity of the corpus callosum in the developing brain is not clear. One model of callosal growth (Witelson & Kigar, 1988) suggests that completion of the major portion has been accomplished by the end of first two years. This is preceded by rapid development in the fetal stage and by a slower rate of growth after two years (Witelson & Kigar, 1988). However, callosal growth may reflect myelination which also reflects maturation of the cortex which would be related to increased growth of dendrites and synapses. The possibility is also raised of changes in cognition and in interhemispheric communication skills facilitated by the maturing corpus callosum. For example, three-year-old children were found to have more difficulty in comparing two different tactile stimuli presented to each hand, a contralateral task, than comparing two tactile stimuli when presented to the same hand,an ipsilateral task (Witelson & Kigal,1988). Difficulties on the same task were not found in five-year-olds (Galin, Johnstone, Nakell & Herron, 1979) although inconsistencies have been noted in other studies in this age group when comparison were made with older children whose patterns of laterality were more stable (Witelson & Kigal,1988). The nature of the task presented to a young child is problematic in that it is difficult to evaluate whether children are demonstrating weak lateralization or immature judgement. Some objective methods of evaluating lateralization would be required although few may be suitable for younger children.

The examination of models of lateralization have so far failed to address the putative brain mechanisms that may subserve interhemispheric processes (Kershner, 1988).The literature tends to be biased towards a static-based laterality, distracting attention from the issues of brain processing which would investigate the dynamic allocation of resources (Bryden, 1982;Molfese & Burger-Judisch, 1991). The focus on structural aspects of cerebral lateralization is futile if nothing is revealed about the encoding of perceptual processes or the amount of information that can be activated from memory. Processing models, as we have seen earlier, are currently debated in the field of cognitive and neurosciences and, as models, they are used to address the complex set of issues involved in conceptualizing how the hemispheres may work together.The manner in which hemispheric processing may be observed or understood has not been well developed although studies with electroencephalography have been undertaken as an alternative method of understanding lateralization processes.

EEG studies.Brain lateralizing processes can be monitored by electroencephalogram or EEG activity. No overt response is required from a subject and it is possible to study brain asymmetries in infants and other subjects where responses might be difficult to elicit. EEG activity is a continuous measure over time. In many instances an evoked potential response can be used;this is a specific part of EEG activity which is time-locked to the onset of co-occurring events in the subjects environment (Molfese & Burger-Judisch,1991,p.72). Work with electrophysiological procedures, using evoked potential responses, has elicited information on differences between and within the hemispheres and to determine if early evidence of speech lateralization could be used to predict later language development (Molfese & Betz, 1988;Molfese & Molfese,1985). For example, an investigation into speech lateralization processes showed that auditory-evoked responses from infants were documented bilaterally, with speech sounds (articulation),evoking a response from the left hemisphere and voice-relevant stimuli obtaining a response from the right hemisphere (Molfese & Molfese,1985). A follow-up study of 16 infants showed that the electrophysiological measures recorded at birth could successfully discriminate between children who had performed poorly or well on language tasks at three-years (Molfese & Betz, 1988). The crucial distinction was based on the infants' responses to specific hemispheric speech discrimination tasks. Although further research is required to extend and validate these findings, the implications are that some speech discrimination abilities may be lateralized from birth in some children.

The area of speech perception has elicited a number of hemispheric responses in infants and children that appear to vary according to the types of acoustic cues such as `.... *voice onset time and place of articulation change over developmental periods and display complex patterns of discrimination both within as well as between hemispheres.'* (Molfese & Burger-Judisch,1991, p.81). These changes in developmental periods have been empirically verified as studies with adults suggest that over time, the right hemisphere mechanisms appear to operate predominantly in response to the voice onset cue. This might be seen as paradoxical to the belief held that language is attributed to the left hemisphere. However, studies with aphasics confirm that despite impairment, the voice onset time ability remains intact in these patients and seems to be clearly located in the right hemisphere (Molfese & Burger-Judisch, 1991). Responses to types of seemingly simple speech processes may be complex and not accounted for in a simple model of lateralization and this is complicated by the developmental factor.

Studies using EEG activity have shown localizing response signs confirming the differential cognitive activities that stimulate the hemispheres. For example, temporal and parietal areas of the left and right hemisphere were studied while the adult subjects were engaged in arithmetical and visual-spatial tasks. Arithmetical tasks showed clear left hemisphere involvement (serial-analytic operations) while the visuo-spatial tasks showed greater right hemisphere activity (Papanicolaou, Schmidt, Moore & Eisenberg, 1983). Not all results give clear indications and strong statistical support for hemisphere EEG activity based on task differentiation. For example, a study involving normal healthy adults (Papousek & Schulter, 1997) showed measures of hemispheric asymmetries for cognitive lateralizing tasks (verbal and non-verbal stimuli) under conditions of cognitive activity only. However, the correlations between task and hemisphere activity were weak and accounted for very little of the variance. Caution must be used when interpreting measures of EEG activity as it is possible that links to hemispheric lateralization may be empirically unconvincing. The problem is that there is little evidence to suggest that a single hemisphere can perform a specific task alone and as previously noted, there is good evidence from Molfese's studies, for example, that the situation is more complex than previously thought.

Alternative models. Alternative models have tried to address the issues of information processing and cerebral asymmetry. The more contemporary view is that the right and left hemispheres maintain parallel but independent processors, thus information is divided on the basis of each hemisphere's unique processing mechanisms. This implies some

.... regulatory mechanism to coordinate, select, and integrate the

outputs of each processor. Interhemispheric inhibition in conjunction with other types of hemispheric interaction, may be necessary in order to achieve unified performance from a bilateral system capable of producing simultaneous, and potentially conflicting, outputs." (Chiarello & Maxfield, 1996, p.82).

Chiarello and Maxfield (1996) review the notion of hemispheric inhibition, which they define broadly as any effort by one hemisphere to suppress processing in the opposite hemisphere. These authors suggest that inhibition does not apply to synaptic processes, nor does it necessarily imply a role for the corpus callosum or other midline brain structures whose activities are geared to influencing neural activity in the opposite hemisphere (p.82). The alternative would seem to suggest inter- and intra- hemispheric processes.

The interhemispheric suppression hypothesis may operate in either a reciprocal or unilateral manner. The main thrust of the argument is that perceptual asymmetries do not come about because of functional differences in the hemispheres but occur because of differential activation of the two hemispheres. The more activated hemisphere will cause the stimuli to be directed via peripheral attentional processes to the less activated contralateral hemisphere. Thus, concurrently performed tasks, such as tapping the right hand and speaking simultaneously, may be inherently incompatible if they are both controlled by the sites within the same hemisphere. Individual tasks directed to prime a single hemisphere are more difficult to demonstrate because of the need to activate one hemisphere and,at the same time disrupt the information processing in the other (Chiarello & Maxfield, 1996).

From a unilateral suppression perspective,hemispheric asymmetry is emphasized. In this situation the dominant hemisphere impedes or suppresses the expression of a similar function in the opposite hemisphere. For example,the left hemisphere responds to language and suppresses this function in the right hemisphere. Several studies (e.g.Hutner & Leiderman,1991;Landis, Regard, Graves & Goodglass, 1983) have demonstrated that if damage to the left hemisphere language areas occurs, right language functions become disinhibited. However, strong empirical evidence is lacking for reciprocal and unilateral suppression (Chiarello & Maxfield, 1996).

In the cerebral distance model (Kinsbourne & Hicks, 1978),the brain is perceived as a differentiated neural network comprising interconnected functional systems and not as a pool of limited processing resources. In this framework,processing may require a greater portion of cerebral space than the structural area concerned. Thus, subprocessing components or elements compete to the extent that functional component systems overlap and there is inadequate differentiation among tasks (Hynd & Willis, 1988). Two concurrent tasks interfere with each other to the extent that they involve highly interconnected regions of the cerebral cortex. The interaction can be facilitative and produce priming effects if the two tasks are compatible. If the tasks are incompatible, interference effects will follow. More specifically,a review of a series of sequential (sequential finger movements, expressive speech) and simultaneous tasks (imitative effects, between limbs and speech and manual behaviours) by Kinsbourne & Hiscock (1983a) suggest that relative amounts of motor overflow, transfer and interference can be explained in terms of overlap between functional systems involved in respective task processing (Hynd & Willis,1988). Kinsbourne (1982) hypothesized that highly interconnected cerebral regions which probably subserve similar processes may lend themselves to successive processing strategies to permit efficient execution of a particular task (Hynd & Willis,1988). On the other hand regions with widely dissimilar subprocessors may be more suitable for a more simultaneous strategy in task execution. Within this framework cerebral lateralization is seen as a type of neural separation or isolation between complementary component processes that,subsequent to sufficient elaboration, are ultimately aggregated to result in a unitary pattern of behaviour or response. According to this explanation, isolation or distance may be only partial across hemispheres and not complete for every aspect of task or behaviour (Liederman,1986). The challenge is for theorists who adopt this perspective to specify tasks and processes that are isolated and integrated, which would be difficult to demonstrate (Chiarello & Maxfield, 1996).

Although inhibition models offer plausible explanations in conceptualizing hemispheric processes, once again there is a lack of empirical support. In fact, Springer & Deutsch, (1993) note that the major difficulty in referring to the list of proposed cognitive modes attributed to the hemispheres, is that few have been subjected to empirical investigation. In particular, with reference to the terms sequential and simultaneous, while reflecting current thinking,they are not universally accepted as a dichotomy explaining right and left hemisphere function (p.272). The basis for distinction is the model that proposes that the left hemisphere is predisposed towards temporal serial processing and an analytical approach;the right hemisphere adopts a global and gestalt synthesis (p.272). The presence of sequential and simultaneous processing modes has been explored in experimental work (Corballis,1996; Clark & Geffen, 1990). The basis for this approach stems from the belief that in most individuals speech is specialised in the left hemisphere. Speech specialisation also reflects precision and timing in terms of analysis and execution (Efron,1963;Corballis, 1996). If adults are requested to evaluate whether bilaterally presented stimuli are sequential (successive) or simultaneous in pattern, "*... the threshold for detecting successiveness is lower when the stimulus on the right comes first than when the one on the left comes first*" (Corballis, 1996,p.42). Corballis (1996) also found that judgements of sequential and simultaneous visual stimuli depended on factors such as cortical tracking and callosal transfer when bilateral presentation of stimuli occurred. The presentation of unilateral presentations show no evidence of bias. The overall conclusion that the locus of fine temporal judgement is not located uniquely in the left cerebral hemisphere (p48), has also been supported by researchers using tactile stimuli (Clark & Geffen, 1990) and tapping several areas such as rhythm discrimination (Gordon, 1978;Robinson & Solomon, 1974) and noise burst detection (Vroon, Timmers & Tempelaars, 1977). Establishing similar trends in children,especially preschool children,would be difficult for pragmatic reasons.

The K-ABC. Techniques have not been applied to understanding or observing information processing in infants and toddlers, although the data that such a measure would yield would verify normative neurodevelopmental processes and brain correlates in areas such as attention,memory, or language. In the absence of such measures,the alternative is to look at tests that are based on theoretical brain and behaviour models of information processing. Such a set of tasks emerged in the 1983 with the publication of the Kaufman Assessment Battery for Children (K-ABC). As already shown in the previous section,the K-ABC is based on theoretical models which include cerebral specialisation theory,fluid/crystallized intelligence theory (Cattell,1971),and successive/simultaneous processing which could be anchored alternatively in a three stage brain theory (Luria,1970). The fluid versus crystallized dichotomy is captured in the mental ability versus achievement scales, while the mental ability scales tap both sequential and simultaneous processes (Kline, Snyder & Castellanos, 1996). Kamphaus (1990) argues that the two main theoretical links are those of information processing theory and cerebral specialisation. The former is linked to Luria (1966) and the latter is based on the work by Sperry (1968;1974),Bogen (1969) and Wada,Clark and Hamm (1975).

The K-ABC processing scales have been used with children from different populations including at-risk preschoolers (Lyon & Smith, 1987),attention deficit (Carter, Zelko, Oas & Waltonen, 1990), traumatic brain injury (Donders, 1992), bilingual children (Flanagan, 1995; Pearson, 1988), dyslexic and learning disabled children (Hooper & Hynd,1986;Rethazi & Wilson, 1988); gifted and non-gifted multicultural children's groups (Matazow, Kamphaus, Stanton

& Reynolds, 1991; Nolan, Watlinton & Willson, 1989); and with African and Asian schoolchildren (Boivin et al., 1996; Giordani et al., 1996).

Debate has centered on the validity of the sequential versus simultaneous dichotomy in the K-ABC (Das, 1984;Goetz & Hall,1984;Keith & Novak,1987;Strommen, 1988). Children can approach a task from either a sequential or simultaneous perspective so that the division of the two scales of distinct mental processing skills does not guarantee that the child will adopt the process designated by the scale name (Kline et al.,1996). Willis (1985) points out that task construction strategies tapping into modes of behaviour beyond the serial/non-serial approach to processing are problematic. However, this criticism could be extended to all processing models using the two constructs including that of Das and Naglieri in the Cognitive Assessment Battery as discussed in the previous section. Generally, it would seem that as a test the K-ABC has raised more debate since its publication.

> *The most important contribution of the K-ABC may not be the test itself but rather the lesson that it offers. This is not to say that the K-ABC is not a sound viable alternative to other general cognitive measures for children. It is, but the K-ABC is not as radically different from more traditional IQ scales as it seemed 10 years ago.* (Kline et al. 1996,p.14).

Several studies have explored the possibility of linking the K-ABC to hemispheric function. Morris & Bigler (1987) administered the K-ABC,the Wechsler Intelligence Scales for Children (Revised) and lateralizing tasks (e.g.visual, tactile and lateral dominance tests) to 79 children aged between six and 12 years. The results supported the relationship between simultaneous and sequential and right and left hemisphere functioning respectively. Although both test efficient at picking up left hemisphere dysfunction, only the K-ABC picked up right hemisphere deficits. The authors suggest that the results support the notion of one predominant processing style indicating hemisphere strength (p.76). On the other hand, weakness in the hemisphere is reflected by relative weakness in the processing approach. Nevertheless, some caution in such interpretations is advocated in the light of the debate that surrounds the K-ABC's construct validity, reliability and norming procedures (p.76).

A similar study by Shapiro and Dotan (1986) showed that children aged 6 to 12 years with focal or localized brain damage (n=14) demonstrated a discrepancy on the K-ABC in either sequential or simultaneous skills (p.63). Right-handed children with left hemisphere insult were more likely to have higher simultaneous scores than sequential scores. Overall, lateralizing signs may be more apparent in strongly right-handed populations. However, similar cautiousness should be exercised as in the case of the Morris and Bigler study, and, in addition the small sample size must be considered when interpreting these results.

The results so far in terms of hemispheric functions and processing modes are equivocal. The main problem is the difficulty in demonstrating cerebral lateralization in children (Bishop, 1990). The situation has led some workers in the field to advocate an approach that looks at issues of cortical intactness in younger children rather than lateralizing processes (Hynd & Willis, 1988). Frather and Gardner 1992) argue for a constraints perspective. They state that *"Neuroanatomical studies support the inference of innate asymmetries in brain anatomy, particularly in the frontal and temporal regions"* (p.431). When considering lateralization from a constraints perspective then aspects of human cognitive development, such as language, are seen as prewired so that the developing child will attend to or process more specific aspects of its environment in a less than random way (p.430). In support of this view, functional asymmetries have been demonstrated in young neonates (e.g.Bertoncini, Morais, Bijeljac-Babic,1989) and it is the research supporting cerebral asymmetries that is most persuasive in terms of neurological constraint theory (Prather & Gardner, 1992). This raises several questions the first of which is the reason why there are inconsistencies in the findings and the failure to replicate data in neonatal asymmetries. On this issue,Bishop (1990) suggests that inconsistencies may be the result of methodological problems as there is sufficient evidence to support left hemisphere language location early in the first few months of life. The second is the role of environmental factors and the part played in neuro-cognitive developmental processes. Both these issues raise obstacles to acceptance of the constraints approach and much research is required which may shed further light on these ideas.

Currently there is a search for measures that will portray the manner in which children's mental skills develop in a variety of different environments and at different ages which might reflect contrasting aspects of mental processing (Boivan et al.,1996;Hynd & Willis,1988). The psychometric evidence suggests that the K-ABC can demonstrate changes across developmental stages in children aged between two-and-one half years to twelve-and-one-half years (Kaufman,Kaufman,Kamphaus & Naglieri,1982). Evidence from factor analytic results suggests that, for example, the Hand Movement subtest loads on a sequential factor in younger children and on a simultaneous factor in older children (Kaufman et al. 1982). However, the implication of the developmental changes in mental processing are not always clear,as demonstrated by Smith,Bolin and Stovall (1988). These researchers showed that preschooler's scores at four and six years were higher for simultaneous tasks with a decrease in sequential scores from ages four and five (p.402). The significance, if any, of these patterns of sequential and simultaneous skills are not as yet fully understood in larger populations in different environments.

The task content of the K-ABC, which focuses on problem-solving strategies both from a sequential and simultaneous perspective, is based on the notion of intellectual skills that are not reliant on education or training. In this respect it is appealing from several dimensions, one of which is the early age at which assessments can be made and the fact that children can be tracked and compared in the preschool period. The other dimension is the task content of the processing scales which is aimed at non-school going children such as the current sample. Generally, the K-ABC is regarded as `a comprehensive and multifaceted measure of cognitive ability.' (Boivan et al., 1996, p.589). There is a further benefit in choosing the K-ABC as a measuring instrument. Apart from the number of studies based on the K-ABC scales (e.g. Haddad, 1986; Hooper & Hynd, 1986; Inglis & Lawson, 1986; Keith, 1986; Lampley & Rust, 1986; Lyon & Smith, 1987; Morris & Bigler, 1987; Shapiro & Dotan, 1986; Smith, Bolin & Stovell, 1988; Worthington & Bening, 1988) more recent research has focused on sociocultural perspectives in cross-cultural psychology, emphasizing the need for evaluative techniques for at-risk populations. There has also been a greater emphasis on understanding cognition through understanding the environment in which individuals think, interact and carry out their daily activities. At the same time there has also been a tendency in recent years to discourage the adaptation of standardised tests for non-western samples (Boivan et al., 1996). This has placed researchers in a dilemma and increased the need to explore different approaches to assessment. As Giordani, Boivan, Opel, Dia Nseyila & Lauer, (1996) point out

> *The reliability of Western culture-fair assessment procedures based on non-verbal, visual problem-solving tasks may not be as appropriate as we might expect when adapted across nonwestern cultures. As*

Ornstein (1972) has noted, entire cultures may place primary emphasis on different types of skills in learning and problem-solving, some verbally-dependent, and others visually dependent" (p.21).

In this respect the K-ABC has been regarded as an instrument that can be used as a valid and comprehensive measure of children's cognitive abilities from a wide variety of socio-cultural milieu. Of particular relevance to the current research is the fact that the test has been administered to a sample of Central African children (Giordani et al.,1996)) and North African children (Elwan, 1996). In both these samples the distinction between the sequential and simultaneous processing abilities was found to be valid. The current study can also extend this application further to gain information from a population in a Southern African environment.

Conclusions

In more recent years the desirability of early identification of problems in mental processes and their consequences have been strongly advocated. Approaches to reading acquisition and mathematical ability have been shown to emerge from distinct ways in processing information. In addition, it has been largely acknowledged that the cerebral topology and function in the general population demonstrate that right-handers manifest a left lateralization for language while left-handers and ambiguous handers present with a variety of patterns (Goldstein, 1981). This view has been supported by findings in the literature. The question is whether such patterns can be observed in coding and processing of information.

The emergence of processes and early signs of lateral preferences in children is an area that has raised debate. For example, it is now known that homologous areas of the two hemispheres do not mature at the same rate and children apply different cognitive strategies at different age levels (Helligle, 1993; Hynd & Willis, 1988). In choosing a measuring instrument for the present study, it would be necessary to take into account a number of factors. First the language differences found among children living in Soweto, which would necessitate the administration of tasks that could be easy to explain,demonstrate or mime that would be within reach of all the childrens' capabilities. Secondly, the nature of the environment,as many of the children live in impoverished circumstances, where the variations in environmental stimulation might be detrimental to performance in some preschoolers (e.g see Reynolds,1989). One solution would be to look at the manner in which the children's thinking and information processing styles could be tapped. Psychometric evidence for this phenomenon has been demonstrated by the Kaufman Assessment Battery for Children. From a conceptual perspective,in the quest to find functional dichotomies that characterize hemispheric asymmetry in the developing brain, the Kaufman Assessment Battery offers the possibility of exploring two types of processing, simultaneous and sequential, which may have a relationship with brain function, and the possible influencing effects of lateral preferences (Shapiro & Dotan, 1986). Since current research with the K-ABC has been undertaken with brain damaged children it as yet does not clarify the issues of hemispheric specialisation and lateral preferences in the developing brain with no known pathology. The current study offers the opportunity to explore these issues in a sample of black children and to contribute to the current fund of knowledge which is debated around the constructs of simultaneous and sequential processes and the Luria-Das/ hemispheric specialisation issue.

Prior to stating the aims of the current study the main points raised in this chapter are summated. The major issues raised concern a neuropsychological approach to information processing. A brain and behaviour perspective requires a theoretical framework sufficiently flexible to incorporate a developmental approach. Luria's work represents the theoretical foundation for the Luria-Das information processing paradigm the PASS (Planning,Attention,Simultaneous and Successive processes) model. It was observed that the neuropsychological theory of brain functioning on which the PASS model is founded has been overtaken by contemporary views which suggest a more complex brain system. Nevertheless,the practical utility of PASS lies in the possibility of linking neuropsychological function, cognitive processes and intelligence to assessment, intervention and remediation in problem learners. The simultaneous and successive coding dimensions appear robust in response to empirical investigation. The two additional processes of planning and attention are sufficiently close in task requirements, so that many of the tests constructed to tap these two cognitive processes appear to overlap. Indeed, the two processes are probably built into some of the tasks designed to tap simultaneous and successive coding. Finally the hypothesized cortical areas involved on the anterior-posterior axis, are difficult to link to brain-behaviour relationships.

The alternative information processing paradigm, cerebral specialisation theory, was discussed as an alternative neuropsychological model. The cerebral specialisation model has been linked to the K-ABC as a possible theoretical source. The K-ABC contains a mental processing scale in which two styles of processing are presented which may be related to the manner in which the two hemispheres of the brain process information. It must be acknowledged that asymmetry in the brain cannot be reduced to any simple dichotomy, however,implicit in the approach is a search for cognitive tasks where strategies involving perception and problem solving may be lateralized in a different manner.

Aim and Theoretical Rationale

The current study aims to assess mental processing skills in a group of urban black preschoolers. The present research will adopt a theoretical stance within the cerebral lateralization paradigm. The studies discussed in this Chapter clearly show that aspects of cognition or perception can be composed of elements that can be differentially lateralized. The K-ABC incorporates a main theoretical idea embedded in the distinction between sequential and simultaneous processing. Consequently, the hemispheric location of these processes is as yet empirically unconfirmed. The study further aims to investigate the usefulness of the K-ABC as a fair assessment tool for urban black preschoolers whose background is largely characterized by impoverished circumstances. The environmental/background factors will be considered in terms of their influence on current cognitive and motoric functioning. The K-ABC contains tasks that are geared to children as young as 2 and one half years. Thus, the content of the tasks does not rely on prior scholastic knowledge. In addition, the role of developmental patterns of lateral preferences will be assessed both as developmental neuropsychological phenomena and to evaluate their role within the cerebral lateralization paradigm. The aims are summarized as follows:

1.To assess sequential and simultaneous processing skills in black preschoolers using the K-ABC.

2.To docun ıt early patterns and prevalence of right- and left-handedness, footedness and eyeness patterns in the same group of children at ages three and five years.

3.To explore relationships between cognitive processing and lateral preferences

4.To consider the role of environmental and background variables in developmental lateral preferences and processing skill.

A major aim is to establish a body of data regarding neurodevelopment by exploring preschool cognitive and motoric functions in children where empirical resources are lacking. It has been found that samples of nonwestern children cannot easily be compared with western counterparts so that issues of culture and urbanicity have yet to be clearly understood (Liddell, Kvalsig, Shabalala & Qotyana, 1994).

CHAPTER 4

METHODOI · .

The current study explores the development of lateral preferences and mental processing skills in a sample of urban black children. Developing patterns of laterality, handedness, eyeness and footedness, are informative both in terms of their patterns of emergence but also if they can be related to cognitive behaviours although such an association remains speculative. Yet in the past 20 years approaches to child neuropsychological/neurodevelopmental/cognitive assessment have adopted a strong theoretical basis (e.g. Kaufman & Kaufman, 1983; Naglieri & Das, 1997). The advantages of adopting such an approach have been observed in a wide range of empirical studies involving children from a variety of backgrounds, including Western, Eastern and African environments (e.g.Boivan et al., 1996; Giordani et al.,1996; Smith et al., 1988), and lie in the opportunity to study children's behavioural measurements with same-age peers. However, there has been less success in demonstrating adequately the neuronal underpinnings of the test behaviours observed. As Segalowitz and Hiscock (1992) have noted many of the characteristics of neuropsychological function in adults are also observable in children, although embedded within a development framework. A possible beginning may be made by relating dimensions of cerebral lateralization to 'behavioural characteristics'(p.55). Such an association is explored between overt signs of hemispheric specialisation (such as motoric biases) with cognitive processing within a cerebral lateralization model. Nevertheless, Aysto (1988) cautions that it might be premature to think that information processing systems divide themselves in an arbitrary manner according to hemispheres. On the other hand, there is considerable ambiguity in locating the neuropsychological correlates in the simultaneous and successive modes of processing within the alternative model, the Luria-Das position. It would be useful to consider the hemispheric asymmetry of the two information processing modes in the developing brain where the composite of the interpretative issues may not be as complex (Aysto, 1988). In addition, there is an opportunity to observe the implication, if any, of handedness and the developing patterns of lateral preferences, as discussed in Chapter 2, within the area of hemispheric specialization. In South Africa, the opportunity to study these areas of function in a large number of children, specifically black children, may increase developmental normative data and provide information regarding preschool performance. For example, it is now recognised that simultaneous and sequential processing skills are crucial in reading acquisition (Das & Varnhagen, 1986). Many children, especially black children, enter school with poorly developed motoric and cognitive skills, ill prepared for educational challenges. A greater understanding of patterns of development, especially information processing modes of behaviour, may assist in pinpointing areas of lag and advancement. The opportunity to track a group of preschoolers was presented through the Birth to Ten (BTT) data base. The BTT focus of health and development of urban black children offers the opportunity of exploring a developmental neuropsychological perspective.

Subjects

The subjects comprised a subgroup of the participants enroled for the BTT Study in 1990 during the period between April and July. Without access to such a data base any follow-up of the subjects would not have been possible as previous BTT pilot studies have clearly demonstrated the shifting nature of the population in Soweto. For example, a pilot study which assessed the feasibility of the BTT (Fonn,de Beer. Kgamphe, McIntyre et al.,1991) showed that at least 20% of pregnant women migrate to the Soweto/ Johannesburg area to give birth and return home almost immediately after delivery. Thus children composing the Birth to Ten cohort have been identified and followed since birth. All singleton births in the Johannesburg Metropolitan area, which includes Soweto, and served by the Johannesburg City Health Department were recorded and entered onto a data base (Richter,Yach,Cameron,Griesel,De Wet & Anderson,1993). - Population group differences showed that 80% of black women residing or giving addresses in Soweto were included as were 82% of coloured women and 40% of white women (Richter et al.,1993). Information on family life, psychological development and physical growth have been collected from 2000 participants in stages in the years 1992, 1994 and 1995 (Richter, Yach,Cameron,Griesel & De Wet, 1995).

The main focus of the present research was on neurodevelopmental trends in Black children. The main aim was to follow a group of children who were a representative sample of Black children living in Soweto although children living close by in areas such as Eldorado Park, were also included. A sample of approximately 400 three-year-old children were randomly selected from the data base for a follow-up neurodevelopmental study from the total of approximately 3770 Birth to Ten study cohort data base in 1993. At the initial stage of the study three-year-old children with a known history of head injury or neurological condition such as epilepsy were not included in the sample. Similarly, at the five-year-old stage,children who had suffered head injury or who were diagnosed with epilepsy or any other form of neurological insult in the intervening period of between three and five years were excluded. The children were seen at both three-years in October and November, 1993,and at five years in October and November, 1995,the period prior to starting school in January 1996. In the current study the required background information was obtained from each caregiver on the child's birthweight,maturational age,gravidity,maternal education, home language,home environment and household size.

The children represented at least 11 different groups that make up the 12 language groupings recognised in South Africa. However,the majority can be broadly divided into three main groups,Nguni and Sotho and other first language speakers (e.g.English,Tsonga). Nguni groups are recognised as the Zulu, Xhosa and Swazi group, based on language similarities (van Warmelo, 1974). Sotho speakers include Sesotho,Tswana and Pedi groups who again share a separate but distinctive linguistic similarity (van Warmelo, 1974). The language distribution for the sample can be seen in Table 4.1. English and Afrikaans speakers comprised a small number of children living in the suburb of Eldorado Park, designated a Coloured township under the former government. The conditions are impoverished and similar to those of the children living in Soweto. The majority of the children in this study,that is at least two-thirds,were bilingual.

Information obtained on housing type and household size formed an important part of the data base. The children in the current study lived in a variety of housing types. Table 4.2 shows the type of housing, the number of rooms and the number of people living in the house. This information was documented both at the 1993 and 1995 data collections.In 1995, 34 children were living in either a shack or a single room or a garage although the majority, 241, were sharing a house. The majority of the children, 81%, lived with their mother,12% lived with a grandparent and 6% lived with a relative.

Table 4.1 Home Language of the Children in the Current Study

	1995		Second language	
	N	%	N	%
Mother Tongue				
English	14	4.2	43	12.8
Afrikaans	10	3.0	9	2.7
Zulu	137	40.8	76	22.7
Sesotho	81	2	67	20
Xhosa	12	3.6	7	2.1
Tswana	45	13.4	12	3.6
Swazi	0	0	0	0
Tsonga	12	3.6	5	1.5
Venda	15	4.5	0	0
Pedi	9	2.7	1	0.3
No second Language			115	34.3

n=335

An additional area of information was the presence of household goods including the presence of toys and books for the children. Table 4.3 shows the extent to which households in the current study have consumer goods available. The majority of the households occupied by the children and their families contained items such as electricity, television, radio, fridges and toys for the children, however, the numbers of households with telephones (59.7%) and books (59.7%) were lower.

Of the initial 400 children seen in 1993, 350 (87.5%) were successfully contacted in 1995. Information obtained showed that in the majority of cases the child and caregiver had left the area with no known contact address. For example, in one instance it was reported that the family had moved back to Lesotho, an independent state with borders surrounded by South Africa. In two instances the deaths of children were reported although this could not be confirmed.

Of the 350 children assessed at five years the protocols of nine children were excluded from the data analysis because of a history of head injury sustained between the first and second assessments. Of the remaining six children, one child had suffered sexual assault and was referred to the pediatric clinic. the other children were reluctant to complete the full range of measures and large amounts of data were absent from their protocols. A total of 335 children were seen at three-years and five-years, 170 girls and 165 boys. Out of the 335 children assessed 333 mothers or caregivers questioned confirmed that their child would be starting school in January, 1996. All the participants were born within the period April to July, 1990. The current study adopts a single-group longitudinal design.

The Measuring Instruments

In this section a brief overview of the measuring instruments and the rationale and intentions for their inclusions is given. The selection of assessment measures was guided by the ages of the children, the background of poverty and the home language of the participants. In the

Table 4.2 Housing and Household Size

	1993# N	1995~ N
Type of Home:		
Shack/Room/Garage	12	34
Hostel	23	0
Flat	1	6
Shared House	297	241
House	3	54
Number of Rooms:		
One-two Rooms	202	35
Three Rooms	85	33
Four-five Rooms	39	179
Six Rooms and more	5	45
Occupants in the home:		
1-2	72	7
3-4	126	59
5-6	80	103
7-8	36	69
9 and more	21	87

Information obtained at the 1993 data collection

~ Information obtained at the 1995 data collection

Table 4.3 Presence of Consumable Goods in the Sample

Total sample n=335	1993		1995	
Home Contains:	N	%	N	%
Electricity	333	99	331	98.8
Television	275	82	306	91
Radio	263	67.5	302	90.1
Fridge	272	81.2	292	87.2
Washing Machine	48	14.3	69	20.6
Telephone	191	57.0	200	59.7
Toys for the children	262	78.2	286	85.4
Books for the children			200*	59.7

* Information not obtained at first interview

first instance, crucial information regarding, delivery, birthweight, factors relating to home environment, home language, maternal education, familial handedness was collected in vivo with caregivers and recorded on questionnaires and forms part of the data base in the current study. Assessment of handedness, footedness and eyeness in preschoolers is usually assessed by tasks in which the preferred lateral bias is noted. Since task complexity or task novelty could result in a misleading picture of preference (Bryden & Saxby, 1986) care was taken to select measures that would be suitable for a preschool population. For example, handwriting is considered to be a suitable technique for handedness measurements in older children but not in preschoolers (Bryden & Saxby, 1986). The intention was to measure indices of laterality in a naturalistic manner.

The measurement of cognitive processing ability was elicited with the Kaufman Assessment Battery for Children (K-ABC). The rationale in selecting this test was largely based on its theoretical basis and the opportunity presented to observe two aspects of neurodevelopmental processes, a cognitive aspect, in terms of the sequential and simultaneous coding, and a motoric aspect in terms of lateral preferences.

Additional tasks were selected on theoretical and pragmatic grounds. A series of tasks. designed to tap largely language processes and basic perceptual skills were included. From a pragmatic perspective,the mental processing scale of the K-ABC lacks a strong language component so that the inclusion of language tasks is warranted. Theoretically, it was intended that the debate regarding left hemisphere language and right handers could also be raised. The alphabet was included to tap the extent to which children, who were about to start school,had been exposed to this knowledge. It was also intended to pursue a theoretical direction regarding the serial or sequential nature of this task.

Given the difficulty in assessing mental ability with culture fair tasks, the Draw-a-Person test was included for several reasons. First as an additional measure of mental age and IQ which could be compared to performance on the K-ABC and secondly as a measure of handedness. A more detailed discussion of the measuring instruments follows.

Questionnaire. Information regarding gestation period, birthweight,history of illness or accidents, home environment (dwelling type e.g. informal housing), home language, family structure (e.g.single parent family, household size) were obtained from caregivers at the three-year data collection (see Appendix A). At the five-year data collection procedure further information regarding preschool and environmental experience was documented. The language,family structure (e.g.single parent, household size, the presence of consumable goods) was again recorded. The interviews were carried out by trained multilingual personnel who had previously collected data with BTT researchers. More detailed information and discussion on the living environments and background factors for the group appears in Chapter 7.

Handedness measures (three and five years). There are several handedness inventories that have been well validated with adult populations but require written or verbal responses. With younger children, especially children from high risk environments,it is necessary to use measures where the tasks are age appropriate, can be demonstrated by the child and allow for within-task stability of preference which is necessary for identifying ambiguous as opposed to mixed or between-task preferences (Bishop, 1990). The need for appropriate items in handedness inventories assumed to be familiar to children was noted by Brito and his co-workers(1992). Thus, tasks such as using a spoon as opposed to novel tasks such as lighting a match or dealing a pack of cards may affect results. Work by Soper and colleagues which produced The Hand

Preference Demonstration Test,((HPDT) (Soper, Orsini, Henry, Zvi & Schulman, 1986) provides a good method for evaluating handedness and ambiguous handedness in children (Bishop, 1990). The original test consists of eight items and each stimulus is presented with both hands along the midline, with minimal use of speech. However, in the current study some of the items have been excluded or altered to ensure that the children, who come from a variety of areas with varying degrees of deprivation,will be familiar with the tasks and that they will complete all of the tasks. In order to improve the reliability of th- assessment all children were required to handle and demonstrate hand use with all the objects. The items for the three-year-old and five-year old handedness assessment were:

1.Eating with a spoon (a small toy plastic spoon approximately 7 cm in length)

2.Drinking from a (toy) cup at least a quarter filled with water. (Each cup was approximately 6 cm in diameter with a small handle).

3.Pick up a small toy car (a small metal car coloured either blue or grey approximately 5 cm in length).

4.Pick up a button (approximately 1.5 cm in diameter).

5.Pick up a sweet.

6.Draw on a piece of paper(Specifically for the five year stage).

Each item was examined over two trials, with 10 possible responses during the course of interaction.

The Laterality Index (Soper et al. 1986) is based on the proportion of right-handed responses to the total unimanual responses (right plus left) times 10 (the maximum number of responses), that is Handedness Index =right hand unimanual responses/all unimanual responses X 10. This yields a range of scores from 0 (strong left hand preference) to 10 (strong right hand preference). In the current study an individual was considered left-handed if 100% of the responses are made with the left hand, and right-handed if 100% of the scores are made with that hand. An individual whose score ranged between these two extremes would be considered to be mixed-handed. Soper et al.(1986) found test-retest reliability (.86) in handedness scores across two testing sessions with retarded adults. Th same items were applied to a three-and-one-half-year-old Black (non-BTT) sample (n=26) and readministered after a one week interval. The children were assessed at two creches in Soweto and were comparable to the sample in the current study (Nohr,1995). It was found that reliability was greater for the right hand (r=.84) than for the left (r= .76), however, both coefficients are high and suggest good stability over the time period assessed.

Footedness (three and five years). Foot preferences are considered to be valid measures of lateral bias (Peters, 1988). The foot is not used in a variety of skilled manipulations of objects, however, foot preferences show high stability and are related to handedness (Bishop, 1990). The following were used in the assessment of footedness:

1.Kicking a ball.

2.Balance on one foot.

The latter task is recognised as a poor measure of footedness as previously noted in Chapter 2. However, any changes over the two year time span could be noted in terms of maturation. A medium sized multi-coloured ball, approximately 16 cm in diameter, larger than a hand ball,was used on each testing occasion. The foot used was noted as right,left or mixed for each task.

Eyeness (Administered at Three and Five Years)

Eyeness (three and five years). As previously noted the use of eye preference is debatable as it is suggested that it may not be closely associated with other motoric preferences. Nevertheless the issue of crossed preference for eye and hand is a subject worthy of research (e.g. Dawson, 1972).The following task was used:

1.Looking through a toy telescope.

A toy telescope, 28 cm in length and 4cm in diameter, was used for this task. Two trials were administered. Child was designated right eyed, left eyed or mixed.

Pegboard. This task has been established as . ask of hand skill and was introduced at the five years stage. The trial consists of moving 10 pegs from the back to the front of a board. Performance is timed from touching the first peg to releasing the last. Trials are made by the two hands alternatively. The pegs are moved from right to left by the right hand and from left to right by the left hand. Normative data is available (Annett & Kilshaw, 1983) and test-retest reliability has been established at .69. Two trials for each hand were administered.

Kaufman Assessment Battery (B-ABC). This battery was administered at the five-year data collection according to the standardised protocol (Kaufman & Kaufman, 1983). The three age appropriate component sub-scales,Simultaneous (SIM), Sequential (SEQ), Mental Processing (MPC) were translated into the variety of local languages spoken by the children although no 'back' translations were performed. All mental processing tests were used as the focus of the research was placed on the dichotomous modes of processing. The Achievement Scale on the K-ABC (Easel 3) contains a variety of items which were considered difficult to translate. The Faces and Places subtest is specifically challenging in terms of content and translation. Thus, the focus was placed on the mental processing tasks. It should also be noted that the Non-Verbal scale was not employed because of the major interest in the two processing modes and the ensuing theoretical debate. Three scales emerge,Sequential, Simultaneous and Mental Processing composite score. Two summary scales reflect the scores along the Sequential and Simultaneous dichotomy. These scores also reflect the individual's particular style of problem solving and information processing. The two processing styles form the theoretical foundation of the K-ABC and evidence from cognitive studies,cerebral specialisation research and the Das-Luria perspective is discussed (Kaufman & Kaufman, 1983). The K-ABC battery has been used with a variety of children with different cultural backgrounds including Zairian children from a rural environment (Giordani et al. 1996) and an Egyptian sample of school children (Elwan, 1996). Sequential, Simultaneous and Mental processing scores for the African-American sample were 97.0 (Sd=14.9), 92.8 (Sd=14.5 and 93.7 (Sd=14.2) respectively (Kaufman & Kaufman, 1983). The Zairian sample scored 80.56 (Sd=13.84), 63.53 (Sd=9.91) and 67.59 (Sd=10.39) for the same three scales (Giordani et al., 1996). In the current study, a small pilot study of preschoolers (n=5) was carried out with a black urban sample by the researcher in order to ascertain the suitability of the scales and the additional tasks, and to estimate the time taken to administer the tests. Using the Sequential and Simultaneous scales, the scores obtained were 93.5 (Sd=6.4) for the former and 96.0 (Sd=6.7) for the latter. However, it must be conceded that black children resident in (formerly) white urban areas are not living in exactly the same conditions as those in the main sample, although they have similar first and second language exposure. There are, however, differences between the Zairian sample and the South African children which require mention. For example, a large proportion of black township children in Soweto have access to electricity and exposure to television (Barbarin & Nkomo, 1997). Giordani and his co-workers concede that the conditions in Zaire are less conducive to the acquisition of visually-dependent or visual-kinaesthetic skills, hence the low Simultaneous scores (p.20). Generally there appears to be sound support for the use of the scales as sensitive measures in the light of a variety of disease and health issues in Central African children (Giordani et al., 1996). The global mental processing score has been shown to be predicted by environmental factors such as parental education. Further, the construct validity of simultaneous-sequential processes within culturally diverse populations has been well demonstrated (Boivan et al., 1996). The following scales and tests have been included in the current study:

Sequential Scale

Hand movements. This has been adapted from Luria's (1966) approach to the assessment of motor functions. The task measures the child's capacity to copy a series of movement using fist,palm and side of the hand. The sequencing of hand movements is sensitive to distractibility and anxiety (Kaufman & Kaufman, 1983).

Number recall. The child is required to repeat a number of digits spoken by the examiner. Only digits forwards are used. The child is not required to mentally hold and manipulate numbers backwards, is required in the WISC-III,for example. This test is also susceptible to anxiety and distractibility.

Word order. The child points to a series of silhouetted shapes of common objects (e.g. Star, Cup) in the same sequence as the objects are spoken by the examiner. Thus the responses are non-verbal and motoric and tap auditory-visual integration and auditory-motor memory (Kaufman & Kaufman 1983). Poor concentration and limited attention span would adversely affect performance on this task.

Simultaneous Scale

Gestalt closure. The task measures the child's capacity to give closure or to complete and to identify, an ink drawing of an object. Kaufman and Kaufman (1983) regard this task as an 'accepted prototype of simultaneous processing and right hemisphere functioning'(p.41). A number of the items,(such as a television set or a camera) were familiar to the children.

Triangles. The child is required to reproduce a copy of a design by piecing together flat rubber triangles.

Matric analogies. In this task the child is required to select the best design that matches a 2X2 visual analogy (Kaufman & Kaufman, 1983). The items range in difficulty from concrete objects to more abstract designs. Flexible thinking strategies are required for this task.

Spatial memory. The child is required to remember the number of pictures placed at various places on a page. The task involves a capacity for organising stimuli. Once again poor attention and anxiety can affect performance and produce low scores (Kaufman & Kaufman, 1983).

Although administration instructions were largely adhered to,given the large number of children and the relatively unknown levels of skills within the group it was decided to adopt the procedure of starting with the first item in each subtest for every child. This served to allow the child to `warm-up' and adapt to the test items before encountering the more difficult tasks. The stopping point recommendations were strictly adhered to. Scores were computed for each test and age appropriate norms were used.

Additional Tests

The K-ABC does not overtly tap into language based skills yet language has lateralizing implications. Thus, the following language tests, together with the lateral preferences measures,selected on the basis of their hemispheric lateralizing implications were administered. In addition, simple perceptual skills were also tapped in order to establish a baseline in understanding performance on the K-ABC subtests. It was important to select tasks that all the children could attempt. For example, the Trail Making Test (Part A) a special children's version with numbers 1 to 15,was initially included as a task of visual scanning,visual attention and psychomotor speed. The test was originally validated as part of the Halstead-Reitan Neuropsychological Battery (Mittelmeier, Rossi & Berman, 1989). In Part A, the child is required to join circles numbered 1 to 15 in ascending order. Prior to starting the task, each child was asked to count to 20. The majority of children were able to count, however, when asked to identify the numbers and connect them ,the majority of children were unable to complete this task independently.

Because of the large amounts of missing data, the Trails A measure was omitted from the results. The following additional tasks were administered:

Naming. Consideration of a formal measure (such as the Boston Naming Test) was hampered by the lack of normative data for instruments of this nature with Black South African populations. In this respect a criterion-based approach was adopted with the introduction of a naming task. Bagnato and Neisworth (1991) suggest that a basic language and developmental skill lies in the identification of body parts. In this task six common body parts names were introduced. In the first three, Nose, Ear, Knee, the examiner points to his/her nose for example, and says "*What do you call this" or "What is this called"*. The child must respond by naming the item correctly. For the second three items (eye, hair and ankle) the examiner says "*Point to (or show me) your eye"*. A score of six indicates that all items were correctly identified. This task was administered in the child's home language.

Verbal fluency. This is an expressive language task, involving specific semantic categories, animals, food items and clothing items. Naming of objects in a child's environment is recognised as a basic skill (Bagnato & Neisworth, 1991), although a timed period of forty seconds was allocated to each category as observed in the McCarthy Scales of Infant Development (McCarthy, 1970). The task was administered in the child's home language. The examiner says "*Can you tell me the different kinds of animals (or food or clothing)?. Tell me as many as you can as quickly as you can"*. The score comprised the total number achieved across all three categories. Welsh, Pennington and Groisser (1991) reported results of a multiracial American sample of five-year-olds score an average of 19 words for a timed (40 second each category) three category verbal fluency task. The task has been used in other studies however, comparisons vary as workers in some instances use a 60 second span per category.

Alphabetic knowledge. The alphabetic system is regarded as a basic step in acquiring phonological knowledge and may be part of a hierarchy of prerequisite skills that comprise a child's literacy development (Naslund & Schneider, 1996). Alphabet learning is recognised as one of the earliest literacy experiences for children prior to entering school (Treiman, 1997) although it is recognised that not all children start school with such skills (Naslund & Schneider, 1996). Alphabetic learning takes place in sequence with the basic starting point being the mastery of the names of letters followed by the sounds that each letter would represent (Worden & Boettcher, 1990). The possibility is also raised that the alphabetic system is associated with a linear style of processing associated with a predominantly left hemisphere style (Tzeng & Huang, 1994). In the current study the children were asked to recite (in some instances sing) the alphabet. "*Can you say the alphabet?* " or to prompt them or to clarify the request "*Can you say A B C right up to the last letter Z?*". Although Bagnato and Neisworth (1991) also suggest that recognition of the letters is a basic prerequisite this level of skill was not pursued. The scoring system was as follows:

1. Alphabet correct.
2. Correct with errors.
3. Able to say about half the alphabet.
4. Unable to say any part.

Digits span recall. In this task the raw scores of the K-ABC task were used.

Accuracy for shape and size. Basic perceptual skills, the ability to distinguish shape and size were evaluated by a screening procedure which was a broad adaptation of the drawing tasks from the Halstead-Wepman Aphasia Screening Test (1959). Four items were presented to the child on a sheet of paper. A large circle and a large square, a small circle and a small square. In order to ascertain knowledge of shape the child was asked "*Show me a circle*" once the child has pointed to an object the examiner asked "*Show me a square*". Correct and incorrect answers were scored accordingly. Knowledge of size was ascertained by saying to the child "*Show me the biggest circle*". Once the object has been identified by the child the examiner asked "*Show me the smallest square*". Each correct or incorrect answer was scored accordingly.

Draw-a-person. The Draw-a-Person task was administered to each child,both as a drawing task for a demonstration of hand preference and as a non-verbal assessment of mental age. The task is regarded as culturally fair although reservations have been raised regarding the estimation of mental age. For example,Reynolds (1989) suggests that the Koppitz (1969) scoring system underestimates mental age in Black children. A similar finding was reported by Richter, Griesel and Wortley (1989) for the Goodenough-Harris (1950) approach. However, Richter et al. (1989) reported that the Goodenough (1926) method was a valid indicator for black children of between five to eight-years of age. These researchers also found that the consistency of the Goodenough (1926) system could be demonstrated within the five to eight-year-old age range over a 50 year period. In the current study,measures of mental age and IQ, calculated with the Goodenough scoring method, will be correlated with scores on the processing scales. In the event of high correlations, this would further serve to support the use of this useful non-verbal measure with young black children. A relatively independent measure of mental age and IQ is also a prerequisite,as a separate measure is required for estimating global intellectual function in this sample (Becker,Isaac & Hynd, 1987).

Scores were computed and converted to mental age level and intelligence quotient strictly according to Goodenough's (1926) guidelines. Both mental age and IQ estimates are shown in the results. The scores were computed by the researcher. A random sample of drawing protocols, one out of every 30, was extracted and checked by an independent researcher. A 98% agreement rate was established.

Procedure

The 400 child participants were randomly selected in collaboration with t' Birth to Ten study. In the initial assessment of lateral preferences in 1993,four field-workers were involved in making contact with the parents or caregivers in order to gain permission for the assessments. Contact was made either telephonically, by letter or personal visit, either directly to the mother/caregiver or through relatives or neighbours. In all cases permission was given to obtain the information required and to assess the child. This particular period, October, and November, 1993, the child's third year, was also the period prior to the first general election in South Africa and there was a marked increase in both criminal and political violence (see Minnaar,1994). For this reason permission was obtained from the principal caregiver to visit the home, or the caregiving environment, to carry out laterality assessments and obtain background information from the mother or the child's caregivers.

Visitations to the homes was carried out by trained multilingual personnel,who are residents in the community and members of the BTT team. Intensive group training was given to the assistants in the administration of the lateral preference measures. The measures were then administered in the child's home or caretaking environment.

The 400 children originally assessed in 1993 were again contacted in 1995. The assessment procedures were held at Baragwanath Hospital in October and November, 1995, the children's fifth year. Field workers contacted the family/ caregiver and requested permission to see the child. Methods of contact varied and included telephone contact but also messages delivered to those residences where there was no telephone. Transport to the hospital,which is located at the outer limits of Soweto,may have been a problem for some caregivers who lived in suburbs distant from this area. In these instances taxi drivers' services were employed to facilitate transport for the children and their caregivers both to the hospital and to return home. Reimbursement was made to mothers/caregivers for travel costs and on arrival both mothers/caregivers and children were provided with refreshments. The assessment venue was within the hospital grounds but comprised a separate small building with four rooms. One of the rooms was used as a kitchen and two rooms were allocated for the assessments.

The K-ABC assessments and tasks were carried out by a Masters level research psychologist,who is multilingual and a resident of the Soweto community;an Honours level intern psychometrist, fluent in English and Afrikaans; and the researcher. In addition two multilingual assistants were available for obtaining background information during interviews with caregivers/mothers who did not speak English. In addition, they assisted as interpreters with the administration of language-based tasks. Thus, test instructions and language-based test items were given in the home language of the child.

Testing sessions were held daily, starting in the morning and completed by approximately early afternoon daily. Children were tested individually at appointed times. The children circulated at four assessment areas in the two rooms available until the entire protocol was completed. Typically, the child was administered language tasks by the assessor fluent in the language, the K-ABC was then administered,assisted by an interpreter as required,lateral preferences and pegboard was then completed and this was followed by the perceptual tasks and the DAP. While the child was being assessed the caregiver/mother was interviewed by the multilingual field assistant. Some children showed reluctance to be tested and in these instances mothers were present at the assessment. Mothers who requested to be present were also accommodated. As Bagnato and Neisworth (1991) point out the presence of parent can be reassuring for the child and parents can observe where the child may be experiencing problems.

Statistical Analysis

The basic design of the study is longitudinal. In the first part of the study,the emphasis was on development and change of lateral preferences,so that handedness specifically was regarded as a dependent variable, an attribute inherent in the individual (Kerlinger, 1973). Handedness was also computed as both a continuous and categorical variable,whereas foot and eye items were considered categorical variables only. As a continuous variable, the computation of the handedness scores of the laterality quotient enabled comparison between the two time periods based on the means obtained at each assessment. Although the two means obtained reflected `scores' veering towards higher levels "*...even substantial departures from normality, may under certain conditions, have remarkably little influence on the final result* (Howell,1992,p.289). For this reason, analysis of variance (ANOVA) was employed when handedness was considered as a continuous variable. When handedness,footedness and eyeness were considered as categorical variables,nonparametric approaches were employed. In addition, the independent variables considered to be influential in handedness direction and degree, that is sex,birthweight, gestation period, familial sinistrality were correlated (Pearson correlation coefficient) with measures of handedness at the two time periods. Overall,descriptive statistics and frequency tables were computed in order to determine the changes occurring over the two time stages. In this section an attempt was made to understand,integrate and relate the role of influential variables involving birth risks,gender,familial handedness and cultural influences. To this end multiple regression analyses were computed although the problems inherent with using this approach will be explored below.

Information processing measures comprised two independent variables, Sequential and Simultaneous. The emphasis was placed mainly on the two processing profiles and to a lesser degree the subtests. Because the psychometric properties of the test are unknown in a Black

South African sample, factor analysis was performed in order to validate the two processing modes. Further elaboration on this approach will be continued in Chapter 6.

Cases were distributed into groupings representing variations of the two processing styles. The method employed was based on factor scores as discussed in Chapter 6. Cluster analysis would not have been appropriate because of the fixed requirements for the processing groups. With clusters there is a tendency to group on general or natural tendencies which would have restricted the information. The criteria for divisions was based on previous research and recommended Sequential-Simultaneous score divisions (Morris & Bigler, 1987;Kirby & Das, 1979). Groups were established based on scores above and below the group mean,in the following manner:

1.LowSIM and Low SEQ (Kirby & Das, 1979).

2.LowSIM and HighSEQ (Kirby & Das, 1979).

3.LowSEQ and HighSIM (Kirby & Das, 1979).

4.HighSEQ=HighSIM (Kirby & Das, 1979).

5.HighSIM by at least 10 points greater than HighSEQ (for example see Morris & Bigler, 1987).

6.HighSEQ by at least 10 points greater than HighSIM (for example see Morris & Bigler, 1987).

By dividing the two processing modes into groups, the group status of the combination of processing styles, i.e. HighSIM=HighSEQ, became the independent variable and the linked level of the two processing styles dependent variables. Where possible, analysis of variance (ANOVA) and Multivariate analyses of variance (MANOVA) were utilized to test for statistically significant effects among the SEQ-SIM groupings. The Cochran C test was computed to test for the homogeneity of variance of the groups following the divisions,and where this was found to differ non-parametric measures, the Kruskal-Wallis test was employed. The three processing scale performances, Sequential, Simultaneous and Mental processing composite scale score, were compared across groups. In addition,the dependent variables of handedness direction, handedness consistency,handedness skills, mental age and IQ plus additional perceptual and language tasks were also compared. It should be noted that handedness consistency means the reliability `with which each task is carried out by the same hand' (McManus et al.,1988,p.258). Handedness skill refers to the performance on timed pegboard tasks. Handedness direction refers to the scores obtained on laterality quotients.

Where multivariate analyses were computed the Wilks' lambda F approximation was used in place of the unitary generalisation of the normal univariate F statistic. Where the numbers of dependent variables were involved Spector's (1977) recommendation was followed and a combination of both MANOVA and ANOVA types were computed and separate univariate ANOVAs were portrayed. In this way it was hoped to diminish the possibility of Type I and Type II errors. Where significance between the groups occurred, post hoc procedures (Sheffe or where appropriate, Tukey HSD for unequal sample sizes (Spjotvoll & Stoline test) were employed. Each grouping of the SIM-SEQ dimension comprised six levels of the independent variables. Where categorical variables were involved the Kruskal-Wallis nonparametric test was employed. The 5% level of significance, that is $p < .05$, was employed in the assessment of statistical analyses.

Apart from the cognitive variables,background and socio-economic variables (such as household size,mothers education,mother's employment status,type of housing, consumables in the home) in addition to factors such as birthweignt, gestation, first and second language, were also distributed across the groupings and compared,using both parametric and non-parametric methods.

In setting out the presence of consumables in the home, one consideration was to combine the items present (such as television, electricity etc) into a single score. However, this could have masked information regarding the presence of absence of some items, such as books in the home, which could have significant implications. For this reason, items such as books, toys, television and a telephone (the latter item might discriminate more between the groups as it may reflect income level) were retained and displayed rather than items such as electricity, a radio or washing machine. Further discussion on the rationale of selecting consumable items takes place in Chapter 7.

Multiple regression analyses is the most suitable technique for understanding the manner in which all of the variables are interrelated and integrated. However, as previously noted, problems emerge in determining the role of dependent and independent variables. First, there is the problem of selecting the dependent variable and the independent variables. It is rare that the selection of independent variables are found to correlate highly with the dependent variable but not with each other (Kerlinger, 1973). A further but related dilemma is the relative instability of the regression coefficient, which is susceptible to change with a different sample or/and the number of independent variables in the equation. Finally, Miller (1976) raises the issue of how to select the single dependent variable when many of the independent variables may be viable contenders for this role. In the current study, for example, in order to seek viable predictors for sequential processing skills, this variable will have to masquerade as a dependent variable. One answer may lie in the role of causality which is not inherent in correlational models (Miller, 1976). However, it has been observed that in non-western research, variables such as household size or mothers educational level require exploration in a broad analytical framework and not in isolation (Liddell et al., 1994). Regression models are particularly useful in such circumstances.

A final problem relates to the longitudinal nature of the study itself. As with all data bases it is difficult to know whether the children enroled on the data base are different in any way to other children living in the Soweto area. One way around this problem would have been to test a separate (non-data base) sample at both stages. Once again we would be faced with the problem of contacting,obtaining permission and assembling a comparable age group. The viability of assembling such an age group,procuring a group of multilingual psychologists and field workers was beyond the scope of the current research. Thus,the data yielded will comprise three main sets:

1. The data on lateral preferences which will be shown largely via frequency tables and nonparametric strategies. Missing data have been incurred and will be shown where relevant.

2. The data for the two processing modes which will include subsidiary scores for the additional cognitive tasks and compared via ANOVA and MANOVA and where indicated by non-parametric procedures. Where relevant, missing data will be shown.

3. The data from the background variables which will closely adhere to the patterns emerging from the processing data and displayed via non-parametric methods. Once again, where relevant, missing data will be indicated.

The analyses and results of the data will be presented in three chapters. In Chapter 5 the longitudinal data for lateral preferences will be displayed. The mental processing data, analyses and results, will be contained in Chapter 6. The analyses and results for the background variables will be shown in Chapter 7.

CHAPTER 5

RESULTS AND DISCUSSION:LATERAL PREFERENCES AT THREE AND FIVE YEARS

The objective in this chapter is to describe the patterns of lateral preferences at three and five years and the factors, background and environmental, that may influence their development. In Chapter 2 studies of the general developmental patterns of handedness were reviewed. As observed, the trend is one of increasing right-handedness in preschoolers, with some variations observed in different samples (Bryden & Saxby, 1986). For example, right-handedness was reported at 91% at age 4 years in one study (Van Camp & Bixby,1977), while an 80% rate was reported in preschoolers (Porac & Coren, 1981). There is a lack of data on the developing patterns of handedness in black South African preschool children although Herbst,Schoeman and Huysamen (1993) have observed a lack of consistent handedness in their sample of preschoolers. The current study offers the unique opportunity to document handedness at two developmental stages, at three years and at five years. The information will indicate the directions of handedness and also the degree of change at five years. Bryden and Saxby (1986) maintain that by the age of three, right-handedness is already established in the majority of children. An opposing view suggests that manual dominance is not well established in the preschool child (Bishop,1990). In the current study it will be useful to explore how left-, right- and mixed-handedness is presented at both three and five years. From this it will be possible to observe changes in the handedness patterns for children in this sample. In addition, the number of actions performed with the same hand over a number of tasks would, as Bishop (1990) suggests, also shed light on developmental patterns. It is intended to observe the patterns of consistency, the degree to which the same hand is used, and stability over two time periods. Additionally, in the current study, it will be possible to consider the effect of these two elements,if any, on hand skill. The proficiency of handedness has been cited as an important benchmark of laterality (Bishop, 1990). Comparison of the left- and right- hands on a unimanual speeded task, such as peg-moving, has produced normative data (e.g.Annett, 1985) so that comparisons can be made between the current sample and children of the same age.

There is some debate on the establishment of footedness with some studies (e.g. Belmont & Birch, 1963) reporting strong right-footedness by 4-and 5-years. Porac & Coren (1981) report, however, that the overall trend is one of increasing right-footedness with increased age. In the present study the patterns of footedness will be presented at the two time stages, three and five years. The patterns of eye dominance would seem to be rightward,increasing with age (Bryden & Saxby, 1986). It has been suggested that 60% of children show right-eye dominance and 35% are left-eyed (Iteya & Gabbard, 1996). In the current data,it will be possible to extract the degree of rightward prevalence in the eye dominance data.The overall developmental pattern would seem to reflect that handedness is established before foot and eye preferences (Belmont & Birch, 1963).

It has been suggested that there is no strong relationship in developmental patterns of hand, foot or eye (Bryden & Saxby, 1986). The degree to which an association between eye and limb can be described has been investigated by Iteya and Gabbard, (1996). Same side preference for either hand-eye or hand-foot is said to reflect congruence. It has been hypothesised that individuals displaying a right congruence for hand-eye or hand-foot are more skilled in the execution of a motor plan than their incongruent peers, although this has not been supported empirically (Iteya & Gabbard, 1996;Gabbard, 1992). Nevertheless,the degree to which patterns of congruency have emerged in the present sample will be documented.

The variables hypothesized to affect handedness direction have been discussed in Chapter 2. Familial handedness has been regarded as an influencing factor on handedness direction and information on this component will be extracted from the current data for consideration. Birth risk factors have also been identified as a possible causal source of left- or mixed-handedness. The pertinent background factors of the sample,gestational age,delivery type, birthweight and sibling order will be examined,documented and compared with handedness status at five years. Birthweight has been highlighted as a significant risk factor (Richter & Griesel, 1994). Normal birthweight is thought to be about 3300 grams, while low birthweight refers to a weight of 2500 grams and below (Ross et al. 1987). Very low birthweight refers to infant birthweight of 1500 grams and below. The normal gestational age is 37 to 40 weeks,and infants born below 37 weeks are regarded as preterm. Preterm deliveries pose a risk to the child (Hacker & Moore, 1992) and can result in developmental problems (Richter & Griesel, 1994). The majority of infants are delivered through the birth canal. Occasionally, medical complications of either mother or infant or both may require interventions such as forceps delivery or vacuum extraction (Harker & Moore, 1992). However, in some cases where adverse circumstances affect either mother or infant,delivery is accomplished by caesarian section in order to optimize maternal and infant outcome. Sibling order, that is the child's place in the family, has been raised has a possible influential factor in handedness although researchers such as Bishop (1990) do not regard it as a strong handedness determinant. In terms of the present study it was considered useful to document information of the child's sibling status.

Another source which is thought to encourage right-hand use in children is social pressure and etiquette. The differing background characteristics of the current sample,such as home language,allow for handedness comparisons between groups. The manner in which familial, birth risk and social pressure factors combine to affect handedness direction will be considered within regression models.

Of considerable importance is to construct a data base of patterns of handedness factors,including normative data for boys and girls on hand skills, which in this study is demonstrated by Annett's peg-board task. A total of 335 (165 males and 170 females) children were compared across the two time periods. A discussion of the findings will conclude the chapter.

Direction of Handedness

Developmentally, descriptions of handedness as either right and left are insufficient and do not reflect the complexity of this phenomenon. However, handedness can be described from two dimensions, degree and direction, and both of these issues will be examined in this chapter. The direction of handedness, that is the extent to which a sample demonstrates a rightward or leftward bias is first explored. In order to obtain an overall view of direction,a laterality quotient (LQ) was obtained for the three year and the five year handedness patterns over the same tasks. For convenience,abbreviations of terms are as follows: laterality quotient is abbreviated as LQ ;laterality quotient at three years is denoted as LQ3;laterality quotient at five years is shown as LQ5. These LQs were calculated according to Soper et al.'s (1986) formula (Right-Left)/Total hand responses X number of tasks,placing the distribution on a scale from 0 (left) to 10 (right).

At three years a mean of 7.72 (SD=3.13) was obtained and at five years the mean was 8.26 (SD=2.7). Comparison of these scores by the computation of the Sign Test showed a significant difference between the two time periods,z=2.84, p=.0044. The standard deviations are less at five years reflecting less variation and increased rightward direction in handedness. A 2 X 2 (Gender X Age Stage) ANOVA showed no significant differences between boys and girls over the two time periods (Wilk's lambda, F=1.00, df=2/332. p=.66).

Rightward and Leftward Bias

A comparison between male and female changes in degree of handedness was computed, based on the laterality quotients at three and five years. As previously described an absolute value of zero denoted left-handedness,an absolute value of 10 denoted right-handedness. In this approach scores at the mid-point of five on the LQ scale and below portrays a mixed to leftward trend;a score of six and more a rightward trend.

On comparing these two rightward and leftward trends a change can be observed for females over the two periods of time (Chi Square=6.09,df=1) with a significant change in righ'wardness. No significant changes were found for males based on this dichotomous distribution at three and five years (Chi Square=2.44, df=1, p=.11. These patterns can be seen in Table 5.1 A slightly leftward bias can be observed for females at three years, however, by five years the female pattern is similar to the males. It can be observed that the trend is predominantly rightward at three years.

Patterns of Left-,Right-and Mixed-Handedness

In Table 5.2.,LQs were strictly allocated for right=10 and left=0. As Bishop (1990) noted situational variables such as labile shifts,can affect handedness measurement and by adopting strict criteria it was hoped to observed the degree of stability over the two time stages. The number of children whose scores fall between 0 and 10 (reflecting mixed-handedness) over the two year period is high. McNemar's test for the same sample over the two time periods shows a significant increase in right-handedness for males (McNemar's Chi-square=62.4, df=1). For females the shift was also significant (McNemar's Chi-square=58.6 ,df=1). Overall comparison between the two groups showed significant differences in observed and expected frequencies (Ci Square=419.5, df=334). The main shifts in direction seemed to stem from left-and mixed-handedness to right in females. In males the predominant direction was from mixed to right.

Table 5.1 Frequencies of the Laterality Quotient Ranges for Males and Females in the Current Study

	LQ3			LQ5		
Sex	N	0-5	6-10	N	0-5	6-10
Males	165	29	136	165	19	146 NS
Females	170	37	133	170	20	150*

*p<.05

Table 5.2 Laterality Quotients for Mixed, Right and Left Handedness at Two Age Periods

	LQ3			LQ5		
	Left	Mixed	Right	Left	Mixed	Right
Males	10	74	81	8	67	90****
Females	16	71	83	7	64	99****
Total	26	145	164	15	131	189***

***p<.001 ****p<.0001

Congruence Patterns

The amount of congruence, same limb and same eye, preferences are also examined. Table 5.3 shows hand and foot congruence patterns at three and five years. The number of children demonstrating consistent right-hand and right foot congruence at three-years was computed, the number was 149 or 44% (78 or 23% male and 71 or 21% female) and at five years 185 or 55% (87 or 26% male and 98 or 29% female). McNemar's calculation showed a significant rightward shift for congruence in females (Chi Square=4.0, df=1 p=.04) but not for males (Chi Square=.39, df=1, p=.53).

For left hand and foot cong[illegible]e the number was substantially smaller, 10 or 3% (2 or .05% males and 8 or 2% females) at three-years and 12 or 4% (5 or 1.5% males and 7 or 2% females) at five years. A decrease in left congruence was found for females. No significant differences were observed for increased leftwardness in males (McNemar's chi square=.57, df=1,p=.44). Females showed a marginal decrease in leftwardness.

In the current study the right hand and right eye congruence at three-years was 33% or 111 (50 or 15% males and 61 or 18% females). At five years the number increased to 37% or 125 (57 or 17% males and 68 or 20%). McNemar's test showed no significant [illegible]fts for either males (Chi Square=.34, df=1, p=.56) or females (Chi Square=.28,df=1,p=.59). The left hand, left eye combination was 13 or 4% (6 or 1.8% for males and 7 or 2% females) at three-years and 11 or 3% at five years (6 or 1.8% males and 5 or 1.5% females). Female numbers decreased slightly while males remain[illegible] [illegible]. Patterns of congruence over tasks can be seen in Appendix C.

Table 5.3 Congruence Patterns at Three and Five Years

n=335 Item	Three years Total	 Male	 Female	Five years Total	 Male	 Female
Right Hand and Foot	149	78	71	185	87	98*
Right Hand and Eye	111	50	61	125	57	68
Left Hand and Foot	10	2	8	12	5	7
Left Hand and Eye	13	6	7	11	6	5

*p<.05

Drawing task at five-years. The drawing task was administered at the five year old stage only. The results showed that 92% of the females and 91.4% of the males used the right-hand. A smaller percentage showed a left-hand preference (8% for boys and 7% for girls).A smaller group showed mixed-handedness (0.6% boys and 1% girls). Because drawing requires relatively greater eye-hand skill eye/hand, congruence figures were elicited for this task. Of the males 88 or 26% showed congruence, 93 females or (28%) showed eye/hand congruence. Although higher than for other items, analysis showed no significant differences between congruency numbers for males or females (Chi Square=1.11, df=1, p=.29) on this task. Leftward congruency was also higher,a total of 18 children, 11 males and 7 females.

A table depicting the range of congruence responses for the right-hand and eye pattern and the left-hand and eye pattern over the tasks presented is shown in the appendices. However, the data show (Appendix C) that task requirements will cause the congruence responses to vary in the sample so that these issues are now explored.

Consistency and Stability Over Tasks and Time

Consistency and stability of handedness determinants of lateral preference development over time,were explored in the present study. In the current sample frequency counts indicated that of the total sample LQ at three-years,56.7% that is 190, demonstrated consistent hand preference for all the tasks presented. Of these 167 (81 or 24% male;83 or 25% female) were right-handed and 26 (10 males or 3% and 16 females or 5%) were left-handed. Of the remaining 145 children who showed inconsistent hand preferences 74 (22%) were males and 71 (21%) were females.

At five years, and using the same tasks at three years, frequency counts on the same number and type of tasks as at three years,showed a total of 204 children (61%) with consistent hand preferences (106 females or 32% and 98 or 29% males). Of these 4% or 15 were left-handed (8 males and 7 females). The remaining 131 (39%) showed inconsistent handedness, 64 (19.1%) females and 67 (20%) males. Both males and females showed a marginal reduction in inconsistency, increasing the degree of handedness at five years. If consistency measures are examined over the two periods the question is whether children maintain a consistent or stable pattern from three to five years. Overall LQ3 and LQ5 showed a total of 112 (33%) children, 64 (19%) girls and 48 (14%) boys, with stable patterns of handedness over the two age stages.

Developing patterns of handedness suggest that the degree to which handedness has become established and its stability over a number of tasks vary in young children. However, the manner in which handedness is assessed and documented becomes important. For instance Bishop (1990) notes that a child can show a right-handed preference for three tasks and a left for a fourth task. On the basis of this display such a child may be shown to have unestablished dominance. Similarly a child whose labile responses show no fixed pattern will also be classified as having no fixed dominance yet the laterality patterns in these cases is different. In the present study it was hoped to examine the patterns over time and extend these observations so that gross instabilities can be observed. For example, are the laterality patterns initially random, gradually progressing to more fixed patterns, or are they well established?. One method of exploring these questions is to survey the manner in which each task is approached.

Table 5.4. shows the overall lateral patterns at 3 and 5 years. The table shows the lateral preference of the children on each of the six hand tasks, two foot measures and one eye measure over the two age stages. McNemar's test was used to show increases or declines in hand,

Table 5.4 Laterality Patterns for Tasks at Two Age Periods

n=335	Three years			Five years		
Item	Left Total+	Right Total+	Mixed Total+	Left Total+	Right Total+	Mixed Total+
Hand						
Spoon	54	276	3	41	288	6
Cup	79	227	28	67	246	22
Toy	78	244	13	55	269	11
Button	62	271	0****	55	263	17
Sweet	71*	252	4	43	287	5
Foot						
Ball	40	284	9	36	292	6
Balance	143****	123**	59****	248	79	8
Eye	92*	193	46***	128	190	17

*p<.05, **p<.01, ***p<.001, ****p<.0001
+Total number of children in each hand, foot or eye category

Table 5.5 Laterality and Gender Patterns for Tasks Across Two Age Periods

n=335 Item	Three Years Left M~ N#	Three Years Left F^ N	Three Years Right M N	Three Years Right F N	Three Years Mixed M N	Three Years Mixed F N	Five Years Left M N	Five Years Left F N	Five Years Right M N	Five Years Right F N	Five Years Mixed M N	Five Years Mixed F N
Hand												
Spoon	27	27	137	139	0	3	19	22	145	143	1	5
Cup	36	43	115	112	13	15	32	35	121	125	12	10
Toy	33	45	122	122	10	3	27	28	130	139	8	3
Button	30	32	134	137	0	0	29	26	127	136	9	8
Sweet	35	36	124	128	2	2	23	20	140	147	2	3
Foot												
Ball	21	19	140	144	3	6	19	17	143	149	3	3
Balance	62+	81**	71	52	25+	34+	123	125	41	37	1	7
Eye												
Telescope	51	41*	87	106	25**	21	63	65	95	95	7	10

*p<.05, **p<.01, +p<.0001 (McNemar's Test)
~Male ^Female #Number of children in each task category for hand, foot and eye

foot or eye preference. For the button item a comparison between the distribution at three and five year performance showed a significant increase in mixed-handers (McNemar's Chi square=15.06, $p<.0001$). A significant decline in left-handedness,between three and five years, was found for the sweet item (McNemar's Chi Square=6.39,$p<.05$). Although there are no further significant differences in hand preference at three and five ye there is a variation in the patterns from task to task. With the exception of the button item,there is also an increasing bias towards right-handedess. Thus, the data again reflect that the majority of children seem to have established rightwardness for manual preference by three years. Variations seem to lie in mixed and left patterns.

Comparisons of foot and eye items showed no significant difference for the item Ball ($p=.52$). The item Balance showed a significant change with an increase in left-footedness (McNemar's Chi Square=27.66, $p<.0001$) and a decline in right-footedness (McNemars Chi Square=9.15,$p<.01$). However, this item may be reflecting coordination rather than preference and is therefore not a robust measure of footedness. Eye differences between the two periods were significant with an increase in left preference (McNemar's Chi Square =5.57,$p<.05$) and a decrease in mixed preference (McNemar's Chi Square=12.44,$p<.001$). Overall, foot preference for the item ball would appear to be stable although variations in eye dominance at the two age stages appear to confirm ongoing change.

Table 5.5 shows gender differences in lateral preferences for the same tasks and over the same period. Percentage left-hand responses for boys ranged from 8.5% fo holding a spoon to 11% (holding a cup) over the five tasks at three years,while the right-hand responses showed a 34% (holding a cup) to 41% (holding a spoon) fluctuation. At this stage girls' left-hand responses ranged from 8.5% (holding a ... , ... 13.5% (taking a toy) and the right-hand, 33% (holding a cup) to 42% (holding a spoon).

At five years, boys' left-handed response range was 5.5 % (holding a spoon) to 9.5% (holding a cup) and right-hand response range was 36% (holding a cup) to 43% (holding a spoon). Girls showed a 7% (holding a spoon) to 10% (holding a cup) left range and differed from 37% (holding a cup) to 44% (taking a sweet) with the right. Clearly the results show some fluctuations among tasks.

Percentage of mixed-hand range at three years, 0% to 4% (cup) and .3% (spoon) to 3.5% (cup) for boys at the two stages. For girls, the range was 0% to 5%(cup) and 1% (Toy) to 3% (cup) respectively. Overall there would seem to be combinations of right,left, and mixed responses over the range of tasks although these did not show significant shifts per task in handedness over the two time periods. Significant shifts were found for balance in increased left-footedness for boys at five years (McNemars Chi Square 19.46,p<.00001) and girls (McNemars Chi Square=8.98,p=<.01). Mixed-foot preferences showed a significant decline at five years for boys (McNemars Chi Square=20.35,p<.00001) and for girls (McNemars Chi Square=16.49, p<00001). Shifts in eye dominance also showed an increase in left-eye preference for girls (McNemars Chi Square=4.24,p<.05) and a significant decline in mixed-eye patterns in boys (McNemars Chi Square=9.03, p<.05). - Overall, shifts for specific items (Button and Sweet) were noted although there were no gender differences. The greatest variations were found for balance and eyeness.

Correlations Between Lateral Preference Measures

Because the hand and foot items are thought to be the most strongly related, a Pearson correlation was computed with the foot item, ball, and handedness items based on the five-year old measures, with alpha at .01. A strong correlation was found between kicking a ball and a number of handedness measures including drawing (r=.36), sweet item (r=.29),spoon (r=.22), cup (r=.23) toy (r=.21) and button (r=.19). A correlation between the foot item ball and the eye item was also found (r=.20). The hand-eye relationship yielded a correlation of .14 (p=.012). The current result would support the notion of relationship with handedness and eye and foot preferences.

Birth Risk Factors and Handedness

Factors that are associated with motor asymmetries in children such as low birthweight, birth rank, caesarian birth, are frequently cited as manifestations of decreased right-handedness. Risk factors may be viewed in Table 5.6 which shows birthweight, gestational age, delivery type and sibling order for the present group. The table shows male and female patterns of right-, left-and mixed-handedness distributions for birthweight, delivery type, gestational age and sibling order.

The mean birthweight was 3067.51 grams (512.00) and the range 1200-4255 grams. The mean birthweight veers slightly to lower than average although there is substantial variation within this sample. The number of low and very low birthweight babies (2500 grams) and below,40,is slightly more than 10% of the sample. The results in Table 5.6. suggest an unusual trend showing an increase in mixed-handedness with increased birthweight although group differences were not significant (Chi Square =.33,df=3, p=.54, numbers concatonated for empty or low cells). There are no compelling indications of left-handedness distribution according to birthweight and the mixed-hander's numbers are relatively small both for males and females.

Table 5.6 Birthweight, Gestational Age, Delivery Type and Sibling Order for the Sample

	N	%	Handedness						
			R+		L+		M+		
Birthweight	Total		M#	F$	M#	F$	M#	F$	
<1500	5	1.5	3	1	0	0	0	1	
1501-2000	7	2.1	0	0	0	0	3	4	
2001-2500	28	8.3	7	10	0	0	3	8	
2501-3000	103	30.7	29	36	1	5	15	17	
3001-3500	127	38.0	36	33	3	1	28	26	
3501 +	65	19.4	13	17	4	6	15	10	NS
Gestation Period in weeks*									
<37	83	24.7	24	23	1	0	15	20	NS
>37	234	69.9	62	71	6	6	49	40	
Missing data	18	5.4							
Delivery									
Normal	310	92.5	83	92	7	7	59	62	
Vacuum	3	.9	1	1	0	0	1	0	
Forceps	3	.9	1	0	1	0	1	0	
Caesarian	19	5.7	5	6	0	0	6	2	NS
Sibling Order									
1	132	39.4	32	44	3	2	26	25	
2	94	28.1	30	25	2	2	19	16	
3	53	15.8	15	13	2	3	10	10	
4	23	6.9	7	7	1	1	4	0	
5	24	7.1	4	13	0	0	7	0	
6 and more	9	2.7	2	2	1	0	0	4	NS

* Information on 18 cases unavailable
+ R=Right, + L=Left, + M=Mixed
# M=Male, $ F=Female

A similar pattern to birthweight appears in gestation period but again this was not significant (Chi Square=4.75,p=.44). Out of a total of 83 cases for gestation periods below 37 weeks, a mixed-handedness group of 35 children emerged. Males in this group (n=15) did not outnumber females (n=20). The majority of the children were placed in the normal delivery category but the largest number of mixed-handers was observed in the Caesarian group although this was non-significant (Fishers Exact Probability Test,p=.46). Differences relating to sibling order and handedess patterns were also non-significant (Chi Square=2.57,p=.76). The highest numbers of mixed- and left-handers were found in children who were first or second in sibling order. For example, a total of 51 first-born siblings were documented as mixed-handers. However, at least a third of the sample were first-borns while comparatively less (56 mothers) were recorded as having four children or more. Overall no significant differences in male and female handedness patterns and birth risk factors were found.

Birth Risk Factors and Handedness Correlations

A Pearsons correlation between handedness quotients at three and five years can be seen in Table 5.7. No correlations were found between birth risk factors and the handedness quotient at five years. A negative correlation was found between birthweight and the three-year-old handedness quotient. However, the lack of correlation at five years supports the notion that the associations weaken with increased age. Although significant, on the whole the correlations are small and account for little of the variance.

Table 5.7 Correlations Between Handedness Quotients at Three and Five Years and Birth Indicators

	LQ3	LQ5	B/W	Gest Age	Delivery	Sib Order
LQ3$_a$	1	.54*	-.13	-.06	-.00	.04
LQ5$_b$	.54*	1	-.10	-.10	-.01	-.00
B/W$_c$	-.13*	-.10	1	.49*	.04	.12
Gest Age$_d$	-.05	-.10	.49*	1	-.01	.09
Deliv$_e$	-.002	-.01	.04	-.01	1	-.06
Sib Order$_f$	.04	-.04	.12	.00	-.06	1

*p<.05

$_a$ Laterality Quotient at three years, $_b$ Laterality Quotient at five years,
$_c$ Birthweight, $_d$ Delivery Type, $_e$ Delivery, $_f$ Sibling Order

Familial Patterns of Handedness

In the current study mother's handedness patterns show that 10% of the total sample were left-handed, 89.5% right-handed and .6% were mixed-handed. Eighty-one percent of the sample live with the mother, 12% with a grandparent and 6% with a relative.Table 5.8 shows the information obtained on the patterns of parental handedness. Observations of the patterns of familial handedness show that the incidence of maternal left-handedness (9.3%) is similar to that found in the general population. On the other hand paternal left-handedness at 6.8% is less than that found in the general population. Examination of the data in the current sample showed that four children (three boys and one girl) identified as left-handed at five years had a left-handed mother. Three children (two boys and one girl) had a left-handed father. Only one incident of left-handedness (male) was found with left-handed parents.

In Table 5.9, Pearsons correlation were computed and showed a positive relationship between mother's handedness and the three-year laterality quotient (LQ3). A negative relationship was also found between father's handedness and the three year LQ. No correlation was found between handedness and the five-year LQ.

Cultural and Social Pressure

Because cultural influences on handedness have been observed in other African studies (e.g. Verhagen and Ntumba, 1964) some grouping on an ethnic basis was carried out. Table 5.10 shows three groups demarcated broadly according to language as divisions into exact language groupings would have resulted in extremely small numbers. Two distinct traditional groups emerged, Nguni and Sotho. The Nguni group contains Zulu and Xhosa first language speakers (van Warmelo,1974). The Sotho group comprises Pedi,Tswana and Sesotho who claim these languages as their first or home language and between whom there are common traditional and linguistic ties (Monnig, 1967). Language speakers who did not fall within the two groupings (n=51) are also grouped and shown for comparison. Males and females in the three groups are compared on left (L), right (R) and mixed (M) patterns of handedness based on the laterality quotients at both the three-year-old stage and at the five-year old stage. Overall, Nguni children showed an increase in right-handedness over the two age periods and comparison between right and non-righthanders almost reached significance (Chi Square=3.05 Df=1, p=.08).

Nguni speaking girls showed a decline in left-handedness, 11 girls at three years to 5 at five years, although this was not significant (McNemar's Chi Square =1.56,p=.21). Nguni males showed a general decrease in non-right-handedness, that is 40 non-righthanders at three years (33 mixed-handers and 7 left-handers) to 29 non-right-handers (25 mixed-handers and 4 left-handers) at five years,although the result was not significant (McNemar's Chi square=1.45, p=.21) (see Table 5.10). Differences in manual lateralization in Sotho speaking males and females were not significant however, decreases in mixed and increases in right- and left-handedness were seen. Girls showed decreased mixed-handedness, 34 at three years and 26 at five years. Sotho girls also showed increased right-handedness,29 at three years and 40 at five years. Sotho boys showed a decrease in mixed-handedness, 35 at three-years and 29 at five-years, but the single male left-hander at three-years had increased to three left-handers at five years. While the Sotho speaking group showed an increase in righwardness the third group showed a very slight decline in rightwardness. A 3 (Language Group) X 2 (Gender) X 2 (Time stage)

Table 5.8 Familial Handedness

n=335	N	%
Mother's Handedness		
Left	31	9.3
Right	300	89.5
Mixed	2	.6
Missing Cases	2	.6
Father's Handedness		
Left	23	6.8
Right	262	78.2
Mixed	1	.3
Missing Cases	49	14.7

Table 5.9 Correlations Between Mother's and Father's Handedness and Laterality Quotients at Three and Five Years

	Mother's handedness	Father's handedness
LQ3	.11*	-.13*
LQ5	.10	-.02

*p<.05

Table 5.10 Handedness and Ethnicity

	LQ3[a]						LQ5[b]						
	Male			Female			Male			Female			
	L+	R#	M~	L+	R#	M~	L+	R#	M~	L+	R#	M~	Total
Nguni	7	33	33	11	42	23	4	44	25	5	45	26	149
Sotho	1	31	35	5	29	34	3	35	29	2	40	26	135
Other	2	17	6	0	12	14	1	11	13	0	14	12	51

[a] Laterality Quotient at three years, [b] Laterality Quotient at five years

+ Left #Right ~Mixed

MANOVA showed no significant main effect for either group (F=.76, p=.47) or gender (F=.59, p=.44) for LQ at three years No significant effect was found for LQ at five-years (Group,F=1.07,p=.34; Gender,F=.43, p=.51).

Hand Skill and Hand Preference

Hand skill was tested with the Annett Peg Board task. The overall mean time was recorded in seconds for the group,Right=18.6, SD=3.8 and Left=20.9, SD=4.6.Comparison of the two means showed a significant right hand advantage (t=11.9, df=334, p<.00001). Boy's speed was slower for the right-hand (Boys =19.2,SD= 4.1;Girls=18.1,SD=3.4) and the left-hand (Boys=21.4,SD=4.6;Girls=20.4,SD=4.6). Data entered into a Gender X (R) Speed ANOVA showed an overall significant effect for Gender (F=6.64, df=2, p<.05).

It has been suggested that handedness consistency,that is the extent to which the same hand is used more frequently for tasks,is a positive factor in enhancing handedness proficiency. Table 5.11 shows the patterns of handedness consistency,based on the laterality quotient at five years, and the recorded right-hand time for speed. Out of the total sample,189 consistent right handers (91 girls and 98 boys) and 131 inconsistent handers (64 girls and 67 boys) were identified. A Gender X Speed X Hand Status (i.e.consistency versus inconsistency) showed a significant main effect for Gender (F=5.76, df=331, p<.05), but no interaction (p=.74). Sheffe post hoc procedures showed that boys and girls in the inconsistent group differed significantly in speed (p=<.05). The question of left-hand speed in consistent left-handers is also examined. However, this is a small subgroup group with n=8 males and n=7 females. Girls recorded a faster time (Mean=16.6,SD=3.7) than boys (Mean=20.37,SD=3.1) with the left hand (t=4.7 df=13, p<.05). It is noteworthy that the left-handed girls' performance was closest to that of Annett and Kilshaw's (1983) right-handed norms for 66 months (16.35,SD=1.96).

Whether consistency over time,that is persistent consistency would produce faster scores was explored. Children who showed consistency on tasks both at the three- and five- year-old stages numbered 112. Mean scores for right-handed speed for this group was 18.6 (4.0),for girls (n=64) mean=17.8 (3.3) and boys (n=48) mean=19.6 (4.6). A significant difference in speed was found between males and females in this group (t=2.3, p=.02). However, there were no differences between persistent hander's speed and consistent (n=92) hander's speed at five years only (t=.44, p=.33). Boys' scores in the persistent hander's group were slightly slower than the 5 year (n=50) consistency group (t=.94, p=.34);girls' scores (n=42) were almost identical. Differences in these subgroups raise the possibility of a gender advantage for girls in consistency measures.

Predicting Handedness

Longitudinal research offers the opportunity to explore cause and effect in relationships over a number of time periods. In the current study a regression model would appear to be well suited to comparing and evaluating the different variables and their effects on the dependent variable. The possibility is raised that a regression model could provide information on the amount of variance in a dependent variable such as handedness, which can be explained by an independent variable such as birthweight once the effect of other, often highly correlated variables, such as mother's handedness, have been removed. In the current study two separate regression analyses, handedness direction at three years and handedness direction at five years, were carried out with the CSS Statistica Programme. Both analyses contained birth risk factors, predetermined factors (sex and parental handedness), one analyses had the additional variable

Table 5.11 Hand Speed and Handedness Consistency in Consistent Right and Inconsistent Handers on Right Pegboard

	Mean Speed# Total	Mean Speed Females	Mean Speed Males
Consistent Handers	N=189 18.3+(3.7)~	N=91 17.8 (3.4)	N=98 18.9 (4.0)
Inconsistent Handers	N=131 19.0 (3.8)	N=64 18.6 (3.5)	N=67 19.4 (4.0)*

*p<.05 (Between inconsistent handers)
Recorded in seconds + Mean ~ Standard Deviation

of hand speed at five years. Predictor variables were entered into a stepwise regression. The order in which these variables are entered is influenced by current theory and analytical basis. Mother's handedness, father's handedness, and gender are entered as predetermined or epigenotypic factors in the equation as they are causally prior to, for example, birth risk factors. Risk factors are entered in the following order of events: gestation type; delivery type; birthweight, sibling order and language grouping. Hand speed on the right-handed task is also entered last into the second analyses. Table 5.12 contains the first analyses. The dependent variable LQ3 shows the direction of handedness as reflected by the laterality quotient at three years. The predictive model incorporates rnal and maternal handedness as two separate variables, and birthweight as a single risk facto.. lthough the F value is significant, the standard error is large, R-squared is small and does not explain a large percentage of the variance, however, the sample size is large and thus smaller values will achieve significance. The predetermined factors of mother's handedness and father's handedness would appear to differ in the eff t on lateral preference in the child. The possibility is raised that maternal handedness alone does not influence handedness however, paternal handedness and low birthweight together combine 'to act in a negative way on lateral direction. The possibility is that the status of mother's handedness, left or right, may be an important factor in the determination of handedness in the child at three years of age. Presumably after this age other factors come into play. On this basis the five year model entering the same independent variables, would contain fewer predictors. It might be useful to observe the components of the regression model for the five-year age stage of handedness.

<u>Five year stage.</u> Analyses using LQ at 5 five-years as the dependent variable was computed. These results can be seen in Table 5.13. At five-years mother's handedness and birthweight emerged as predictors but only mother's handedness was significant at the p. <05 level. Thus, F and R-squared values are lower than the three-year regression model and it would seem

Table 5.12 Stepwise Regression Analysis for the Dependent Variable Laterality Quotient at 3 years

Multiple R	.25
R_2	.06
Adjusted R_2	.05
Standard Error	1.43

Analysis of Variance

	df	Sum of Squares	Mean Square
Regression	5	191.45	38.29
Residual	304	2918.69	9.6

F=3.99 p<.01

Variables in the Equation

Variable	BETA	SE B	*B*	T
Father's hand	-.15	.06	-.19	- 2.68**
Mother's hand	.14	.06	.87	2.46*
Birthweight	-.15	.06	-.001	- 2.57*
Gender	-.08	.06	-.52	- 1.47
Sibling order	.06	.06	.13	1.05

*p<.05, **p<.01

that the role of maternal handedness is again a significant influence, however, the model, based on birth risk-factors, familial factors as predictors cannot account fully for handedness determinants at five years.

Handedness consistency. The third regression equation examined the effects of consistency of handedness, which was based on consistency levels at three and five years. The same variables were entered into a similar equation with consistency as the dependent variable. In this equation, stepwise regression showed that birthweight and mother's handedness were the most significant independent variables. Once again the values of F and R-squared are low, much of the variance is unexplained. The findings suggest that higher birthweight emerges as a positive predictor of the degree or consistency of handedness but maternal handedness would seem to exert a negative influence. This raises the possibility that maternal sinistrality may be a negative factor. Variables such as language, gender or sibling order do not feature significantly in this equation, nevertheless, consistency may be reliant on other factors such as opportunity to develop and practice hand skills. The investigation of background and environmental issues would seem warranted as it is difficult to account for the determinants of handedness and handedness consistency on the basis of familial and birth risk factors alone.

Discussion

The estimation of handedness at ages three and five years show significant changes in the total LQ at each stage. The distribution of the LQ quotients at both stages support increased right-handedness at five years. Similar J-shaped distributions in young children have been reported (Brito et al., 1992; Maehara, Negishi, Tsai, Lizuka, Otsuki, et al., 1988).

Overall, the mean LQ scores showed no significant gender differences between males and females at both age levels. However, an overall significant general rightward trend

Table 5.13 Stepwise Regression Analysis for the Dependent Variable Laterality Qudtient at 5 years

Multiple R	.15
R_2	.02
Adjusted R_2	.02
Standard Error	1.11

Analysis of Variance

	df	Sum of Squares	Mean Square
Regression	2	52.00	26.00
Residual	307	2236.87	7.29

$F=3.57, p<.05$

Variables in the Equation

Variable	BETA	SE B	*B*	T(307)
Mother's hand	.12	.06	.62	2.05*
Birthweight	-.10	.06	-.001	- 1.74

*p<.05

Table 5.14 Stepwise Regression Analysis for the Dependent Variable Handedness Consistency

Multiple R	.25
R_2	.06
Adjusted R_2	.04
Standard Error	.46

Analysis of Variance

	df	Sum of Squares	Mean Square
Regression	7	4.31	.62
Residual	302	65.13	.22

F=2.85,p<.01

Variables in the Equation

Variable	BETA	SE B	*B*	T(302)
Birthweight	.18	.06	.0001	2.75**
Mother's hand	-.14	.06	-.13	-2.42
Child's language	.11	.06	.07	1.92
Gender	-.07	.06	-.07	-1.32
Father's hand	.07	.06	.01	1.23
Gestation	-.08	.06	-.02	-1.19
Sibling order	-.06	.06	-.02	-1.07

*p<.05, **p<.01

for females, but not for males, was observed from the three to five year stage. A stricter division of the data showed that generally, there were significant differences in the patterns of right-, left- or mixed-handedness between the two age periods, although no significant difference could be found between boys and girls. These results are consistent with those of Longoni and Orsini (1988) and Coren, Porac and Duncan (1981) who reported no gender differences in children. However, Brito and his associates (1992) noted an increased number of boys who were more mixed- and left-handed in comparison to girls. In the current study the major differences found related to the amount of shift to right-handedness from one age to the next, which was significant for both male and female children. Here some differences emerge as boys show a shift towards rightwardness away from mixed-handedness. Girls showed both a decrease in mixed-handedness and leftwardness. These findings do not support those of McManus and his coworkers (1988)who reported that over time, mixed or bila al responses are probably better indicators of left-handedness. Few studies have looked at developing patterns over several years as there has been a tendency to conduct cross-sectional research which reflects static patterns of handedness at a particular point in time. Thus,in the current research ,the developmental trend has been rightward,although the amount of shift may vary between boys and girls. Further research of a longitudinal nature with more diverse groups would clarify gender differences in terms of shift from left- to right-handedness or mixed- to right-handedness and possible environmental or cultural factors that might be influential.

Gabbard (1992) suggests that consistency of hand choice has been associated with enhanced motoric development. The implications here are that (a) children who show a greater amount of lateralization would show greater functional asymmetries than their less lateralized peers and (b) the greater the consistency the greater the maturation or developmental status of lateralization with co-occurring functional superiority (p.749). In the current study the percentage of consistency at three years was 49% right-handed;at the five year stage 57% were right-handed. In the present group 8% were consistently left- handed and 43% showed mixed-handedness at three years. At five years 4% were left- handed and 39% were mixed-handed. McCarthy's (1970) study showed a three-year-old consistency (right and left) of 61% and a five-year-old consistency of 70%. Thus the three year-old stage in the present group does not differ greatly from the McCarthy study. The five-year-old stage shows a slower trend towards consistency in the current sample. Comparison with other studies show variations in the pattern. Gabbard and his co-workers (1993) and Gabbard (1992) showed 77% right-handed, 6% were left and 17% were mixed in two preschool samples. Such a low percentage of mixed-handers was [illegible] served in the current sample where few changes in inconsistency appear to occur be[illegible] three and five years. The African children's consistency trends are lower and the proposed pace of change from mixed-handedness is slower. Within the proposed model of consistency as a hallmark of both maturation and lateralization, the African sample seem less lateralized.

Coupled with the consistency issue is the pattern of handedness across a group of tasks which were examined at two age stages. In males, between 34% and 41% performed tasks with the right-hand at three-years and between 36% and 43% at five years. The number of left-handed activities at the two ages were 8.5% to 11% and 5.5% to 9.5% respectively. For females 33% to 42% at three years and 37% to 44% at five years and for left-hand activities 8.5% to 13.5% and 6% to 10% respectively. The patterns suggest the reported trends (Bishop, 1990) of less left-wardness and increased rightwardness although cross combinations of handedness are apparent at both stages. However, the kind of items involved may be a crucial factor.

In the current study the spoon item showed a higher amount of consistency while the item cup showed a lower consistency for right-handers. It is useful to consider familiarity versus novelty in these instances. A difficulty in selecting items and objects that are familiar to the child has been noted by Brito and his associates (1992). These researchers point out that a familiar task might be holding a spoon whereas a novel task might be lighting a match. In terms of the current African sample it is difficult to decide whether changes in handedness across items is due to lack of object familiarity or to immaturity. The cup item, for example, might have posed a difficulty in grasping behaviour because of differences, perhaps in size or even shape, to those used by some children daily. Thus, the extent to which children in this group might demonstrate a greater degree of right- or left-handedness instead of mixed patterns might be prevented by task demands or task familiarity. McManus et al (1988) have considered this perspective and maintain that although much could be learnt if the "skill demands of the tasks were known in addition to lateral preferences for such skills"(p.269) the relatively low level of task demand is not a likely explanation. Instead it is argued that a simpler explanation is that preference rather than skill predominates in handedness behaviour. Thus, the explanation as applied to the current sample suggests that preference is not fully established.

Ipsilateral patterns, that is a pattern of right-foot, right-hand and right-eye are said to demonstrate congruency. Conversely cross-lateral patterns describe alternate preferences such as right-foot, left-hand. The current study explored the congruence patterns at the ages of three and five years. The left hand/ left eye combination showed the largest number, 13 (6 males and 7 females) at three years and 11 (6 males and 5 females) at five years. The foot/hand trend 10 (2 males and 8 females) at three years and 12 (5 males and 7 females). Gabbard (1992) reported a small percentage, 1% of the left hand/left foot combination compared to the present study, [illegible]% at five years and 3% at three years. The right hand/right foot combination was 149 (44%) at three-years and 185 (55%) at five-years. By comparison, Gabbard found 52% of his sample demonstrated the right hand/right foot congruency. Perhaps there is greater maturation in increased congruency patterns, and similarities can be observed with the current research especially for females who showed a significant rightward shift in right hand/right foot congruence. In comparing the relationship between hand and eye, 30% were congruent at three years and 37% at five years. Left congruence was 4% at three-years and 3% at five-years. Overall it is noteworthy that hand-foot congruence exceeds the number of consistent handers. This trend supports previous findings that congruency patterns are not necessarily compatible with lateral dominance patterns (Gabbard, 1992).

The current findings support the view that a stronger congruence relationship exists between hand and foot relationship than between hand and eye. The correlation of hand preferences with other indices of lateral preference, such as foot or eye, have shown that hand-foot relationship is strongest (e. g. Nachshon & Denno, 1986; Gabbard, 1992). In the current sample correlations between hand and foot items were stronger than for hand and eye. The relationship between foot and eye was also found to be stronger than the hand-eye association. Environmental factors may influence hand-eye and hand-foot interactions as Dargent-Pare, De Agostini, Mesbah and Dellatolas (1990) reported differential rates of eye-hand and eye-foot combinations in adults, which varied according to the country of origin. Results similar to those in the current sample have been reported on the eye-hand association for children (Hebben, Benjamin, & Milberg, 1981; Van Camp & Bixby, 1977). Thus developmental and environmental issues emerge and warrant further investigation. The congruency factor and crossed dominance (left-hand/right-foot or right-hand /left -foot or right-hand /left- eye) has been noted as a reflection of incomplete cerebral dominance and poor reading skills (Orton, 1966). Bryden (1970) also confirmed the presence of crossed dominance in poor readers. However, in a specific situation such as reading, eye movements or ocular-motor control does not appear to be well established in some children (Iaccino, 1993). In this instance lack of stability in ocular-motor action rather than eye dominance must be distinguished. Nevertheless the overall view would seem to support the inclusion of eyeness as a legitimate measure of lateral preference.

According to Bakan et al. (1973) birth risk factors are thought to give rise to perinatal hazards leading to underlying brain damage. This particular perspective is highly criticised because it does not take into account a number of environmental factors such as culture or familial patterns of handedness. In the current study,information on gestation period,delivery type and birthweight were available. The handedness distribution does not suggest increasing patterns of left-handedness with lower birthweight,in fact the opposite trend was suggested with for example, increased incidences of mixed-handedness appearing with higher birthweight. Similarly,delivery type and gestation period also seemed to follow a similar direction. This is a perplexing issue and it may be that either the environment plays an influential role (for example the absence of adults to model handedness) or, there are birth (or even pregnancy) complications unknown to the researcher. The third possibility is that the accuracy of the data could be questioned although the difference for each child would be recorded to the nearest 5 or 10 grams in the majority of cases (Ellison et al.1997).Schwartz's (1990) longitudinal study showed only one predictor of pathological left-handedness, the Apgar score at two years. However, a longitudinal study by Ehrlichman and his colleagues (1982) showed no association between Apgar scores and handedness at seven years. The differences may be accounted for by greater influence of these ratings in early vulnerable years but further growth and development may weaken the relationship over time. Apgar scores were not available for the current study but a relationship between birthweight and the LQ at three years produced the only correlation. This would support the view that other factors influence handedness after three years or that there is a weakening in the predictor, birth weight after this age (Bishop, 1990). In addition, there are studies that comment on the psychomotor skills of African babies and toddlers, and refer to the developmental process as precocious (Liddicoats, 1969; Mwanwenda, 1995). More recent work by Cameron (1993) with Soweto children shows that physical development, weight and height, appear to wane after 12 months, falling to below the accepted normal levels (Hammill, Drizd, Johnson, Reed, Roche & Moore, 1979). If such deterioration is present, then the effects on motor and intellectual development could be observed in the current sample. The amount of mixed-handedness present in the current sample, for example, might be seen in this light. The majority of studies regarding pathological left-handers are carried out on already designated populations, such as the mentally retarded (e.g. Soper et al., 1986; Batheja & McManus 1985) or the learning disabled (e.g. Hynd, Obrzut & Obrzut, 1981). In this sense much of the research is retrospective rather than prospective. In the current study the predictors associated with pathological left-handedness might be observed further in the efficiency of coding skills as an intellectual exercise. A plausible hypothesis would thus be associated with the number of left-handers who perform poorly on this task. As in other studies the left-handed numbers are low and based on the hand speeds of the left-handers in the current sample, it would seem that boys might be the most vulnerable. This aspect will be explored more fully in the following chapter.

The tendency for some families to show proneness to left-handedness has been used as an index of a leftward predisposition. The possibility that left-handed parents unconsciously model left-handedness has also been raised (Harris, 1992). Maternal influence has been specifically highlighted with imitation as a strong influencing factor in infant hand use (Harkins & Michel, 1988) although findings in the current study of more mixed-handedness in first-borns raise the possibility that sibling influence may be worthy of exploration in some populations. However, Bishop (1990) maintains that familial handedness is not a strong indicator of PLH. In the current study the number of children with a left- handed parent is small although the bias is in favour of males. Other factors, environmental pressures such as religious or ethnic taboos may be more potent sources of pressure to decrease left-handedness. In the present sample observation of the dis' ıct groupings shows a rightward trend in the five year assessment by Nguni speakers. Whether this is the result of cultural pressure or to natural developmental trends would be difficult to determine. Currently, information on handedness patterns in urban African children has not been well researched largely because the overall emphasis has been placed on handedness in a social context (Hammond-Tooke, Personal Communication, 1996). However, some ethnic groupings who adhere to strong traditional rules might be more likely to insist on a right-handed code for greeting, eating or offering gifts. Zulu and Xhosa speakers have been noted for maintaining such traditions (Reynolds, 1989). A note of caution must be sounded as the language groupings are based on self-report measures from caregivers in some instances and are difficult to verify.

The notion that hand sp. ed or hand proficiency might be superior in more consistent handers was not fully supported in the current study. Girls who displayed persistent consistency at three years and five years performed faster than boys. It would be useful to confirm this trend in other samples as it may account for the variations in findings in largely cross-sectional research. In addition, previous research has noted that Annett's peg-board is not closely related to hand preference (De Agostini et al., 1992). The use of different types of peg-board instruments render comp :isons of motor performance difficult (Gabbard et al., 1993). Thus, referral to Annett's pegboard norms were probably more informative. However, the mean speed for right- and left-hands is slower than those reported by Annett and Kilshaw (1983) for 60 month-old children (right: 17.40, SD=2.07; left: 18.67, SD=2.71) and for 66 month-month-old children (right: 16.35, SD=1.96; left: 17.56, SD=2.53). In the current study, left-handed girls produced speeds that were closer to the norms of the Annett and Kilshaw sample. In the present sample this was a small group although it confirms Annett's (1985) view that left-handers are as proficient as right-handers on this task. Gender differences found between inconsistent handers favoured girls.

Multiple regression with the three years laterality quotient as the dependent variable,yielded three significant independent predictor variables,maternal handedness,paternal handedness and birthweight, the latter two being negatively biased. A plausible hypothesis might be that paternal handedness and low birthweight combine to act negatively on the child's lateral preference. In this instance the influence of maternal handedness appears to be minimum. Saling (1983) reported similar findings for head turning bias in three-day-old children. He concluded that the factor of paternal handedness may render the child and its lateral organisation more vulnerable to the effects of b. .a risk. Porac and Coren (1981) argue that the age of the parent is the crucial issue with older parents incurring greater birth risk. Data in the current study do not allow for further analyses in support of these debates and the present conclusions must be viewed as speculative. However, the effects of birthweight as a predictor variable appear to diminish with age as at five-years, mother's handedness was the only significant predictor of handedness. The current findings suggest that familial handedness and birth risk factors, specifically birthweight,appear to have important consequences for laterality in African children but especially males. However,the nature of the relationship is unclear. In the first place the role of environmental factors require clarification and secondly,the findings on p.139 suggest that the relationship is indirect,complex and non linear.

The consistency of handedness was also subjected to regression analyses. Birthweight appeared as the most potent predictor while maternal handedness was a negative predictor. McManus et al.(1988) suggest that the degree to which a child shows greater handedness consistency,in other words the extent to which they are lateralized,is not related to familial trends. The present findings are not fully supportive of this view. Instead the possibility is raised that normal birthweight might be seen as a decreasing risk factor for handedness consistency. Where birthweight is low, the factor of maternal handedness, possibly left-handedness, may increase vulnerability and affect consistency. However, the mechanisms of such interactions would be pure conjecture and require further exploration in future research. It is also clear that as the child develops environmental factors (e.g. exposure to skilled motoric behaviours) become increasingly important in determining consistency.

Finally, the overall impression is that development of lateral preferences in African children is generally similar to trends in other children, that is the direction of handedness, footedness and eyeness show the expected rightwardness. Although the current findings show the expected rightward trends, the degree to which preferences are established is weaker. This would account for the large percentage of mixed- and inconsistent- handers at the five-year-old stage. In the following chapter the results of the assessment of sequential and simultaneous skills will be examined and manual preferences will be explored within the context of cognitive processes.

CHAPTER 6

ANALYSIS AND RESULTS OF MENTAL PROCESSING AND COGNITIVE/ BEHAVIOURAL TASKS

In this chapter the results of the assessment of sequential and simultaneous processing skills will be explored. As observed in Chapter 3,several types of processing have been identified and applied in the assessment of cognitive behaviour. Sequential and simultaneous processes have been identified as two forms of coding information that is the basis for knowledge acquisition, its storage and retrieval (Naglieri & Das, 1987). Simultaneous processing requires holistic,spatial and gestalt synthesis while sequential processing involves a linear, analytical approach so that analysis involves a 'chain-like progression'. (Naglieri & Das, 1987,p.354;Kaufman et al., 1982). Although theorists do not agree on the neurological correlates of these two processes there has been separate and independent strivings on devising assessment tools for the measurement of the two coding processes (Das et al., 1975;Das et al., 1979; Kaufman et al.,1982). The Kaufman Assessment Battery (K-ABC,1983) has been shown to be supportive of the existence of the two modes of processing in several African samples (e.g.Giordani et al., 1996;Elwan, 1996). This raises the possibility that the K-ABC contains processing tasks that are not dependent on formal schooling measures for assistance in problem-solving. Another reason for it usefulness in a wide range of subjects is the age range which caters for children as young as two-and-one half years. Thus it is possible to introduce older preschoolers from a variety of backgrounds and environments to lower level items as a `warm-up' strategy.

In this chapter the results of the K-ABC assessment of the children in this sample will be examined and discussed. As explained in Chapter 4, in addition to the K-ABC items additional verbal and non-verbal items were included in the protocol in order to broaden the amount of assessment information obtained from this African sample of preschoolers. The means and gender scores for the two coding processes, Simultaneous and Sequential, and the composite Mental Processing scale scores will be examined. In addition,the scores for the additional cognitive tasks will be presented. The two processing scales, Sequential and Simultaneous, will be subjected to a factor analysis. Exploration of group differences and the possibility of group divisions,based on processing styles,will be determined. The profiles of cognitive tasks and the developing patterns of manual laterality will be inserted into each group profile. Thus, the analyses and results will be described in three phases. In the first phase the entire data base of 335 cases will be examined in terms of the internal consistency of the three processing scales for the current sample. This will be followed by a factor analysis and examination of the factor structure. The second phase of the results will commence with the division of the groups in accordance with the stated aim of examining the processing patterns present in the current sample of children. Having divided the groups,comparisons in terms of the cognitive and motoric variables will be performed. The third phase will examine the regression models comprising the cognitive and motoric independent variables to explain the two modes of processing.

Internal Consistency and Skewness

The coefficient alpha, an estimate of internal consistency was calculated for Sequential, Simultaneous and Mental processing scales. A high coefficient of .88 was established. However, there is a mild to moderate amount of skewness (.49) in the distribution of the scaled scores. This implies that there are more children at the lower end of the continu··· of scores than at the higher end.

Sequential and Simultaneous Processing

The means and standard deviations were extracted for the two processing types and the subtests comprising the two Sequential and Simultaneous scales. Table 6.1 contains this information for the entire group (n=335). The overall impression is one of little differentiation between scales and subtest tasks for the sample. The standard deviations on the Sequential and Simultaneous scores show variation within the group,specifically on the gross Simultaneous score.

A Gender X Processing (Sequential, Simultaneous, Mental Processing (MPC)) multivariate analyses of variance (MANOVA) showed no significant difference for Gender on either Sequential,Simultaneous or the composite Mental Processing scale (Wilks Lambda, $F(3,331)=.99$, $p=.47$).

Using the K-ABC metric of a mean of 10 and a standard deviation of 3,the weakest mean scores for the group,including boys' and girls' subgroups,were Gestalt Closure on the Simultaneous Scale and Word Order on the Sequential Scale. Both these scores were in the below average range. The highest scores obtained were Matrix Analogies and Spatial Memory, both on the Simultaneous Scale. All other scores were within average range (see Table 6.1).

Table 6.1 Means and Standard Deviations for Mental Processing Tasks - Standard Scores

	n=335 Group		n=165 Male		n=170 Female	
Task	Mean	SD	Mean	SD	Mean	SD
Word Order	5.2	2.0	5.1	1.7	5.3	2.0
Hand Movements	8.7	2.2	8.6	2.0	8.7	2.4
Number Recall	8.4	2.5	8.2	2.6	8.6	2.4
Sequential Score	88.7	9.7	87.8	9.2	89.5	10.2
Gestalt	6.1	2.9	6.3	2.9	5.9	2.7
Triangles	8.1	1.9	8.0	2.0	8.2	2.0
Matrix Analogies	10.9	1.9	10.8	2.0	11.0	1.9
Spatial Memory	9.4	2.7	9.4	2.8	9.5	2.7
Simultaneous Score	90.7	11.6	90.6	10.5	90.7	11.5
Mental Processing	88.3	10.6	87.9	10.5	88.7	10.7

Cognitive and Motor Tasks

Scores for tasks such as Verbal Fluency, Naming, Shape and Size accuracy, Mental Age and IQ (based on the DAP) for the whole group and for boys and girls were computed. Table 6.2 contains the total sample (n=335) scores, and the scores for boys and girls including means,standard deviations and frequency distribution for these measures.

A Gender X Task (Verbal Fluency, Mental Age, IQ and Mean Number Span) MANOVA showed an overall main effect for Gender, (Wilk's lambda $F=4.72, p<.01$)). Specific effects were found for Verbal Fluency, where the mean was significantly higher for females ($F=9.42, p<.01$). Girls also showed significantly higher scores on mental age ($F=4.33, p<.05$) and IQ ($F=12.1$, $p<.001$). No significant effect was found for the raw number span ($F=.74$, $p=.4$). A Gender X Task (Right and Left Pegboard Speed,Laterality Quotient at three years,Laterality Quotient at five years) MANOVA was applied to the motoric tasks separately to avoid including large numbers of variables (e.g.Howell, 1992). No significant main effect was found (Wilks Lambda,$F(4/330)=1.89, p=.11$). Applying the Kruskal-Wallis statistic,gender differences were also found for alphabetic knowledge ($H=11.6, p=.0007$). Naming skills were higher in females ($H=5.04, p=.02$). Chi Square analysis showed that the number of girls achieving size ($p=.67$) and shape ($p=.16$) accuracy was slightly but not significantly higher than boys.

Intercorrelations between Cognitive Tasks

An intercorrelation matrix incorporating the independent variables, Sequential, Simultaneous and Mental processing and the dependent cognitive variables is presented in Table 6.3. Of particular interest was the findings that mental age correlated with Sequential processing ($r=.28$, $p<.0001$), Simultaneous processing ($r=.34, p<.0001$) and Mental Processing composite score

Table 6.2 Language, Mental Age, IQ and Cognitive Scores for the Group

n=335 Item	Total ~ ^	Male	Female
Verbal Fluency	13.9 (3.8)	13.3 (3.6)	14.5 (3.8)**
Mental Age	56.1 (8.9)	55.0 (8.7)	57.3 (9.0)*
IQ	86.3 (10.4)	84.3 (10.7)	88.3 (9.9)***
Mean Number Span	3.5 (0.7)	3.5 (0.7)	3.5 (0.7)
Alphabet +	26 (8%)	8 (5%)	18 (11%)***
Naming a[illegible] correct +	43 (13%)	16 (5%)	27 (8%)*
Names all Shapes +	272 (81%)	133 (39%)	139 (41%)
Identifies all sizes +	262 (78%)	127 (38%)	135 (40%)
LQ3#	7.72 (3.13)	7.85 (3.03)	7.60 (3.23)
LQ5#	8.25 (2.73)	8.25 (2.72)	8.26 (2.75)
Pegs: R$	18.6 (3.8)	19.2 (4.1)	18.1 (3.4)
L$	20.9 (4.6)	21.4 (4.6)	20.4 (4.6)

*p< .05 **p< .01 ***p<.001
+only 'all correct' levels are shown. Tables in Appendix D portray all levels
#Laterality Quotient at three years #Laterality Quotient at five years
~ Mean ^Standard Deviation
$ Pegboard speed Right and Left hands

(MPS). Mental age also correlated highly with IQ which was expected as the computation of IQ was based on the mental age score of the Draw-a-person Test (DAP, Goodenough, 1926),($r=.75, p<.0001$), but also with Verbal Fluency ($r=.24, p<.0001$);alphabet knowledge ($r=-.21$, $p<0001$). IQ correlated with MPS ($r=.56$, $p<.0001$), Verbal Fluency $r=.30, p<.0001$, Simultaneous processing ($r=55, p<.0001$ and Sequential processing ($r=40, p<.0001$) Thus mental age and IQ based on the Draw -a-Person (DAP) at five years in this sample, would appear to correlate highly with a number of cognitive skills, however, the most substantial correlations were observed with the cognitive processes of Simultaneous, Sequential and Mental Processing skills. This would support the use of the DAP as a useful non-verbal measure of both mental age and IQ for five-year-old black preschool children. The composite mental processing scale score (MPS) also correlated with verbal fluency ($r=31, p<.0001$) alphabet knowledge ($r=-.29, p<.0001$), Right and left Pegboard performance (both $r=-.27, p<.0001$), knowledge of shape ($r=..23, p<.0001$) and knowledge of size ($r=.30, p.<.0001$). Although significant correlations for Verbal Fluency, Naming skills, Size accuracy and right pegboard speed, are portrayed they are smaller and given the large sample size, may have have little practical significance (Neale & Liebert, 1986). Handedness direction showed no significant correlation with either mode of processing (See Table 6.3).

Correlations do not explain the causal relationships between variables and for this reason it would be useful to explore the predictive capacity of variables such as mental age and IQ measures on simultaneous and sequential processing skills. Regression analyses were computed and will be discussed further in the chapter. However, it was considered necessary to first submit the Sequential and Simultaneous scales to factor analysis.

Table: 6.3 Intercorrelations between Cognitive Tasks, Handedness and Hand Skills

	Gender	SEQS	SIMS	MPS	Naming	Verbal Fluency	Alpha-bet	RPEG	LPEG	Shape	Size	Age	IQ	LQ3	LQ5	Hand Consist	Lang. Group
Gender	1	.09	.01	.05	.12*	.17**	-.19****	.-14*	-.11*	.02	.08	.13*	.19***	-.04	.00	-.06	.00
SEQS	.09	1	.47****	.79****	.15**	.24****	-.31****	-.21****	-.20****	.20****	.23****	.28****	.39****	-.07	.02	-.03	-.09
SIMS	.01	.47****	1	.88****	.12*	.30****	-.23****	-.27****	-.26****	.22****	.30****	.34****	.55****	-.03	.08	-.10	-.02
MPS	.05	.79****	.88****	1	.16**	.31****	-.29****	-.27****	-.27****	.23****	.30****	.36****	.56****	-.05	.06	-.08	-.07
Naming	.12*	.15**	.14*	.16**	1	.05	-.17***	-.06	-.06	.09	.08	.09	.09	-.01	-.08	-.00	.13
V.Fluency	.17**	.24****	.30****	.31****	.05	1	-.20****	-.17**	-.19****	.15***	.20****	.24****	.30****	-.08	-.03	-.00	-.03
Alphabet	-.19****	-.31****	-.23****	-.29****	-.17***	-.20****	1	.09	.09	-.14*	-.16**	-.21****	-.24****	.03	-.02	-.01	.04
RPEG	-.14*	-.21****	-.27****	-.27****	-.06	-.17**	.09	1	.68****	-.12*	-.13*	-.18***	-.25****	-.05	-.07	.04	-.08
LPEG	-.11*	-.20****	-.26****	-.27****	-.06	-.19****	.09	.68****	1	-.19***	-.15**	-.16**	-.24****	.13*	.18***	.01	-.07
Shape	.02	.20****	.22****	.23****	.09	.15**	.14*	-.12*	-.19***	1	.46****	.15**	.16**	-.06	-.04	.05	.08
Size	.08	.23****	.30****	.30****	.08	.20****	-.16**	-.13*	-.15**	.46****	1	.16**	.24****	-.01	.04	.04	.10
Age	.13*	.28****	.34****	.36****	.09	.24****	-.21****	-.18***	-.16**	.15**	.16**	1	.75****	.00	-.00	-.03	-.05
IQ	.19***	.40****	.55****	56****	.09	.30****	-.25****	-.25****	-.24****	.16**	.23****	.75****	1	-.03	-.00	-.04	-.05
LQ3	-.04	-.07	-.03	-.05	-.01	-.08	.03	-.05	.12*	-.06	-.01	.00	-.03	1	.55****	-.08	.06
LQ5	.00	.01	.08	.06	-.08	-.03	-.02	-.07	.18***	-.04	.04	-.01	-.00	.55****	1	-.22****	.02
Hand. Consist	-.06	-.03	-.10	-.08	-.00	.00	-.01	.04	.01	.05	.04	-.03	-.04	-.09	-.22****	1	.13*
Lang. Group	.00	-.09	-.02	-.07	.13*	-.03	.04	-.08	-.07	.08	.10	-.05	-.05	.06	.02	.13*	1

* p<.05 ** p<.01 *** p<.001 **** p< .0001

Note: Data incomplete for 4 cases

Factor Analysis

Despite the fact that studies carried out with the K-ABC on non-American samples have endorsed the notion of the two types of mental functioning, that is Simultaneous and Sequential processing,it has been observed that different samples and different conditions can alter the factor structure (Kerlinger,1973). More specifically, Kerlinger (1973) points out that differences in the social and cultural milieu of the sample can influence the nature of the emerging factors. It would then be necessary to perform factor analysis relevant to the South African milieu especially on tests that were not standardised on South African children. If distinct processing factors are present,the current sample could be said to process and code information in a manner similar to other samples on the K-ABC. Factor analysis techniques,principal component and varimax rotation were used. The orthogonal rotation is the least complicated and,as Kerlinger (1973) points out it maintains the independence of the factors (p.673). In keeping with Child's (1979) recommendations, the acceptance of loadings of .3 and above is regarded as sufficiently rigorous for considering significant items in the factor matrix.

The principal components factor analysis and varimax rotation of the K-ABC scores on the seven subtests comprising the two scales, Simultaneous and Sequential,revealed a two factor solution (see Table 6.4). Kaiser's criterion,the selection of eigenvalues greater than unity, was employed. Loadings on Factor 1,a Simultaneous factor for Gestalt Closure, Matrix Analogies and Spatial Memory were observed,however, Triangles appeared to load on both Sequential and Simultaneous. Similarly,loadings on Factor 2, a Sequential factor,by Word Order and Number recall were present with loadings on both factors observed for Hand Movements. Communality is also the lowest for Hand Movements. Perusal of the communality column, which reflects

Table 6.4 Varimax Rotated Factor Solution for Sequential and Simultaneous Processes

Item	Factor 1	Factor 2	Communality
WO+	.20	.74	.58
HM	.32	.55	.41
GC	.79	.05	.62
NR	.03	.82	.68
TR	.57	.46	.54
MA	.68	.21	.50
SM	.75	.13	.58
Eigenvalues	2.86	1.05	3.91
%Variance	40.9%	15 %	55.9%

+WO=Word Order; HM=Hand Movements; GC=Gestalt Closure; NR=Number Recall; TR=Triangle; MA=Matrix Analogies; SM=Spatial Memory the sum of the square of the factor loadings (h_2), shows that the variance accounted for Number recall is the highest. The first factor, Simultaneous, accounts for the highest amount of variance, that is 40.9%. The Sequential factor would seem to be suspect either because of the imperfections of the tasks used or because it is poorly developed in this sample or both. Low communalities imply that the reliability of the tests for mental processing, especially the sequential tasks is by no means robust. However, the communalities for all tests remain above the .3 level, which Child (1979) recommends as the benchmark for eliminating an unreliable test. Nevertheless, the total variance accounted for by this model is low at 56% and seems to be accounted for largely from tasks on the Simultaneous scale.

The factor analysis technique was also used to generate factor scores for the Simultaneous and Sequential tasks. Such scores are individual measures on factors, and it is possible to condense information on a number of tasks by using the two scores generated by the factors (Kerlinger, 1973). The factor score coefficients were extracted and a double median split was performed for the cases in the sample (n=335) based on the Simultaneous and Sequential factor scores. This strategy was recommended by Kirby & Das (1979) for examining differences in means for Sequential and Simultaneous processing styles within groups. The median was chosen because of its relative stability in the face of extreme values. As previously noted in Chapter 4, cluster analysis was not employed because of the fixed nature of the groupings required.

Group Divisions for Mental Processing Scales

In order to understand more clearly the patterns of mental processing, the scores were examined with the aim of establishing subgroupings with distinct processing trends within the sample according to the groupings and rational described in Chapter 4, in the Statistical Analysis section. The following groups emerged;

Group 1. Both scale scores below the median (n=115)

Group 2. Sequential< and Simultaneous=> median (n=56)

Group 3. Sequential=> and Simultaneous< median (n=49)

Group 4. Simultaneous > Sequential by 10 points and

both scores => the median (n=28)

Group 5. Sequential > Simultaneous by 10 points and

both=> median(n=11)

Group 6. Remaining cases on both scales who did not meet the above criteria. (n=76).

Two groups, Group 1 and Group 5, produced the largest and smallest sub-samples respectively. A method of checking the accuracy of the classification system was carried out by performing a discriminant function analysis (CSS Statistica) for group allocation accuracy. The majority of the sample 220 (66%) showed a profile whereby one or both of the processing styles were below the group mean. Of the remaining 115 cases (34%) with both scores above the mean the largest group (n=76 or 23%) showed a SEQ=SIM pattern. Thus,of the six processing patterns, four groups, Groups 1, 2, 3 and 6 are comparable in terms of size and processing scores. Groups 4 and 5 appear idiosyncratic both in patterns of processing and in size, and statistically will have to be considered separately. The differences observed in these two latter groups are important and portray clearly lateralized patterns with both processing scores above the group mean. Although the Groups 4 and 5 comparisons will be considered apart from the four largest groups,the entire data base will be maintained.

<u>Comparison of Groups 1,2,3 and 6</u>

The division and comparison of Groups 1, 2, 3 and 6 with unequal sample sizes and variations in test scores first requires an investigation that assumptions of homogeneity of variance have not been transgressed. Despite the robustness of the MANOVA or ANOVA,the effect of differences in variance between groups can seriously affect the F test (Kerlinger, 1973).

The Cochran C Test was computed for the three processing scales, and the five cognitive and four motor tasks (verbal fluency, mental age, IQ,mean recall, LQ3, LQ5, Right Pegboard nd Left Pegboard speeds). Tests which did not meet the assumption of homogeneity were Sequential processing ($C=.25, p<.05$);Mental Processing ($C=.23, p. <.05$);Mental age ($C=.42, p<.05$); Right Pegboard ($C=.21, p<.05$) and Left Pegboard ($C=.21, p<.05$). For these particular tests, the Kruskal-Wallis one way ANOVA was computed (see below). The major difficulty with the Kruskal-Wallis test is a lack of post hoc procedures in comparing group means.

As previously discussed in Chapter 4, a separate multivariate effect was computed using the Wilk's lambda F (Rao R Form) approximation and separate univariate analysis were computed to clarify whether there was an individual multivariate effect. The following dependent variables were inserted, Simultaneous Processing, Verbal Fluency, IQ, Mean digit length, LQ3, LQ5. Independent variables were Gender and Group. A significant main effect was found for group differences, Wilk's lambda (Rao R Form) $F(18/798)=30.4$, $p=<.000000$),but not for gender differences (Wilk's lambda,Rao R Form $F=(6/282)$ 1.4,$p=.10$). Analysis of variance (ANOVA) series was used to examine group differences on each task with Group (four levels) and Gender (two levels) as independent variables. The results can be seen in Tables 6.5 to 6.10. The table contains the Source, Mean Square for the groups (which is computed by dividing the Sum of the Squares by the degrees of freedom), the Mean Square error, the F statistic and the probability calculation for each effect and interaction.

ANOVA revealed expected significant differences between the groups on the dependent variables of Simultaneous processing styles, Verbal Fluency, IQ,and Mean Number recalled. In Table 6.5, there was a significant main effect for group for Simultaneous processing. No Gender effect was observed for this task and interaction was non-significant.

In Table 6.6 a significant main effect for Group and for Gender was observed for IQ. Interaction was non-significant ($p=.144$). In Table 6.7 a similar pattern emerged with significant Group effect and Gender effects for Verbal Fluency with no interaction effects ($p=.38$).

In Table 6.8 a significant main effect was found for the mean number span recalled, however, no effect was found for Gender ($p=.77$) and interaction was non-significant ($p=.308$). No significant values were found for Laterality Quotients either at three (see Table 6.9) or five years (see Table 6.10).

A Kruskal-Wallis statistic (Table 6.11) was computed in order to compare the four groups on tests that failed to meet the requirements for homogeneity and on categorical variables such as knowledge of the Alphabet ($H=29.98, p=<.00001$), Naming ($H=2.57, p=.46$), accuracy in recognising shape ($H=8.75, p<.05$) and size ($H=22.2, p<.001$). Table 6.10 contains this information.

No group differences for consistent versus inconsistent handers were found (Chi Square=2.11, df=3, $p=.54$). No significant differences were found across groups in terms of number of consistent versus inconsistent handers for males (Chi Square=1.11, df=3, $p=.77$) or females (Chi Square=1.96, df=3 $p=.57$).

Comparison of Groups 1 2 3 and 6 are presented in table format (Tables 6.12 to 6.15) on pages 180 to 183. Tables 6.12, Table 6.13, Table 6.14 and Table 6.15 contain the scores for the three processing Scales, Simultaneous, Sequential and Mental processing composite, together with the subtest scores. In addition, the cognitive tasks, verbal fluency, mean number span, mental age scores and IQ scores, naming skills, alphabetic knowledge, knowledge of shape and size, and the motor and handedness measures, LQ3, LQ5, Pegboard speed for right and left hands and handedness consistency are also included. Each table contains the means and standard deviations for the group scores and the individual group means and percentages for the cognitive tasks have been shown. The subtests of the Sequential and Simultaneous processing scales have been shown and the means and standard deviations presented,however, they have not been included in the analyses. Significant differences observed for the Kruskal-Wallis (KW) will be highlighted. Post hoc differences, which will be applied to the ANOVA computations, will be discussed. The Tukey HSD for unequal sample sizes (Spjotvoll & Stoline test) will be given within this context. Each group and its profile will be discussed beginning with Group 1.

Group 1.

The Group 1 profile can be observed in Table 6.12. The scores for this group were below the group mean for both scales. There is an overall impression of flatness in the two processing profiles. All subtest scores were below average with the exception of Matrix Analogies, which was within the average range. Particularly low scores were observed for the subtests Gestalt Closure and Word Order.

Processing Styles. Post Hoc comparisons revealed that Group 1 Simultaneous scores were significantly lower than Groups 2 and 6 (all significant at $p=.00000$). Mental Processing (Kruskal-Wallis) scores were lower than those in Groups 2, 3, and 6. The Group 1 Sequential score (Kruskal-Wallis) was also lower than scores in Group 2 , 3 and 6.

Mental age. The group Mental Age mean obtained was 52.2 months, for boys a mental age of 50.1 months was obtained and for girls 54.1. The overall age for this group is considerably below the expected de facto age of between 60 to 65 months for the sample although the fluctuations in the standard deviations suggest variation of mental age within the group. An overall significant difference was found with the Kruskal-Wallis test and differences can be observed between Groups 2 and 6.

Table 6.5 ANOVA for Simultaneous Processing

Source	df	Mean Square Effect	Mean Square Error df/288	F	p
Gender	1	1.75	31.77	.055	.814
Group	3	6774.85	31.77	213.24	.000***
1x2	3	35.87	31.77	1.13	.338

***p< .0001

Table 6.6 ANOVA for IQ

Source	df	Mean Square Effect	Mean Square Error df/288	F	p
Gender	1	571.86	75.61	7.56	.006**
Group	3	2554.52	75.61	33.78	.000****
1x2	3	137.29	75.61	1.81	.144

**p< .01, ****p< .0001

Table 6.7 ANOVA for Verbal Fluency

Source	df	Mean Square Effect	Mean Square Error df/288	F	p
Gender	1	54.28	12.91	4.20	.041*
Group	3	107.62	12.91	8.33	.0000****
1x2	3	13.21	12.91	1.02	.382

*p< .05, ****p< .00001

Table 6.8 ANOVA for Mean Number Span

Source	df	Mean Square Effect	Mean Square Error df/288	F	p
Gender	1	.03	.39	.08	.77
Group	3	12.96	.39	33.58	.0000****
1x2	3	.46	.39	1.20	.308

****p< .00001

Table 6.9 ANOVA for Laterality Quotient at Three Years

Source	df	Mean Square Effect	Mean Square Error df/288	F	p
Gender	1	2.70	9.54	.283	.59
Group	3	9.65	9.54	1.01	.388
1x2	3	.21	9.54	.02	.995

Table 6.10 ANOVA for Laterality Quotient at Five Years

Source	df	Mean Square Effect	Mean Square Error df/288	F	p
Gender	1	.077	7.35	.01	.91
Group	3	10.65	7.35	1.45	.228
1x2	3	1.88	7.35	.255	.85

Table 6.11. Kruskal-Wallis ANOVA for Cognitive and Processing Tasks

Item	H	P
Sequential Processing	223 .3	.0000****
Mental Processing	224 .5	.0000****
Mental Age	73 .5	.0000****
Right Peg	18 .3	.0004***
Left Peg	17 .1	.0007***
Alphabet Knowledge	29 .98	.0000****
Naming	2 .57	.46
Knowledge of Shape	8 .75	.03*
Knowledge of Size	22 .2	.0005***

*p< .05, ***p< .001, ****p< .0001

Table 6.12 Scores for Group 1: Low SIM - Low SEQ

	n=115		n=56		n=59	
Subtests and Scales Item	Mean	SD	Males	SD	Females	SD
Word Order	4.01	1.3	3.9	1.2	4.1	1.3
Hand Movement	7.4	1.7	7.4	1.5	7.3	1.7
Number Recall	6.8	2.0	6.5	2.1	7.0	1.8
Sequential	80.6	4.8+	79.9	4.7	81.3	4.8
Gestalt	4.3	1.9	4.5	1.8	4.0	2.0
Triangles	6.8	1.2	6.8	1.3	6.7	1.0
Matrix	9.8	1.9	9.6	1.9	9.9	1.9
Spatial Memory	7.6	2.1	7.5	2.2	7.6	1.9
Simultaneous	80.5	5.6*****	80.8	5.8	80.3	5.4
Mental P	78.0	4.6+	77.7	4.7	78.4	4.6
Cognitive Tasks						
Verbal Fluency	12.5	3.7**	11.7	3.4	13.3	3.9
Mental Age	52.2	6.3+	50.1	6.3	54.2	5.6
IQ (DAP)	79.8	8.8*****	76.8	8.1	82.7	8.6
Mean Span	3.1	.6*****	3.1	.5	3.2	.6
Alphabet	3	(3%)+	1	(2%)	2	(3%)
Naming: All correct	13	(11%)	5	(9%)	8	(14%)
Shapes: All correct	85	(74%)+	40	(71%)	45	(76%)
Size: All correct	84	(73%)+	38	(68%)	46	(78%)
Handedness Tasks						
LQ3	7.9	3.0	8.1	3.0	7.8	3.0
LQ5	8.0	3.0	8.0	3.0	7.9	2.9
Pegs: R	19.6	4.2+	20.3	4.7	19.0	3.7
L	22.2	5.3+	22.9	5.1	21.5	5.5
Consist	66	(57%)	33	(59%)	33	(56%)
Inconsist	49	(43%)	23	(41%)	26	(44%)

*p< .05, **p< .01, ***p< .001, ****p<0001, p< .00001*****
+Group Significance obtained with Kruskal-Wallis test.

Table 6.13 Scores for Group 2: High SIM-Low SEQ

Subtests and Scales Item	n=56 Mean	SD	n=33 Males Mean	SD	n=23 Females Mean	SD
Word Order	4.6	1.4	4.8	1.3	4.3	1.5
Hand Movement	7.8	1.8	7.9	1.7	7.6	1.9
Number Recall	7.1	1.5	7.4	1.6	6.8	1.4
Sequential	83.2	3.7+	84.1	3.4	82.0	3.8
Gestalt	7.8	2.3	8.2	2.3	7.2	2.3
Triangles	8.3	1.6	8.2	1.6	8.5	1.6
Matrix	11.6	1.4	11.5	1.4	11.8	1.3
Spatial Memory	11.3	1.9	11.5	1.7	10.9	2.2
Simultaneous	97.8	5.7*****	98.5	6.0	96.9	5.3
Mental P	89.8	4.6+	90.5	4.6	88.9	4.5
Cognitive Tasks						
Verbal Fluency	14.6	3.4**	14.8	3.5	14.5	3.4
Mental Age	58.5	6.6+	58.0	6.9	59.3	6.1
IQ (DAP)	88.9	9.9*****	88.5	10.5	89.5	9.3
Mean Number Recall	3.2	.6*****	3.3	.7	3.1	.4
Alphabet	5	(9%)+	2	(6%)	3	(13%)
Naming: All correct	7	(12%)	3	(9%)	4	(17%)
Shapes: All correct	49	(88%)+	30	(91%)	19	(83%)
Size: All correct	52	(93%)+	31	(94%)	21	(91%)
Handedness Tasks						
LQ3	8.2	2.6	8.3	2.6	7.9	2.7
LQ5	8.7	2.3	8.8	2.1	8.5	2.6
Pegs: R	18.2	3.8+	17.9	4.2	18.6	3.1
L	20.1	4.0+	20.0	3.9	20.3	4.2
Consist	37	(66%)	22	(67%)	15	(65%)
Inconsist	19	(34%)	11	(33%)	8	(35%)

*p< .05, **p< .01, ***p< .001, ****p< .0001, *****p< .00001
+Significant Group difference obtained with Kruskal-Wallis test.

Table 6.14 Scores for Group 3: Low SIM-High SEQ

	n=49		n=26		n=23	
Item	Mean	SD	Males	SD	Females	SD
Subtests and Scales						
Word Order	5.4	1.7	5.4	1.9	5.4	1.5
Hand Movement	9.2	1.5	9.3	1.5	9.1	1.4
Number Recall	9.9	1.5	9.9	1.5	10.0	1.6
Sequential	93.1	4.0+	92.0	4.0	93.3	4.5
Gestalt	4.8	1.7	4.7	1.6	4.8	2.0
Triangles	7.2	1.5	7.0	1.6	7.5	1.4
Matrix	10.0	1.8	9.9	1.5	10.2	2.0
Spatial Memory	7.5	2.2	7.4	2.3	7.5	2.1
Simultaneous	82.1	6.0*****	81.5	5.5	82.7	6.6
Mental P	85.3	4.4+	84.64	3.8	86.0	4.9
Cognitive Tasks						
Verbal Fluency	13.4	3.1	13.0	2.8	13.7	3.5
Mental Age	54.4	5.8+	53.1	5.5	55.8	5.8
IQ (DAP)	82.6	8.8**	80.6	8.5	84.9	8.7
Mean Number						
Span	3.9	.6*****	3.8	.6	3.9	.6
Alphabet	3	(6%)+	2	(7%)	1	(4%)
Naming: All correct	6	(12%)	3	(11%)	3	(13%)
Shapes: All correct	41	(84%)+	21	(81%)	20	(87%)
Size: All correct	44	(90%)+	22	(93%)	22	(94%)
Handedness Tasks						
LQ3	7.2	3.5	7.2	3.4	7.1	3.7
LQ5	8.0	3.0	7.9	3.1	8.1	2.9
Pegs: R	19.8	3.7+	20.8	3.9	18.7	3.1
L	22.0	4.5+	23.2	5.1	20.7	3.5
Consist	27	(55%)	14	(54%)	13	(57%)
Inconsist	22	(45%)	12	(46%)	10	(43%)

*p< .05, **p< .01, ***p< .001, ****p< .0001, *****p< .00001

+Significant difference obtained on Kruskal-Wallis test.

Table 6.15 Scores for Group 6: High SIM=High SEQ

Subtests and Scales Item	n=76 Mean	SD	n=32 Males Mean	SD	n=44 Females Mean	SD
Word Order	6.6	2.1	6.6	2.2	6.7	2.0
Hand Movement	10.0	2.0	9.8	1.8	10.1	2.2
Number Recall	9.9	2.0	9.7	2.2	10.2	1.9
Sequential	97.0	6.4+	95.6	5.4	98.0	6.8
Gestalt	6.8	2.2	6.7	2.5	7.0	2.0
Triangles	9.3	1.8	9.2	1.7	9.3	1.9
Matrix	12.0	1.4	12.0	1.6	12.0	1.3
Spatial Memory	11.0	2.1	10.7	2.3	11.2	2.1
Simultaneous	98.0	5.3*****	97.0	4.7	98.7	5.7
Mental P	96.9	6.1+	96.3	5.1	97.3	6.7
Cognitive Tasks						
Verbal Fluency	15.0	3.9***	14.1	4.0	15.7**	3.7
Mental Age	59.0	11.4+	60.7	6.4	57.9	13.9
IQ (DAP)	92.0	8.2*	91.5*	7.8	92.2	8.5
Mean Number Span	3.9	.7*****	3.8	.7	3.9	.7
Alphabet	9	(12%)+	1	(3%)	8	(18%)
Naming: All correct	13	(17%)	5	(16%)	8	(18%)
Shapes: All correct	70	(92%)+	30	(94%)	40	(91%)
Size: All correct	72	(95%)+	30	(94%)	42	(95%)
Handedness Tasks						
LQ3	7.7	3.2	7.7	3.2	7.6	3.2
LQ5	8.7	2.3	8.4	2.6	8.8	2.1
Pegs: R	17.5	2.7+	17.8	2.5	17.3	2.8
L	19.7	3.5+	19.2	2.3	20.0	3.5
Consist	50	(66%)	20	(63%)	30	(68%)
Inconsist	26	(34%)	12	(37%)	14	(32%)

*p< .05, **p< .01, ***p< .001, ****p< .0001, *****p< .00001

+Significant difference obtained on the Kruskal-Wallis test.

IQ scores. IQ scores, which were derived from the mental age scores, were significantly lower than those in Groups 2, ($p=.00000$) and 6 ($p=.00000$). The IQ showed a higher trend for girls in Group 1 although this did not reach significance.

Number span. The Mean Number of digits recalled was compared (ANOVA) and Group 1 showed a significant difference with Groups 3 ($p=.00000$) and 6 ($p=.00000$).

Language. The Group 1 scores for Verbal Fluency was significantly lower than Group 2 ($p=.0094$) and Group 6 ($p=.00022$). Eleven percent of the group (9% boys and 14% girls) were able to correctly name all body-part items although no significant differences were found (Kruskal-Wallis test).

Shape, size and alphabetic knowledge. The majority of Group 1, 74% (71% boys and 76% girls) were able to correctly identify shapes and 73% (68% boys and 78% girls) were able to identify size. A significant difference was found (Kruskal-Wallis test, Size, $p<.01$; Kruskal-Wallis test, Shape, $p<.0001$). A comparison between boys and girls for shapes and sizes showed no significant gender differences ($df=1$, $p=.78$). Alphabetic knowledge was poor in this group. The Kruskal- Wallis test showed a significant difference across the four groups.

Handedness trends. Group 1 scores for right-handed pegs showed a significant difference for the four groups (Kruskal-Wallis, $p=0004$). In Table 6.11 it can be observed that the percentage of consistent handers in the group was 57% (59% boys and 56%) and inconsistent handers 43% (41% boys and 44%). There were no significant gender differences for the numbers of consistent versus inconsistent handers (Chi Square $=.11$, $df=1$, $p=.74$). Out of the total number of consistent left-handers in the study comprising 15 (8 males and 7 females) five of the seven males and two of the females are located in this weaker group. No significant differences were found for LQs either on a group or gender basis.

Group 2

In this group the processing profile,as observed in Table 6.13,shows a Sequential Scale below the mean and the Simultaneous Scale was above the mean. The Group 2 Sequential scores for Hand Movement and Number Recall were slightly below the scaled average scores while Word Order was clearly below average. Of the four Simultaneous scores,Gestalt Closure was slightly below average. A higher degree of variation as shown by the standard deviations was observed on the Simultaneous group score. The composite Mental Processing score was significant for the group (KW test, $p<.0001$). The mean in this group is higher than that in Group 1 and lower than Group 6.

Processing styles. Group 2 scores for Sequential processing (Kruskal-Wallis test) were higher by comparison with Group 1 and were lower than Group 3 and Group 6. The Simultaneous mean was significantly higher than Group 1 (Table 6.12) at $p=.0000$.

Mental age. A significant group difference was found on this task (KW test, $p<.0001$).The mean mental age for Group 3 was 58.5 months, higher than Group 1 (Table 6.12) but lower than Group 6 (Table 6.15).

IQ. IQ scores for the group showed high variations as reflected by the standard deviations.The group IQ was significantly higher than Group 1 ($p=.0000$) and lower than Group 3 ($p=.0022$) (Table 6.14).

Number span.The mean number span was significantly lower than Groups 3 and 6 (all at $p=.000$).

Language. The Verbal Fluency group mean was significantly higher than Group 1 ($p=009$). Naming showed that only 12% (9% boys and 17% girls) of the group were able to name all body parts,however, there is a relatively higher percentage of girls.

Shape, size and alphabetic knowledge. Eighty-eight percent (91% boys and 83%) girls correctly identified all shapes. Group differences were significant (KW test, $p < .0001$). Size identification was correct for 93% of the group (94% boys and 91% females). Group differences were also significant (Kruskal-Wallis test $p < .01$). Although there would appear to be greater percentage of boys, the difference was not significant ($p = .83$). Alphabetic knowledge indicates that few children had completely mastered this basic skill.

Handedness trends. There were significant differences found for right- or left-handed Pegboard speed as shown by the Kruskal-Wallis test. In Table 6.12, inconsistent handers totalled 34% as opposed to 66% consistent handers. Boys showed 34% inconsistent and 66% consistent handers. One consistently left-handed male was located in this group. Girls showed 35% inconsistent and 65% consistent handers. The overall difference was not significant ($p = .91$). Inspection of LQs at three and five years shows an increasingly strong right-handed trend at both age periods but no significant differences.

Group 3

The scores for this group can be seen in Table 6.14. The scores show distinct patterns in that the Sequential processing score is at or above the mean and the Simultaneous processing score is below the group mean. Word Order, a Sequential component, is the only score to fall below the mean. However, three out of the four Simultaneous scores, Gestalt Closure, Triangles and Spatial Memory, had scores in the below average range. As observed for Group 1, the Gestalt Closure and Word Order scores were again particularly weak. Overall the Group 3 scores show some marked strengths in Sequential scores and a strong raw mean number recall span. Composite Mental Processing scores showed significant differences for this group (Kruskal-Wallis test $p < .00001$). The scores were higher than Group 1 scores but lower than Groups 2 and 6.

Processing styles. Group 3 Sequential processes were observed as higher than Groups 1 and 2 and 6. Simultaneous scores were lower than Groups 2 (Table 6.13) and 6 (Table 6.15),all significant at $p=.00000$.

Mental age. A significant group difference was found (KW test, $p<.00001$). The mean mental age for this group was lower than Group 2 and Group 6.

IQ. Group 3 IQ scores were lower than those in Groups 2 ($p=.0022$) and 6 ($p=.00000$).

Number span. Post hoc comparisons show significantly higher scores than Group 1 ($p=.000002$) and Group 2 ($p=.00000$) (see Tables 6.12 and 6.13).

Language. The Group language score of 13.4 words generated was not significantly different than the other groups.Boys and girls scores were similar. Twelve percent of the group (11% boys and 13% girls) were able to correctly name all items.

Shape,size and alphabetic knowledge. Overall, 84% of the group (81% boys and 87% girls) correctly identified shapes and 90% (93% boys and 94% girls) correctly identified size. There were no significant differences between genders on these two tasks ($p=.83$). The Kruskal-Wallis test (Table 6.11) showed a significant difference across the four groups on this task ($p<.001$). Few children portrayed sound knowledge of the alphabet in this group.

Handedness trends. The Kruskal-Wallis test showed significant group differences for both right- ($p<.001$) and left-handed ($p<.001$) pegboard speeds. For Group 3, Table 6.13 shows that the speeds recorded are lower than those in Group 2 and in Group 6, but similar to those in Group 1. A high ratio of consistent to inconsistent handers appeared in this group,27 to 22. Of these 54% consistent handers were boys and 57% were girls. Inconsistent handers comprised 46% boys and 43% girls. There were no significant differences in these groupings ($p=.85$). Two boys and one girl, consistent left handers were located in this group. No significant group differences were found on LQ scores. Overall the eleven point difference of SEQ > SIM combination produces a significantly stronger number span and weaker skills in naming shapes and identifying size.

Overview. An overview of Groups 1,(Table 6.12) 2, (Table 6.13) and 3 (Table 6.14) not only show variations in patterns of language, mental age and IQ derivatives but also weaknesses in subtest scores. The Group 1 mental age is significantly low. In terms of handedness trends it is noteworthy that these three groups account for all consistent left-handed males and three of the females in the sample. Group 1 contains the largest number, five male left handers. There are two male left handers in Group 3 and one in Group 2, however, Fisher's Exact Probability Test was not significant (p=.37).

Group 6.

The processing profile for Group 6 (Table 6.15) once again differs in that all scores are above the group mean with no fixed pattern or variation for Sequential and Simultaneous processing observed. Group 6 comprised those children whose scores showed a SEQ=SIM pattern. The results show a flat profile similar to that of Group 1 but at least 17 points higher on each scale. Perusal of the subtest scores shows that the only tests in the below average scale score range were Gestalt Closure and Word Order. The composite Mental Processing score in this group is higher than the scores for Groups 1,2, or 3.

Processing style. The group Sequential score was higher than those in Groups 1, 2 and Group 3. The Simultaneous group score was significantly higher than the scores in Groups 1 and 3 (p=.00000). Once again there were no significant Simultaneous gender differences.

Mental age. The group mental age of 59.0 was higher than that in Group 1.

IQ. The group IQ score was significantly higher than Groups 1 (p=.00000) and Group 3 (p=0113). Boys IQ scores in this group were significantly higher than girls in Group 1 (p=.029).

Number span. The group mean number span was significantly higher than Groups 1 and 2 ($p = .00000$).

Language. The group Verbal Fluency score was higher in comparison with Group 1 ($p = .00022$). - The girls in Group 6 showed a significantly higher score than the boys in Group 1 ($p < .01$). Naming scores were low as only 17% (16% and 18% girls) showed complete accuracy.

Shape, size and alphabetic knowledge. A total of 92% of the group correctly identified shapes (94% boys and 91% females). Ninety-two percent of the group correctly identified size (94% boys and 91% girls). Comparisons showed no significant differences (Chi Square=2.06, df=1, p=.85). Children with complete alphabetic knowledge were not highly represented in this group, however, the percentage was the highest of all four groups (Kruskal-Wallis test, Table 6.11).

Handedness trends. Pegboard speeds recorded were higher than those in Group 1. Overall, 66% of the group were consistent handers (63% boys and 68% girls) while 34% of the group were inconsistent handers (37% boys and 32% girls). There were no significant differences ($p = .61$). One consistent female left-hander was found in this profile. LQ patterns showed overall rightward trends. Figures 6.1 to 6.7 depict the overall patterns and comparisons of the four groups and these can be seen on page 197. A comparison of Groups 4 and 5 is now explored.

Groups 4 and 5

The processing profile of these group can be seen in Tables 6.16 and 6.17. In Table 6.16 there is a HighSIM > HighSEQ profile and in Table 6.17 a HighSEQ > HighSIM profile. It should also be noted that the difference of 18 points between Sequential-Simultaneous scales, as seen in Group 4, is regarded as significant ($p < .01$). The differences for task means between the groups were computed with a non-parametric Mann-Whitney U (two tailed) test. These results, depicted in z scores and probability values, can be seen in Table 6.18.

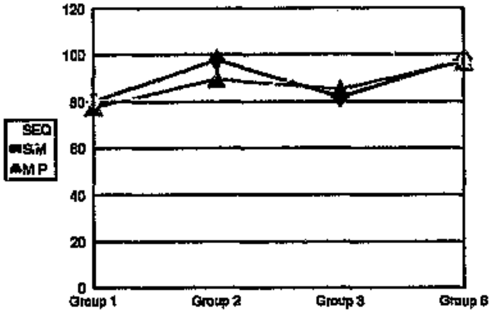

Figure 6.1 : Sequential, Simultaneous and Mental Processing

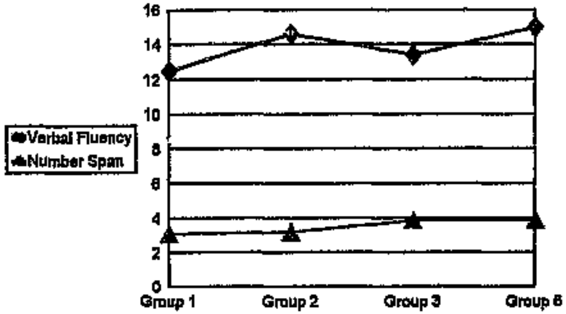

Figure 6.2 : Verbal Fluency and Number Span

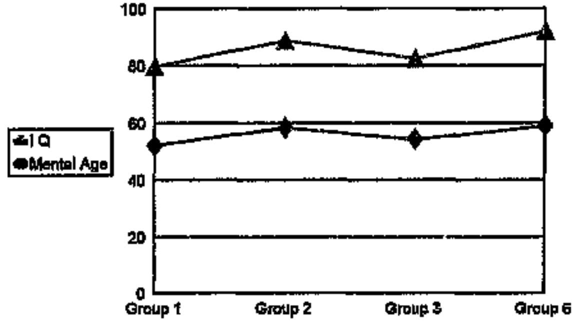

Figure 6.3 : I Q and Mental Age

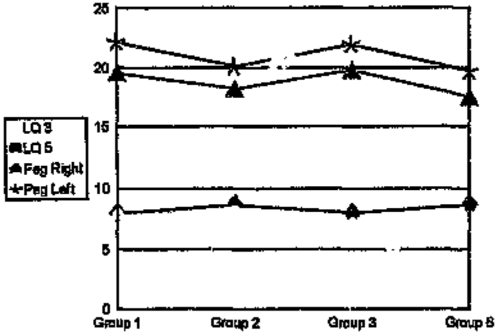

Figure 6.4 : LQ 3, LQ 5, Pegboard Right and Left

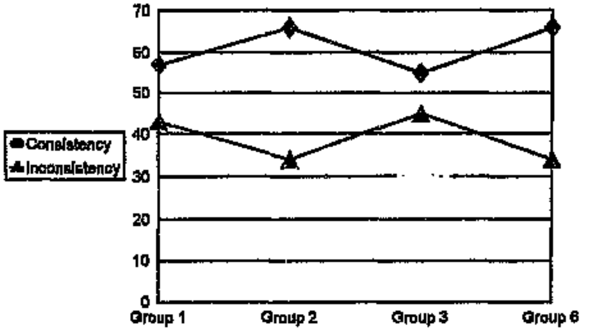

Figure 6.5 : Consistency and Inconsistency in Handedness

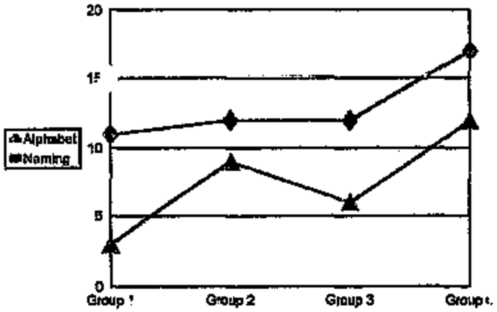

Figure 6.6 : Alphabetic Knowledge and Naming Skills

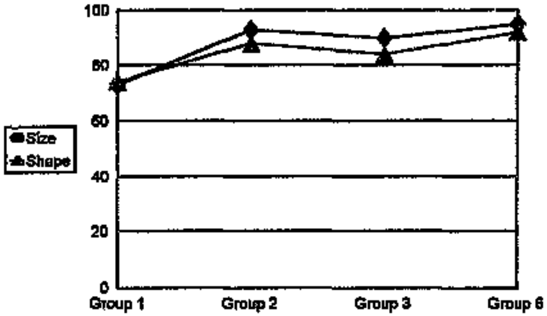

Figure 6.7 : Knowledge of Size and Shape

Table 6.16 Scores for Group 4: High SIM>High SEQ

Subtests and Scales Item	n=28 Mean	n=28 SD	n=14 Males Mean	n=14 Males SD	n=14 Female Mean	n=14 Female SD
Word Order	7.8	1.3	7.7	1.6	7.9	1.1
Hand Movement	9.9	1.9	10.1	1.7	9.8	2.0
Number Recall	9.0	1.7	9.0	1.9	9.1	1.4
Sequential	92.6	3.3*****	92.8	4.0****	92.4	2.6***
Gestalt	10.4	2.3	10.9	2.4	9.8	2.0
Triangles	10.7	1.6	10.6	1.6	10.7	1.7
Matrix	12.7	1.7	13.0	1.1	12.4	.9
Spatial Memory	12.2	1.7	11.9	2.0	12.5	1.4
Simultaneous	110.0	6.5**	110.9	7.3*	109.1	5.6*
Mental P	102.3	4.5	102.8	5.1	101.7	4.0
Cognitive Tasks						
Verbal Fluency	14.[illegible]	3.2	14.5	3.7	[illegible]	2.6*
Mental Age	62.4	4.1	60.8	3.9	63.8	3.8
IQ (DAP)	95.7	6.2	93.1	5.2*	98.1	6.2
Mean Number Span	3.6	.6**	3.5	.7	3.6	.5
Alphabet	2	(7%)*	1	(7%)	1	(7%)
Naming: All correct	6	(21%)	2	(14%)	4	(29%)
Shapes: All correct	28	(100%)	13	(93%)	14	(100%)
Size: All correct	28	(100%)	13	(93%)	14	(100%)
Handedness Tasks						
LQ3	7.6	3.3	7.4	3.5	7.7	3.3
LQ5	8.1	2.6	7.5	2.5	8.7	2.7
Pegs: R	17.4	3.4	18.2	2.4	16.5	4.2*
L	19.4	4.1	20.2	2.5	18.6	5.3
Consist	15	(54%)	5	(36%)	10	(71%)
Inconsist	13	(46%)	9	(64%)	4	(29%)

*p< .05 **p< .01, ***p< .001, ****p< .0001, *****p< .00001

Table 6.17 Scores for Group 5: High SEQ>High SIM

Subtests and Scales Item	n=11 Mean	n=11 SD	n=4 Males Mean	n=4 Males SD	n=7 Females Mean	n=7 Females SD
Word Order	9.1	2.4	10.8	1.9	8.1	2.2
Hand Movement	12.5	2.4	11.5	3.0	13.0	1.9
Number Recall	13.1	2.5	14.5	2.4	12.3	2.4
Sequential	114.1	10.5*****	117.5	10.5****	112.1	10.8***
Gestalt	6.6	3.0	7.5	2.1	6.1	3.5
Triangles	9.7	1.4	10.0	1.4	9.6	1.5
Matrix	12.3	.9	12.5	.6	12.1	1.1
Spatial Memory	11.1	1.2	10.5	1.0	11.4	1.1
Simultaneous	99.3	8.1**	100.5	4.1*	98.6	9.9*
Mental P	108.0	12.8	112.5	14.3	105.4	12.1
Cognitive Tasks						
Verbal Fluency	17.1	4.5	13.5	3.7	19.1	3.6*
Mental Age	63.8	4.9	63.0	3.5	64.3	5.7
IQ (DAP)	96.8	7.2	95.5*	5.2	97.6	8.4
Mean Number Span	4.5	.8**	5.0	.8	4.1	.7
Alphabet	4	(36%)*	1	(25%)	3	(43%)
Naming: All correct	2	(18%)	1	(25%)	1	(25%)
Shape: All correct	11	(100%)	4	(100%)	7	(100%)
Size: All correct	11	(100%)	4	(100%)	7	(100%)
Handedness Tasks						
LQ3	6.6	4.2	8.0	2.8	5.9	4.9
LQ5	7.7	4.0	10.0	.0	6.4	4.5
Pegs: R	16.2	2.5	17.8	3.1	15.3	1.8
L	17.9	2.9	20.8	2.1	16.3	1.9*
Consist	9	(82%)	4	(100%)	5	(71%)
Inconsist	2	(18%)	0	(0%)	2	(29%)

*p< .05, **p< .01, ***p< .001, ****p< .0001, *****p< .00001

Table 6.18 Comparisons of Processing, Cognitive and Motor Tasks Between Groups 4 and 5 with Mann-Whitney Test

Variable	z	P
Sequential	4.80	.000002*****
Simultaneous	3.20	.0013**
MPS[a]	.69	.492
Verbal Fluency	1.56	.118
Mental Age	.98	.32
IQ	.72	.468
Number span	2.82	.0047**
Alphabet	2.11	.026*
Naming	.16	.875
LQ3	.51	.606
LQ5	.34	.73
RPeg	1.11	.267
LPeg	1.01	.310

*p< .05, **p< .01, *****p< .00001

a Mental Processing Scale

Cognitive tasks.

The following differences were found:

1.Comparisons between the boys in Groups 4 and 5 showed significant differences on Sequential ($p=.000029$) and Simultaneous scores ($p=.01$).

2.Differences for girls in Groups 4 and 5 were found for Sequential ($p=.00025$), Simultaneous ($p=.033$) and Verbal Fluency ($p=.025$) scores.

3.No significant differences were found between boys and girls in Group 4 on Verbal Fluency scores ($p=.45$). In Group 5 a significant gender trend ($p=.057$) was found on this task with girls showing a higher score.

4.In Group 4, mental age showed a higher trend for girls ($p=.059$) in comparison to Group 4 boys. No mental age differences between girls in Groups 4 and 5 or between boys in Groups 4 and 5 were found ($p=.65$ and $p=.32$ respectively).

5.In Group 4, IQ ($p=.043$) was significantly lower for boys in comparison to Group 4 girls. No significant differences were found between girls in Groups 4 and 5 or boys in Groups 4 and 5 ($p=.84$ and $p=.54$ respectively).

6.Mean number span was significantly higher in Group 5. No significant gender difference was found for either Group 4 ($U=81.5, p=.39$) or Group 5 ($U=6, p=.10$). However, differences in boy's scores in Groups 4 and 5 showed a significant difference in mean span length ($U=4.5$, $p=.007$), while differences for girls showed a significant trend ($U=29.5$, $p=.09$) (See Tables 6.16 and 6.17).

Comparison on Naming skills showed no significant difference between the two groups (Fishers Exact Probability Test,$p=.64$). The majority of the children showed accuracy on the Shape and Size tasks. Overall Alphabet knowledge levels was significantly different between the groups (7% in Group 4 as opposed to 36% in Group 5). However, boy's scores did not show a significant difference (U=19, p=31) while the difference between the girls showed a significant trend (U=24, p=.0495).

Handedness trends and skills. Gender comparisons in Group 4 showed a significantly higher trend for Right Pegboard speed for girls (p=.046). In group 5 a significant gender difference was observed on left-handed pegboard speed (p=.014), with girls showing faster time. There were two (consistent) left-handed girls in this group. In Group 4, LQ differences showed a non-significant higher right-hand trend for girls at five years (p=.078). Boys in Group 5 showed a considerably stronger right-hand bias at five years in contrast to their peers in Group 4,and this reached significance (LQ5 difference, U=10.0,p=.040).

Handedness consistency. Once again a significant trend was found between consistent versus inconsistent handers in Group 5 (Chi Square=3.59, df=1, p=.058). Boys showed a greater tendency towards consistency while girls veered towards a more inconsistent picture. No significant difference was found on this measure in Group 4 (Fisher's Exact Probability Test,p=.38).

Summary of Group 4 and 5 findings. Although the low numbers in Group 4,but especially Group 5, require caution in interpreting results, the SIM>SEQ and SEQ>SIM patterns respectively reflect gender differences in performances. In Group 4, girls showed significantly higher IQ than boys, and greater tendency towards consistency in handedness. In Group 5, girls showed higher verbal fluency,lower LQs and lower levels of handedness consistency but greater pegboard speed, especially with the left hand. However, boys showed greater levels of handedness consistency and higher LQ scores at five years denoting greater right-handedness at this age. Comparison between the groups suggest that HighSEQ>HighSIM (Group 5) was reflected in greater number span length,higher consistency in handedness and a higher degree of right-handedness for

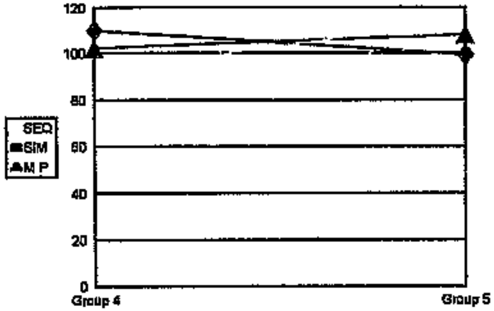

Figure 6.8 : Sequential, Simultaneous and Mental Processing

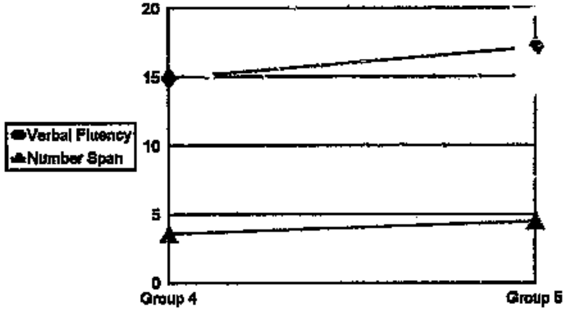

Figure 6.9 : Verbal Fluency and Number Span

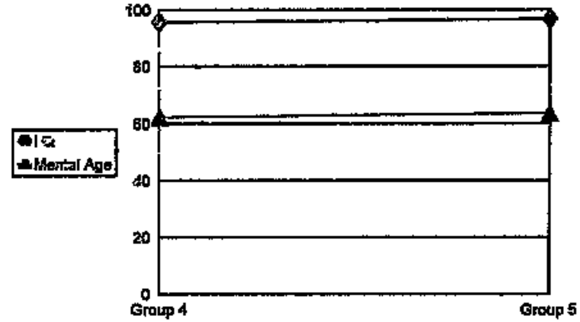

Figure 6.10 : I Q and Mental Age

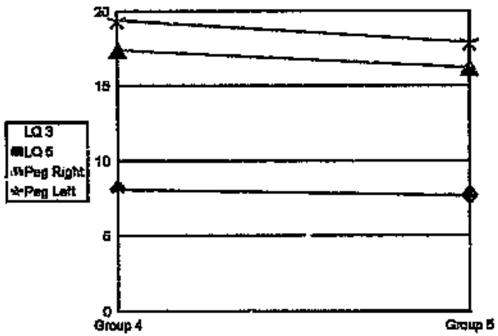

Figure 6.11 : LQ 3, LQ 5, Pegboard Right and Left

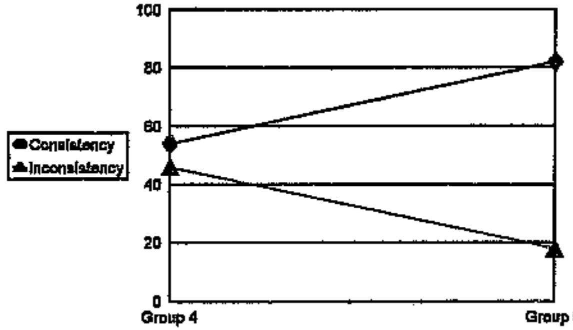

Figure 6.12 : Consistency and Inconsistency in Handedness

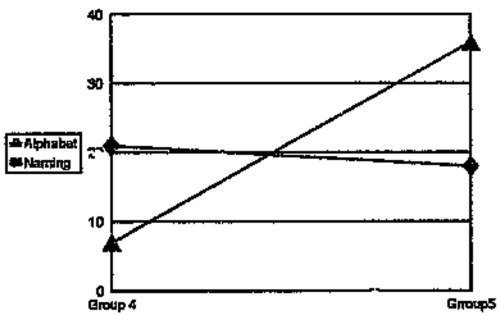

Figure 6.13 : Alphabetic Knowledge and Naming Skills

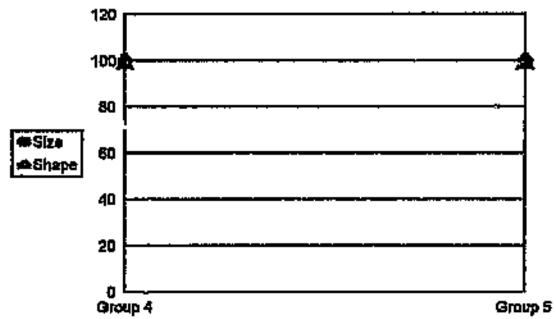

Figure 6.14 : Knowledge of Size and Shape

boys. For girls, differences were reflected in stronger verbal fluency scores and higher pegboard speeds. HighSIM > HIGHSEQ (Group 4) gender patterns were not demonstrated as strongly,however, girls did show higher IQ scores and higher handedness consistency trends. Figures 6.8 to 6.14 contain visual comparisons between the two groups and are portrayed on page 203.

Interaction Between Variables

Separate regression equations were computed to explore the independent variables which would predict both processing modes. These analyses were performed in order to ascertain the kinds of cognitive and motoric tasks that would be explained by the two modes of processing. Included are the pegboard scores for hand proficiency because of the skilled nature of the task. The results can be seen in Tables 6.19 and 6.20.

The variables entered into the regression equations were the cognitive tasks,verbal fluency,mean number span,mental age,IQ,alphabet knowledge, knowledge of shape and knowledge of size. The motor tasks included Right and Left Pegboard speeds. In Table 6.19 R_2 showed that 25% of the variance could be accounted for in this regression model. It would seem likely that other cognitive factors may be involved. On the other hand,cognitive components alone do not uniformly account for sequential processing differences found amongst the current sample. The significant variables that remained in the equation were IQ and alphabetic knowledge. The variable IQ emerged as a highly significant positive predictor of sequential processing ability (see Table 6.19). Despite the fact that the extraction of IQ was based on a single measure, the Draw-a-Person test, it emerges as a useful and simple non-verbal procedure for gauging mental function in five-year-old black preschoolers. Alphabet knowledge was also found to be a highly significant negative predictor. This raises the possibility that level of alphabetic knowledge may be a prominent factor in the promotion of sequential processes. Lower levels or little knowledge

Table 6.19 Regression Analysis with Sequential Processing as the Dependent Variable

Multiple R	.50
R_2	.25
Adjusted R_2	.23

Analysis of Variance

	df	Sum of Squares	Mean Square
Regression	7	7733.70	1104.81
Residual	325	23742.56	73.05

F=15.1,p<000001

Variables in the Equation

Variable	BETA	SE B	*B*	T(325)
IQ	.27	.05	.25	5.0*****
Alphabet	-.19	.05	-1,96	-3.72***
Size	.08	.05	2.19	1.37
RPeg	-.09	.05	-.24	-1.88
Naming	.07	.04	2.02	1.47
Verbal Fluency	.07	.05	.19	1.42
Shape	.07	.05	1.90	1.24

***p<.001, *****p<.0000001

Table 6.20 Regression Analysis with Simultaneous Processing as the Dependent Variable

Multiple R	.61
R_2	.37
Adjusted R_2	.36

Analysis of Variance

	df	Sum of Squares	Mean Square
Regression	6	16321.08	2720.18
Residual	326	27764.06	85.17

F=31.9,p<.0000001

Variables in the Equation

Variable	BETA	SE B	*B*	T(326)
IQ	.44	.05	.48	8.97 ******
Size	.15	.05	4.98	3.19 **
RPeg	-.11	.05	-.35	-2.49 *
Verbal Fluency	.11	.05	.33	2.32 *
Naming	.06	.04	2.10	1.42
Alphabet	-.05	.05	-.64	-1.13

*p<.05, **p<.001, ******p<.0000001

would thus be seen as a negative influence in the acquisition of processing skills. One possibility is that there is a sequential component embedded in the alphabetic task which may be less powerful for simultaneous tasks. Thus,a further regression model was constructed for the prediction of simultaneous processes in this group of children. The same number and type of independent variables entered for the prediction of sequential processing were entered for the simultaneous processing analyses. In Table 6.20 it can be observed that R_2 accounts for 37% of the variance. As observed for the sequential regression model (Table 6.19),it would seem that a larger number of cognitive and hand-skill factors cannot uniformly account for simultaneous processes (see Table 6.19). There are, however, a greater number of significant variables in the equation in comparison to the Sequential model. IQ emerges again as positive and highly significant predictor. Knowledge of size and verbal fluency were also positive significant variables, however, right-hand pegboard speed was a negative predictor. The possibility is that slowness in handedness proficiency does not contribute to this processing mode. Overall processing modes are not fully accounted for by the cognitive and motor variables, and the role of environmental and background factors may contribute further information.These issues will be explored more fully in the following chapter. The current results are discussed below. The main emphasis will be placed on the groups and patterns of processing.

Discussion

Factor analysis broadly confirms the two processing styles, sequential and simultaneous,in this five year-old group of black preschoolers although the Sequential factor did not emerge strongly. Some questions regarding the loadings of Hand Movements (HM) and Triangles surfaced in the analysis. The HM task has been prone to split loadings in the early investigations of the model (Kamphaus, 1990). However, previous research (Kaufman et al., 1982) showed that age was an important factor. Performance of preschoolers resulted in a loading on the Sequential scale whereas in older children the loadings appeared on a Simultaneous factor. HM is a Lurian task with a strong visual-attentional component and current trends would suggest that a proportion of the children in the present sample were using a simultaneous coding approach. Although the Triangles task would seem to be an unambiguously simultaneous process, loadings on a Sequential factor also emerged in the current sample. This could be explained within the present study, as children were observed to adopt a 'matching' or jigsaw-style approach by attempting to place the triangles over the stimulus picture. Despite conforming to the manual's instructions which expressly discourages this practice, children may have continued to use this coding strategy which reflects a more sequential approach to solving each Triangle task. Whether this is a specific tendency within the group or whether the large pictures (which are supplied in the test and are equivalent in size to each piece) encourage this reasoning strategy, would be difficult to establish. In a previous study, Das and his associates (1979) suggest a cultural bias in coding strategies in which simultaneous tasks may be approached by sequential (or successive) strategies. However, a study with a sample of Zairian school children (Giordani et al., 1996) showed that some simultaneous tests clustered together as a separate factor. These tasks, which included Triangles, Matrix Analogies and Photo series, may be reflecting the ability levels of the children rather than cultural factors (Giordani et al., 1996). A similar possibility is raised in the current sample where the two coding styles appear to be differentially developed across six groupings. Variations in mental age, which correlated with processing styles, would seem to support this perspective.

In examining the group differences the results obtained may be more meaningfully interpreted by first comparing the performance across the groupings in the current sample and by comparing the patterns and possible implications with other studies with similar findings. Secondly, by drawing comparisons of the current findings with other cultural groupings. An initial appraisal shows the overall scores achieved by the entire group present a flat profile with no differences between the two modes of processing. Previous research has indicated that a consistent percentage of children demonstrate specific processing patterns although the majority will display no differences between the two processing scales (Smith, Bolin & Stovall,1988). In the current sample, 57%, more than half, did not demonstrate any particular bias in processing style, however, 34% of these produced scores that were below the group mean. The remainder,43%, showed specific patterns, although once again 31% of these showed one processing score that was below the group mean. This is important in terms of processing styles and their development, as environmental factors (which will be discussed in the next chapter) have been cited in producing differences in encoding and processing information (Giordani et al.,1996; Moon, 1988). Smith and his co-workers (1988) identified a trend in their sample where between the ages of four to six years processing changes occurred so that children who showed a two-point scale difference at four-years were showing a nine point difference in favour of the Simultaneous scale at six years. However, there may be variations in the development of these skills in different groups and different environments (Smith et al. 1988). Thus, the current sample of African preschoolers present an opportunity to explore this question and the implications,if any, for neurodevelopment.

In the present study,the group with the lowest group scores also contained the largest number of children. This means that at least a third or 34% of the sample group, Group 1, presented a profile of Sequential and Simultaneous scores below the group mean. The mental age means and IQ,both based on the DAP, were both below those expected for the known chronological age of 60-66 months. Although statistically significant group differences were found,gender differences were not observed for processing styles; the mental age and IQ derivatives were lower for boys. The verbal fluency mean was the lowest across all the groups and particularly low for boys. The trend in motoric information shows a large number of inconsistent handers and slow speeds on pegboard tasks which would support the notion that motor asymmetries are not well developed in lower mental functioning groups (Bishop, 1990). A further finding was that this group contained the largest number of male left-handers, however, the number of left-handers in the entire sample is small and in these circumstances the interpretation of this finding must be one of caution. Nevertheless the linking of weak cognitive performance with left-handedness in boys is one that has been previously hypothesized (Geschwind & Behan,1984). Overall there is a general picture of slower development for both cognitive and motoric skills in comparison to the other groups. In the South African context,Herbst,Schoeman and Huysamen (1993) have noted that the cognitive and motoric skills of 'a disproportionately large percentage' (p.93) of black preschool children have not been well developed. More specifically, these researchers point out that laterality, directionality and skills involving number and colour concepts are lagging. In such instances entry into the school environment increases the likelihood of difficulties. This is best illustrated by the large number of black children who fail school during the first year (Herbst et al. 1993; Liddell,Kvalsvig,Shabalala & Qotyana,1994). The extent to which further development can take place,in other words, whether increases in cognitive skills occur in response to classroom stimulation, is difficult to predict. Richter and Griesel's (1994) view is pessimistic in this regard. *"Prolonged exposure to adverse environments which offer few opportunities for recovery diverts the trajectory of growth and development further and further from the standard"* (p.85).

Moving to developmental implications for processing skills, it would seem that in optimal circumstances changes do occur. An American sample (Smith et al.,1988) whose MPC scores were above the average,showed an increase of six points in Simultaneous processing scores between four and six years of age. The possibility that the increase could be attributed to practice effects is raised,however, there was a co-occurring decrease of five points in sequential scores.

The possibility of change in processing preferences in an at-risk sample of preschoolers, whose scores were low average, was explored by Lyon and Smith (1987). In a nine month period the authors reported a nine point gain for simultaneous scores and a three point gain on sequential processing in this high risk group. Further, it was noted that 50% of children showed a developmental processing preference and 41% of these demonstrated a significant simultaneous bias. The authors caution that the Simultaneous scale appears to be more susceptible to change although the reasons remain unclear. Ongoing development of higher conceptual skills may be important here.

Despite the ongoing debate regarding the validity of the Sequential and Simultaneous processing concepts (e.g. Goetz & 1, 1984) the implications of low and uneven mental processing scores have been seen as a possible reflection of learning difficulties. Worthington & Bening (1988) reported overall low composite Mental Processing scores (mean 85.41 to 87.79) in a cross-cultural sample of learning-disabled children. These scores were lower than those obtained in the K-ABC standardisation sample for black (97.5) and white scholars (102.0) (Kaufman & Kaufman, 1983). There would seem to be more additional problems associated with low or below average scores on both processing scales. In these instances weaker skills cannot be compensated by using areas of strength (Smith, Lyon, Hunter & Boyd, 1988). Against this background, in the present sample the Group 1 profile could be viewed with some concern.

Unevenness in processing styles has been explored in a study by Das and Mensink (1989). These researchers found that the number of Grade five elementary school children who achieved below average scores on both processing modes also showed substantially lower scores on reading decoding tasks, reading comprehension tasks and mathematics. Das and Mensink raise the possibility that sequential processing is crucial in the early stages of reading for the decoding of words while simultaneous processing may be required for a whole word approach to decoding more appropriate for advanced reading skills. This was substantiated by the finding that a high sequential and low (that is below average) simultaneous score produces a similar poor reading and maths profile. It is worth considering these findings as the current sample was assessed two to three months prior to starting school. Thus, the opportunity to explore unevenness in processing styles and profiles for non-scholastic tasks in a younger age group was presented in the current groupings. In the present study, the Group 3 (Table 6.14) sequential score was 10 points higher than the simultaneous score and as expected this was significantly higher than the sequential scores of both the boys and girls in Group 1 (Table 6.12). The pattern of Simultaneous subtest scores were not significantly different to those of Group 1. The mental age averages were again below those expected for the sample with an overall mean for Group 3 of 54.4 months (Table 6.14). The mean raw number span achieved, a sequential task, was found to be significantly higher than the scores in Group 1 and Group 2 (Tables 6.12 and 6.13) where, in both incidences, the sequential scores were generally below the sample mean. Although gender differences were not found, the Group Mental Processing (MP) score was significantly higher than the composite MP for Group 1 but nevertheless, low in terms of the overall group mean. Age differences with subjects in other studies (Das & Mensink, 1989; Worthington & Bening, 1988) prevent any firm comparisons although the possibility of problems in the areas surveyed by these researchers would have to be borne in mind.

Comparison with Group 2 would seem to support the notion by Das and Mensink (1989) that a high SIM low SEQ processing score may be beneficial. These researchers found that Matrix Analogies and Spatial Memory subtests of the K-ABC predict reading decoding and comprehension skills respectively. Contradictory evidence (Smith et al., 1988) showed that children with learning difficulties were more likely to demonstrate a SIM > SEQ profile. In comparison to Groups 1 and 3, the Group 2 profile shows an increase in composite MP, Verbal Fluency, MA and IQ but not in the raw number of digits recalled. The sequential score is below the overall group mean and comparable to the simultaneous score in Group 3, however, there are profile differences which indicate mild advantages for this particular developmental pattern. Nonetheless, the evidence is compelling for weaknesses in processing in Group 1 and differential areas of weakness in Groups 2 and 3. Although it is difficult to apply the findings of other studies to the current African sample, as observed in several studies, similar profiles have been found to be characteristic of children at-risk for learning difficulties (Obzrut, Nelson & Obzrut, 1987; Worthington & Bening, 1988).

Consideration of the other three groupings is carried out separately as the scores obtained were above the overall group mean. In Group 6 (Table 6.15), a balanced SEQ=SIM, shows a high raw mean digit span, a higher trend in verbal fluency for girls and fast right-hand pegboard times for both groups. The possibility that processing style and gender differences may be differentially affected is raised and explored further within the two smaller groups. Group 4 (Table 6.16) shows a SIM>SEQ discrepancy again with some gender differences. Girls showed greater skills in right-hand speed and higher IQ levels but surprising greater handedness consistency than boys. Although this finding would seem to add support for McManus et al's., (1988) view that IQ is more than likely related to the degree or consistency of handedness, the current findings are based on IQ derived from a single task and point to gender specific trends. The SEQ>SIM profile of Group 5 (see Table 6.17) also showed that girl's left-hand speed was faster and girls showed a trend towards higher verbal fluency. The mean level of verbal fluency achieved by girls in this group approximates the developmental levels reached by five-year-olds in an American sample (Welsh, Pennington & Groisser, 1991). Boys in this group showed the strongest direction in right-handedness. Thus, the patterns suggest that uneven development of the two processing styles may present differently in males and females for language tasks, handedness and hand skill. Some support for this view is found in the study by Worthington and Bening (1988) who noted that the K-ABC processing scales were strong predictors of written language, reading and mathematical skills in boys. However, these authors caution that greater care should be taken in interpreting girls' scores on the K-ABC. Further findings also raise concerns regarding interpretation,for example Ricciardi,Voelker, Carter and Shore (1991) noted that the K-ABC processing scales did not adequately discriminate between language impaired and non-impaired children. In this study the language impaired children did not show the expected SIM<SEQ pattern and instead a flat or even profile emerged for the two scales. The only main distinguishing features of the language impaired group were generally weak scores (Ricciardi et al., 1991).

One of the major difficulties in comparing children's test findings is the vastly different environment in which the current sample and the K-ABC samples originate. A study by Matazow,Kamphaus, Stanton and Reynolds (1991) illustrates this point well. These researchers found that the K-ABC was equally reliable for American black and white children across all age ranges from two and a half years and upwards. Naglieri and Jensen (1987) point out that the reason for the K-ABC cross-cultural reliability is based on two effects, psychometric and statistical. The first is the lowering of `g' loadings on specifically the two processing subtests groups. The second is the introduction of factors `besides `g' (p42),largely a memory span factor and greater test specificity which may benefit Black-Americans,independently of `g'. The desire for culture fair tests has resulted in increased popularity for the K-ABC as an instrument that can tap a variety of cognitive skills but does not rely on language skills. However, there are few African studies with which to make comparisons,and based on the current patterns there is considerable variation in the manner in which processing has developed in an African context. One of the few studies in which African children participated and in which the K-ABC processing scales were used took place in Zaire and enables some comparison (Giordani et al.,1996). The current sample was pre-grade level while a proportion of the Zairian sample were the equivalent to Grade one level,although the Central African sample were not urban dwellers. Bearing in mind that the K-ABC has a mean of 100 and a standard deviation of 15,the overall Zairian sequential score was 80.56 in comparison to the current sample mean of 88.3. Differences in the patterns of scores within the sequential domain showed slightly elevated scores for the South African sample. The exception was the Word Order subtest which was lower than the scores obtained by the Zairian children. This particular test,when administered in English, has highly specific characteristics. In the K-ABC,the words selected are strictly monosyllabic so that working memory can accommodate a greater span (Kaufman & Kaufman, 1983). Thus, translations into other languages may have repercussions. It has been shown, for example,that when monosyllabic digits are translated into different languages, variations in span length emerge (Della Sala & Logie, 1993). In the present sample,translations may have contributed to a lower score.

A feature of the current results is the South African preschoolers' simultaneous score (90.1) which is nearer to that of Western groups in comparison to the Zairian children (63.53). The subtest scores for the latter group are extremely low, 2.77 for Gestalt Closure,2.10 for Triangles, 4.33 for Matrix Analogies and 6.00 for Spatial Memory. Despite the variations in group performance the overall impression is that the South African five-year-old urban sample are developmentally more advanced in simultaneous modes of processing. This latter scale appears more susceptible to change,and although practice effects have been suggested,another possibility is that environmental factors may influence development in this sphere. The emergence of `size' determination as a predictor of simultaneous skills is relevant here. This could be explained by South African children's exposure to urban life but particularly to television. Further evidence for this proposition will be explored in the following chapter. However, comparison with other cultural groups has shown that there may be differential development of the two processing modes which may be influenced by a variety of cultural and environmental factors (Boivan et al., 1996). Moon's (1988) study with Korean children shows significantly higher scores for the Sequential scale,although both Korean scale scores were significantly higher than that of the American sample (Kaufman & Kaufman,1983). Boivan et al., (1996) found that there was a significant difference in the scores of urban versus rural Lao children on the K-ABC. Giordani and his co-workers (1996) compared the processing skills of two tribal groups in the Zairian sample. It was reported that the more impoverished group scored significantly lower on the majority of subtests, the exceptions being Triangles, Spatial Memory and Number recall. Kaufman and Kaufman (1983) showed that American Navajos produced scores of 87.7 for Sequential and 99.8 for Simultaneous scales. These findings endorse the notion that environmental variables are imperative in considering task performances. Nevertheless in comparison to the Zairian study (Giordani et al., 1996) the findings in the South African sample provide a more optimistic picture for use of the K-ABC as a viable cognitive measuring instrument. The high level of internal consistency (.88) is more than adequate for individual diagnostic purposes and for definitive research (Watkins & Mboya, 1997).

Finally,to what extent did the cognitive and motoric tasks follow the variations in processing? From a practical perspective, there were no compelling deviations in language tasks according to processing style. The level of mental age and IQ were a more accurate guiding factor in the distribution, the higher the mental age and IQ the better the scores.This was supported by the regression models in which IQ emerged as an important predictor of processing capacity (see Tables 6.19 and 6.20). In terms of handedness, once again the processing skills did not follow a consistent pattern. The only group that portrayed patterns of asymmetry were the small group of males and females in Group 5 (Table 6.17). Males appeared to follow a right-handed pattern in keeping with high sequential scores. Girls appeared to follow a language pattern in keeping with the high sequential or hypothesized left hemisphere function. Few studies have explored this aspect of hemispheric function with the two processing scales of the K-ABC, however, the findings of these two studies (Morris & Bigler, 1987:Shapiro & Dotan, 1986) are worth considering. Morris and Bigler (1987) reported some support for sequential and simultaneous associations with left and right hemispheres functions respectively. However, the numbers are small and the degree to which confidence can be placed in the findings is limited. An interesting finding by Morris and Bigler (1987) was that the association between simultaneous and right hemisphere function was stronger than the association between left hemisphere and sequential function which was contrary to the results in the current study. Morris and Bigler concluded that assuming unilateral function of either a sequential or simultaneous nature might be an oversimplification. Shapiro and Dotan (1986) reported that strongly dominant right-handers who had sustained left focal injury were more likely to demonstrate greater weakness in sequential processing relative to simultaneous skills. The implications are that the K-ABC may be a useful task for diagnostic referrals. Conceptually, the theoretical debate cannot be fully resolved within the current findings, but neither can it be refuted. The question of hemispheric processing and cerebral specialisation theory remains equivocal.

In the current chapter the analyses and results of the processing modes and cognitive tasks were examined and discussed. In the following chapter the role of environmental and background factors will be explored.

CHAPTER 7

THE CONTEXT OF DEVELOPING LATERAL PREFERENCES AND MENTAL PROCESSING SKILLS:THE ANALYSES AND RESULTS OF BACKGROUND CHARACTERISTICS

Introduction

As a country, South Africa contains gross disparities across racial and economic dimensions. On the one hand,there is a well developed agricultural and industrial economy,on the other the vast majority of the population live in poorly developed and impoverished environments. These divisions are largely along racial lines with the majority of whites enjoying the former and the majority of blacks placed in the latter situation (Goduka, Poole & Aotaki-Phenice, 1992). A policy of apartheid was strictly enforced by the former minority white government which resulted in 86% of the land falling under white ownership and/or control. Although the situation has been addressed by the new majority government of the African National Congress, the legacy of placing Africans in designated overcrowded urban and rural areas will remain for some time (Dawes & Donald, 1994). Thus, many black children grow up in unfavourable and overcrowded conditions (Goduka et al.,1992;Richter, 1989;Richter & Grieve, 1991).

Because of the migrant labour system the traditional family structure has altered so that children may live with groups occupying small dwellings with various family arrangements such as grandparents,parents,aunts,uncles or single parent, cousins and step-parent. The varicus family structural arrangements lead to conditions of household crowding which in turn have been shown to be negatively associated with physical growth factors and the development of cognitive skills (Goduka et al., 1992).

The purpose of this chapter is to review the background of poverty,and the impact and relevant research findings pointing to effects on normal growth and especially cognitive development. General factors, which have emerged from studies with black children in South Africa, will be discussed (e.g.Kvalsvig & Connolly,1994;Liddell,Kvalsig,Tshabala & Qotyana,1994;Reynolds, 1989;Richter, 1989). However, the manner in which these factors are woven together to combine and produce the problems facing black disadvantaged communities are non-linear and present a complexity of challenging issues for researchers to unravel.

Socio-economic factors. In general, studies exploring the socio-economic status (SES) factor as a predictor of development and behaviour have largely shown significant results. However, a study by Bradley,Caldwell,Rock,Ramey,Barnard,Gray,Hammond, Mitchell,Gottfried, Siegal & Johnson (1989) showed that SES was a significant predictor of IQ in whites but not in black groups. It is possible that SES can account for a numbers of elements such as low parental education, poor medical service and inadequate housing that could be seen as only partially accumulative in terms of black family and community risk factors (Goduka et al. 1992). This is best illustrated by the number of studies carried out with African populations and communities,all characterized by poverty, that do not reflect the SES factor strongly. Richter and Grieve (1991) explored the influence of home environment on cognitive development in highly impoverished black families but reported that SES accounted for little of the variance in their study. Liddell and her co-workers (1994) also concur that SES is not a sensitive measure in impoverished African samples but attribute this to the fact that it is simply a `saturated' variable. Richter and Grieve suggest lack of SES variance is possibly due to "historical and contemporary forces, not directly addressed by ...SES."(p.99). Work by Barbarin and Nkomo (1997) has revealed that in the South African context specific factors such as single parenthood, whether the single mother lives with a partner or a grandmother, together with household size and lower employment rates, combine in an unique non-linear manner to act as significant indicators of lower SES and greater childhood hunger. Liddell and her co-workers (1994) demonstrated that despite an entire sample living in poor socio-economic circumstance, cultural-specific indicators (urban versus rural and individual community factors) were more meaningful than SES factors. However, Liddell and her associates point out that the skewness of general poverty in African samples create difficulties for researchers in utilising the SES factor as a potential predictor for understanding growth and development in black African children. On the other hand, these authors noted that within-cohort patterns emerged, where specific activities could be distinguished. For example, children who were more deprived in terms of a lack of engaging in school or literacy related activities or who played fewer games or were not exposed to manipulation of objects, could be distinguished in terms of less optimal patterns of development that is less orientated to the requirements of the early years of school environment (Liddell et al., 1994). An important issue raised by such findings is that comparisons can not be easily made with Western research (Liddell et al., 1994).

Nutrition factors. Poverty is a predominant fact of life for the majority of the black South African population. Richter and Griesel (1994) document the effects of poor nutrition as an index of environmental inadequacy. Th , researchers point out that foetal under-nutrition can be inferred from low birth weight. Such infants are vulnerable to a host of economic, biological and social risk factors,which impact on development in a complex diverse fashion (Richter & Griesel, 1994). Similarly low weight and stunted height,which are frequently used as reference values in children,are presumed to be the consequence of poor nutrition. Of particular importance are the findings that suggest that poor growth has been associated with lower levels of IQ (Humpherys, Davey, & Park, 1985) and measures of cognitive development (Emhart & Marler, 1987). Similar findings have been reported in South Africa by Wagstaff, Reinach, Richardson, Mkhasibe and De Vries (1987).

Richter and Griesel (1994) point to the importance of distinguishing between types of malnutrition. When the total food supply is reduced from birth,poor growth denotes a condition known as Marasmus. On the other hand,dietary deficiencies such as a high starch and low protein intake are usually characterised by normal growth during the first year, or more specifically the first six to eight months. This is followed by a deterioration in growth patterns,labelled as Kwashiorkor. However the underlying differences are more serio , in that Marasmus is associated with stunted growth and can worsen as the child gets older (p.72). Kwashiorkor denotes wasting,but not stunting, and this is amenable to improved diet and observable in increased weight and height as the child gets older. The longitudinal study by Stoch,Smythe, Moodie and Bradshaw (1982) demonstrated the long term effects of malnourishment on a group of of children from an extremely impoverished environment. In comparison to a poor but adequately nourished control group, the experimental group were substantially affected in terms of extremely low IQ, reduced head circumference and EEG abnormalities.

However, Richter and Griesel (1994) refer to environmental features that compound and negatively affect the African malnourished child. General inadequacies have been noted in the care of poorly nourished children including poor caretaking practices and disturbed maternal emotional state. The children themselves show a lack of interest in their environment. The major problem is the manner in which children recover having suffered an episode of clinical malnutrition (p.75). The need for studies that will monitor the progress of young developing black children is apparent.

Household density factors. Household crowding has been associated with a number of unfavourable health factors, for example Graham (1972) found that children's height was affected in increased crowding conditions and psychomotor retardation has also been noted (Widmayer,Peterson, Larner, Carnaham,Calderon, Wingert & Marshall, 1990). Some studies have reported on the salience of overcrowding on childrens' developmental status (e.g. Goduka et al., 1992) however, Liddell and her co-workers reported no effect for this variable. A possible explanation is that household density thresholds may have numerical limits in terms of statistical effects and,as Liddell suggests,overcrowding '*represented a saturated variable*' (p.60) in her sample. Despite the lack of clear empirical evidence Liddell notes that overcrowding may be an underlying variable that can lead to a cycle of effects including:

1.Increased interactions and greater exchange of information between children.

2.Adults who are less available to children and less likely to exchange information with children.

3.Less time spent at school related or literacy related activities by children, which suggests an environment less oriented to school preparedness (Liddell et al.,1994, p.60).

In their study,Richter and Grieve (1991) also emphasize the specific importance of the mother's role in interactions and "active structuring of her infant's experiences "(p.99), and the restrictive effect of overcrowding on children's play and activities.Goduka and her associates found household density a useful measure and reported a negative association with developmental outcomes such as height,weight,head circumference and vocabulary.The accumulative effects of unfavourable environmental factors on the preschool child are complex but would appear to influence the level of unpreparedness on entering the school environment and in many cases, the absence of the minimal skills required for academic coping.The manner in which children overcome early disadvantages or whether they eventually 'catch-up' is difficult to predict.The outlook is pessimistic as demonstrated in a recent cross-sectional study.The results showed that on a task such as the Bender Visual-Motor Integration Test (Bender, 1938 cited in Koppitz, 1975), black Zulu-speaking children do not reach the equivalent maturation level of the American sample at nine years until 13 years (Viljoen, Levett, Tredoux & Anderson, 1994).In this study,age accounted for 31% of the variance while sex and geographical area accounted for only 3%.Although cross-sectional studies of this nature are useful, on the whole there is a lack of available normative data of a longitudinal nature on black preschool children.

Family structure factor. Black family structures in South Africa have been radically affected by the migrant labour system during the apartheid era (Liddell, Kvalsig, Shabalala & Masilela, 1991). Over the years large numbers of black men and women defied the influx control laws and moved to urban areas in search of employment and improvements in living status (Reynolds, 1989). Levitt (1994) points out that for women,such a move resulted in a welcome escape from black patriarchy and arranged marriages. Thus,the move to urban life for many women gave a measure of independence that they would be unable to enjoy in traditional environments. Many women preserve their single status and choose to live with a number of partners.The children in these households may be fathered by different partners (Levitt, 1994).

Single parenting is common among urban black South Africans with a substantial number of black women heading their households (Levitt, 1994). Goduka and her associates (1992) reported that in traditional rural areas such as Transkei a higher percentage of married spouses shared a household, in comparison to families living in resettlement areas or working on farms. However, the question of whether the absence of a father impacts negatively on the children is less clear. Fine and Schwebel (1987) found that black families in particular were less likely to be affected by single parenting because of the availability of extended family support systems.The situation in South Africa differs as many single mothers are working mothers. Thus, Goduka and her co-workers argue that child development outcomes in single parent families in South Africa probably depend on factors such as the presence or absence of support structures.Working mothers who live in urban areas may have to rely on child-care facilities available locally or relatives or neighbours to act as child-minders. This would seem to vary with profiles of African family structures which suggest that older children are expected to play a more active role in maintaining the household and younger children are placed in the care of the grandmother (Bozalek,1997). Household tasks will vary, depending on whether the family are urban or rural dwellers.The absence of electricity and water supply place additional burdens on children whose tasks it may be to collect firewood for cooking or fetch water.It is clear that the conditions in which urban and rural black children live are different (Liddell et al., 1994).

The Background and Social Environment of the Current Sample

Information on background which forms part of the data base in the present research is now considered.The children who participated in this study live in Soweto, which is approximately 15km south of Johannesburg. Soweto forms part of the Johannesburg Metropolitan area.Many of the houses, which were built during the apartheid era,are small four-room brick structures. The residents are composed of the main ethnic groups in South Africa and include Sotho, Zulu,Venda, Swazi and Shangaan. With the influx of immigrants into South Africa from countries such as Portuguese speaking Mozambique,the population has increased dramatically, placing a strain on available resources.Table 4.1 in Chapter 4 gives a breakdown of the languages spoken by the children in the current study in the 1993 and 1995 data collections. The broad span of language also stems from the inclusion of children living in the Eldorado Park area which is adjacent to Soweto,a suburb designated `Coloured' by the former government. The culture, religion and schools reflect the predominant group living there and one would expect to find languages such as English and Afrikaans mainly spoken. The fact that Soweto and its environs is home to several language groups is also reflected in the percentage of second language speakers in the current group. At least 65.7% of the children had already acquired a second language (see Table 4.1). Exposure to a second language may depend on several factors such as location of home or child's attendance at a nursery school.

The factors of SES, household density and family structure discussed above are relevant to Soweto and its immediate environs which is home to several million black South Africans. Table 4.2 in Chapter 4 shows the socio-economic environment of the current sample. As previously noted, changes in housing situations are ongoing and reflect improvements where the new government has endeavoured to encourage home ownership. However, the continuous move to urban suburbs from rural areas,places a great strain on already overburdened resources and has led to an increase in informal housing structures,shacks, which are often constructed in backyards or vacant areas of land (Bozalek, 1997).

Generally,it is difficult to estimate the extent to which Soweto has been upgraded following majority rule. In 1993, for example,300 homes were sampled and of these 78% used electricity as the main source of energy,followed by coal in 14% of households (von Schirnding & Mokoetle,1993). Such information becomes important when examining the effects of pollution from indoor sources such as coal fires, and the outdoor environment such as industry or car fumes. Kvalsvig and Connolly (1994) point out that the frequency of respiratory and digestive tract infections of children are endemic in conditions of overcrowding and poverty and lead to a cycle of poor appetite, malabsorption of nutrients culminating eventually in malnutrition (p.92). In the current study, information obtained showed that items such as electricity, television sets, refrigerators and children's toys were present in the majority of homes. Relatively scarce items observed in the 1995 data collection are telephones, washing machines and children's books. Barbarin and Nkomo (1997) note that washing machines may not as yet be seen as a labour-saving device amongst black South African and thus should not be viewed as sensitive indicators of wealth. On the other hand, telephones seem to enjoy widespread usage yet only appear in 59.7% of the households in the current study. The presence of books in the home may reflect educational or literacy levels (Richter & Grieve, 1991). (see Table 4.3 in Chapter 4).

Background Factors of the Current Sample

In terms of the present study the emphasis on neurodevelopmental factors, specifically mental processing and lateral preferences require consideration in an environmental context. The discussion in Chapter 2 has broadly addressed these issues however, Young and his colleagues (1983) point to specific factors that influence the development of lateral preferences and suggest the influence that may result on related specialisation. " *Experiential factors external to the organism that may influence the development of manual and related specialisation have been proposed. The role of hospital practice, parental holding and toy giving styles, cultural proscriptions, and experience acquired in toy play in the development of manual specialisation have been described*". (p.11). Implicit in this view is the notion that early interaction could contribute to, for example, left hemisphere function and possibly its sequential nature or even right hemisphere function and its proposed holistic nature. Thus, daily interactions act in shaping such behaviours (Corter, 1983; Rogoff & Chavajay, 1995).

A further factor which has strongly emerged as influential in the child's general health and cognitive development is the level of education achieved by the mother. Yach,Richter,Cameron, von Schirnding and de Wet (1993b) point out that higher education of the mother has important implications for the entire family. This is probably best illustrated by the fact that increased education in women has been associated with decreased family size (Yach et al., 1993b), better living standards and higher cognitive levels in children (Barbarin & Nkomo, 1996:Goduka et al., 1992). Table 7.1 shows the educational levels of fathers and mothers in the current sample. Because of the substantial number of cases with missing information on fathers education, mothers educational level will be the main focus in the current study.

A further factor is the preschool opportunities which the present group has experienced prior to starting formal schooling. The extent to which children from impoverished circumstances can adapt to the school environment is influenced by early experience and stimulation (Herbst et al., 1993:Meyer, Loxton & Boulter, 1997). In Table 7.2 the information for preschool experience can be seen. The majority of children had been placed in formal preschool,Grade 0. However, a large percentage were staying at home, followed by placement in a day care environment. A small percentage had already started formal school (Grade 1). There were no significant gender differences in preschool experience (Chi Square=.28, df=1, p=.60).

So far the discussion has centred on the context in which development takes place which is crucial for understanding research findings related to different cultural groups. In this chapter the aim is to focus on developmental factors pertinent to the Sequential and Simultaneous groupings in the previous chapter. The division of groups based on the dimensions of the SIM/SEQ dichotomy and described in Chapter 6 will be maintained. In this chapter the personal and home environmental variables will be applied to the groupings and information will be explored pertaining to the background factors discussed above.

Table 7.1 Parents' Educational Levels

	Father's		Mother's	
	N	%	N	%
No schooling	12	3.6	2	.6
Primary schooling	13	3.9	42	12.5
Std 6-7	33	9.8	71	21.2
Std 8-9	67	20.0	129	38.5
Std 10	84	25.1	72	21.5
Post schooling	11	3.3	5	1.5
Unknown	115	34.3	14	4.2

Table 7.2 Preschool Experience at the Five-Year-Old Stage

Preschool experience	N	%
Child minder (not home based)	5	1
Day care centre	62	18.5
Nursery school	29	8.7
Preschool (Grade 0)	128	38.2
Formal school (Grade 1)	13	4.0
Stays at home	98	29.2

A Kruskal-Wallis ANOVA was performed (see Table 7.3) for comparisons across the four groups and between boys and girls for categorical variables. These variables included Mothers' education, delivery type, who the child lives with,preschool experience, mothers' employment status, type of housing, the presence of television , books, telephone and toys in the home, the child's first language and whether a second language was spoken. Computations of the Cochran C test showed that the variables, Birthweight ($C=.34$ $p<.01$) number of rooms ($C=21, p<.01$) and gestation period ($C=.45, p<.001$) did not meet the assumptions of homogeneity and were also included in the Kruskal-Wallis ANOVA, bringing the total number of variables to 16. A Kruskal-Wallis ANOVA was also computed for comparison of the boys in four groups and the result can also be seen in Table7.3. Similarly a Kruskal-Wallis ANOVA was also computed for the girls in the four groups and this is included in Table 7.3.

A 2 X 1 ANOVA (Group X Gender X Number of people in the home) was computed. No significant main effect was found for Group ($F(3/288)= 1.93, p=.12$ or Gender ($F1/288)=1.43, p=.23$). Interaction effect was also non-significant ($p=.76$).

Background Variables

Tables 7.4 to 7.7 contain the background factors for Groups 1,2,3 and 6 distributed according to the groupings based on patterns of processing skills. Each of the tables contains the following information:

1.Who the child currently lives with, that is either mother or a relative.

2.The preschool information including a child minder, a day care centre, a nursery school, a preschool, a formal school or whether the child stays at home.

Table 7.3 Comparisons Between Groups 1 2 3 and 6: Background Factors (Kruskal-Wallis)

Variable	Groups H	Groups p	Males H	Males p	Females H	Females p
Child lives with ..	2. 56	.46	1. 30	.72	2. 73	.435
Preschool experience	18. 27	.0004***	7. 10	.07	11. 96	.0075**
Mother employed	3. 09	.38	3. 70	.29	[illegible]. 01	.569
Housing type	. 23	.97	. 60	.91	. 75	.859
Number of rooms	4. 71	.08	4. 17	.24	3. 53	.32
Television	9. 70	.021*	4. 70	.19	6. 82	.078
Telephone	28. 40	.0000****	11. 70	.0083**	18. 53	.0003***
Toys	3. 11	.37	3. 60	.309	2. 32	.508
Books	10. 19	.017*	3. 50	.324	8. 24	.041*
Language	13. 29	.0041**	3. 20	.36	11. 36	.009**
Second language	3. 21	.359	. 20	.98	7. 36	.0614
Birthweight	2. 21	.52	1. 03	.79	6. 44	.09
Gestation period	3. 34	.34	4. 59	.20	. 75	.86
Delivery type	3. 61	.306	1. 49	.68	4. 82	.18
Mother's education	16. 95	.0007***	7. 98	.046*	9. 46	.0237*

*p<.05, **p<.01, ***p<.001, ****p<.0001

3. The mothers employment status, that is employed or unemployed or whether the mother is a scholar or a student.

4. The type of housing including informal (a squatter settlement), a shack in a backyard, a single room, a flat, a house or sharing a house.

5. The mean number of rooms in the dwelling.

6. The mean number of people living in the household.

7. The presence in the home of television, toys, books, and telephone.

8. The language spoken by the three main groups, Nguni, Sotho and other.

9. The number of children who speak a second language (CSL).

10. The average birthweight for the group.

11. The average gestation period for the group.

12 The type of delivery.

13. The educational status of the mother including illiterate, primary school completed, high school uncompleted, high school completed.

In each table the significant differences that emerged are shown for the relevant variables between the groups, between the boys in each group, and between the girls in each group as elicited by the Kruskal-Wallis ANOVA. Data are presented in frequencies and percentages and where indicated in means and standard deviations.

Comparisons Between Groups 1, 2, 3 and 6

The Kruskal-Wallis ANOVA shows that a significant background factor to emerge is preschool experience. Children in Group 1 were more likely to stay at home (49%) than those in Group 6 (14%). Although Group 1 showed the highest percentage for children remaining at home this was followed by Group 2 (27%) and Group 3 (24%). Factors such

Table 7.4 Background profile for Group 1

	n=115		n=56		n=59			n=115		n=56		n=59	
	Total		Males		Females			Total		Males		Females	
Item	N	%	N	%	N	%	Item	N	%	N	%	N	%
Lives with:													
Mother	48	42	23	41	25	42	TV Yes+	97	84	46	82	51	86
Relative	63	55	31	55	32	55	Toys Yes	92	80	47	84	45	76
Unknown	4	3	2	4	2	3	Books Yes+	52	45	28	50	24	41
Preschool:+													
Child minder	4	3	3	5	1	2	Telph. Yes+	47	41	22	39	25	42
Day care	12	10	5	9	7	12	Mean Number of rooms	3.5~	(1.5)^	3.5~	(1.5)^	3.5~	(1.6)^
Nursery school	7	6	4	7	3	5	Mean number of people	7.9~	(3.6)^	8.3~	(3.9)^	7.5~	(3.4)^
Preschool	33	28	16	29	17	29	Birthweight	2968.8~	(589.9)^	3044.1~	(624.9)^	2897.3~	(550.5)^
Formal school	2	2	0	0	2	3	Gestation period	37.4~	(2.6)^	37.2~	(2.9)^	37.7~	(2.2)^
At home	57	49	28	50	29	49	Normal delivery	109	95	52	93	57	97
Mother													
Employed	38	32	19	34	19	32	Vacuum	1	1	1	2	0	0
Unemployed	66	56	32	57	35	59	Caesar	5	4	3	5	2	3
							Language+						
Student/Scholar	8	7	3	5	5	8	Nguni	40	35	20	36	20	34
Unknown	3	3	2	4	1	1	Sotho	53	46	22	39	31	53
Housing													
Informal	2	2	1	2	1	2	Other	22	19	14	25	8	13
Shack	6	5	3	5	3	5	CSL#	71	62	34	61	37	63
							Mother's education						
Room	8	7	2	4	6	10	No schooling	1	0 .9	1	2	0	0
Flat	2	2	0	0	2	4	Primary	23	20	12	22	11	18
House	73	63	39	70	34	58	Some high school	70	60 .9	32	57	38	64
House shared	24	21	11	20	13	22	High school completed	14	12 .1	8	14	6	10
							Unknown	7	6 .1	3	5	4	8

#CSL = second language spoken

+ Significant difference obtained with Kruskal-Wallis (Table 7.3)

~ Mean ^ Standard Deviation

Table 7.5 Background Profile for Group 2

Item	Total n=56 N	Total n=56 %	Males n=33 N	Males n=33 %	Females n=23 N	Females n=23 %
Lives with:						
Mother	20	36	12	36	8	35
Relative	35	62	16	48	15	65
Unknown	1	2	0	0	1	4
Preschool:+						
Child Minder	0	0	0	0	0	0
Day Care	14	25	10	30	4	17
Nursery School	8	14	2	6	6	26
Preschool	19	34	12	36	7	30
Formal School	0	0	0	0	0	0
At Home	15	27	9	27	6	26
Mother:						
Employed	24	43	13	39	11	48
Unemployed	30	54	14	42	15	65
Student/Scholar	2	4	0	0	2	9
Housing:						
Informal	3	6	3	9	0	0
Shack	1	2	1	3	1	4
Room	1	2	1	3	0	0
Flat	1	2	0	0	1	4
House	38	68	22	67	16	70
House Shared	11	20	6	18	5	22
TV Yes+	56	100	33	100	23	100
Toys Yes	50	89	32	97	18	78
Tel/ph Yes+	37	66	22	67	15	65
Books Yes+	38	33	21	64	17	74

Item	Total n=56 N	Total n=56 %	Males n=33 N	Males n=33 %	Females n=23 N	Females n=23 %
Mean Number of Rooms	3.7~	(2.0)^	3.9~	(2.2)^	3.3~	(1.7)^
Mean Number of People	6.8~	(3.2)^	7.2~	(3.1)^	6.2~	(3.3)^
Birthweight	3076.3~	(400.3)^	3156.7~	(428.6)^	2961.0~	(331.2)^
Gestation Period	38.0~	(1.3)^	38.0~	(1.3)^	37.9~	(1.3)^
Normal Delivery	53	95	30	91	23	100
Forceps	1	2	1	3	0	0
Caesar	2	3	2	6	0	0
Language:+						
Nguni	23	41	15	45	3	13
Sotho	25	45	15	45	10	43
Other	8	14	3	9	5	22
CSL#	39	70	19	58	20	87
Mothers' Education:+						
No Schooling	0	0	0	0	0	0
Primary	6	11	3	9	3	13
Some High School	38	68	24	73	14	61
High School Completed	12	21	5	15	7	30

+ Differences obtained with Kruskal-Wallis ANOVA
~Mean, ^Standard Deviation

Table 7.6 Background Profile for Group 3

	n=49 Total		n=26 Males		n=23 Females			n=49 Total		n=26 Males		n=23 Females	
Item	N	%	N	%	N	%	Item	N	%	N	%	N	%
Lives with:													
Mother	24	49	11	42	13	57	Toys Yes	42	86	22	85	20	87
Relative	25	51	15	58	10	43	Teleph Yes+	32	65	18	69	14	61
Preschool:+													
Child minder	1	2	0	0	1	4	Books Yes+	28	57	16	62	12	52
Day care	10	20	7	27	3	13	Mean Number of rooms	3.0~	(2.0)^	2.9~	(1.3)^	3.1~	(2.6)^
Nursery school	1	2	0	0	1	4	Mean number of people	7.4~	(3.2)^	7.3~	(3.1)^	7.6~	(3.3)^
Preschool	20	41	11	42	9	39	Birthweight	3041.8~	(473.3)^	3061.7~	(493.6)^	3019.3~	(459.3)^
Formal school	5	10	2	8	3	13	Gestation period	37.7~	(2.0)^	37.8~	(2.4)^	37.6~	(1.7)^
At home	12	24	6	23	6	26	Normal delivery	44	90	22	84	22	97
Mother													
Employed	25	51	15	58	10	43	Forceps	2	4	2	8	0	0
Unemployed	21	43	11	42	10	43	Caesar	3	6	2	8	1	3
							Language+						
Student/Scholar	3	6	0	0	3	13	Nguni	29	59	15	58	14	61
Housing													
Informal	2	2	0	0	2	9	Sotho	16	33	9	35	7	30
Shack	2	4	1	4	1	4	Other	4	8	2	8	2	9
Room	2	4	1	4	1	4	CSL#	30	54	17	65	13	57
							Mother's education +						
Flat	1	2	1	4	0	0	No schooling	0	0	0	0	0	0
House	35	71	19	73	16	70	Primary	8	16	3	12	5	22
House shared	9	18	5	19	4	17	Some high school	30	62	18	68	12	52
TV Yes+	49	100	26	100	23	100	High school completed	7	14	3	12	4	17
							Unknown	4	8	2	8	2	9

#CSL = second language spoken

+ Significant difference obtained with Kruskal-Wallis (Table 7.3)

~ Mean ^ Standard Deviation

Table 7.7 Background Profile of Group 6

Item	n=76 Total N	%	n=32 Males N	%	n=44 Females N	%	Item	n=76 Total N	%	n=32 Males N	%	n=44 Females N	%
Lives with:													
Mother	35	46	16	50	19	43	Teleph Yes+	59	77	22	69	37	84
Relative	41	54	16	50	25	57	Books Yes+	48	63	22	69	26	59
Preschool:+													
Child minder	0	0	0	0	0	0	Mean Number of rooms	3.8~	(2.3)^	3.7~	(2.0)^	3.9~	(2.5)^
Day care	15	20	9	28	6	14	Mean number of people	6.9~	(2.9)^	7.2~	(2.9)^	6.9~	(2.9)^
Nursery school	6	8	1	3	5	11	Birthweight	3181.8~	(532.9)^	3219.7~	(482.9)^	3154.2~	(570.4)^
Preschool	41	54	14	44	27	61	Gestation period	38.3~	(1.5)^	38.4~	(1.7)^	38.2~	(1.4)^
Formal school	3	4	1	3	2	5	Normal delivery	67	88	28	88	39	89
At home	11	14	7	22	4	9	Vacuum	2	3	1	3	1	2
Mother													
Employed	35	46	16	50	19	43	Caesar	7	9	3	9	4	9
							Language+						
Unemployed	37	49	15	47	22	50	Nguni	40	53	15	46	25	57
Student/Scholar	4	5	1	3	3	7	Sotho	25	33	13	41	12	27
Housing													
Informal	1	1	0	0	1	2	Other	11	14	4	13	7	16
Room	2	3	1	3	1	2	CSL#	50	66	17	30	33	56
							Mother's education +						
Flat	2	3	1	3	1	2	No schooling	0	0	0	0	0	0
House	63	82	26	81	37	84	Primary	4	5	1	3	3	7
House shared	8	11	4	13	4	9	Some high school	41	54	19	59	22	50
TV Yes+	74	97	31	97	43	98	High school completed	29	38	12	38	17	38
Toys Yes	66	87	28	88	38	86	Unknown	2	3	0	0	2	5

#CSL = second language spoken
+ Significant difference obtained with Kruskal-Wallis (Table 7.3)
~ Mean ^ Standard Deviation

as who the child lives with or whether the mother is employed or unemployed did not emerge as significant. Although the type of housing was not significant across the groups it is noteworthy that the highest percentage of house-dwellers (not sharing) was found in Group 6 (82%). By comparison, 63% in Group 1, 68% in Group 2 and 71% in Group 3 lived in formal housing.

The effect of consumable goods elicited differences with the presence of TV and a telephone emerging as significant markers between the groups. The presence of TV was distributed throughout the groups with Group 1 having the lowest number (84%) and Groups 2 and 3 with the highest (100). Group 1 had the lowest percentage of telephones and Group 6 (77%) the highest. On comparing the presence of toys and books across the groups, toys did not emerge as a significant marker however, the presence of books was significant, especially for girls. The highest percentage of books was found in Group 6 (63%) and the lowest in Group 2 (33%).

The child's home language would seem to be a significant factor for girls. Perusal of the groups on this item showed that the highest number of Nguni language speakers was found in Group 3 (59%) and the lowest in Group 1 (35%). The highest number of Sotho speakers was found in Group 1 and the lowest in Groups 3 and 6 (33%). Second language distribution did not emerge as a significant factor in these four groups.

The variable, Mother's education, was highly significant across the groups. Group 1 contained the highest number of individuals with no or low education levels (21%) and the lowest number of those who completed high school (12%). Group 6 contained the lowest number of primary school levels (5%) and the highest number of high school graduates (38%).

Although delivery type did not emerge as a significant factor, it is noteworthy that the vacuum method of delivery used on one child in Group 1 is not a sign of fetal distress but rather indicates the opposite (Cronje, Grobler & Visser, 1996). In Group 6, two children were also delivered by the vacuum method. Groups 2 and 3 contained children who had forceps deliveries which is often associated with fetal distress (Cronje et al., 1996).

In Group 1, gestation range for boys was from 26 to 41 weeks. Boys whose gestation period was 37 weeks or less numbered 18. For girls the range was 28 to 40 weeks. The number of girls born at 37 weeks and less was 12. In Group 2 the gestation period for boys ranged from 35 to 40 weeks (boys $<=37$ weeks, $n=9$) and for girls from 36 to 40 weeks (girls $<=37$ weeks, $n=7$). In Group 3 gestation period for boys ranged from 28 to 40 weeks ($<=37$ weeks, $n=5$) and for girls 33 to 40 weeks ($<=37$ weeks, $n=7$). The Group 6 gestation period for boys ranged from 34 to 43 weeks ($<=37$ weeks, $n=6$) and for girls 36 to 40 weeks ($<=37$ weeks, $n=13$). Comparison of each group's distribution of gestational periods showed that Group 1 contained the highest number of children with gestation periods of 37 weeks and less (Fisher Exact Probability Test $p=.019$). However, there were no significant gender differences (Chi Square$=4.35$, $df=3$, $p=.22$).

Mean birthweight for each group, an objective measure, was not significantly different for the four groups. In Group 1, the birthweight range for boys was between 1200-4150 grams and for girls 1200-3910. In Group 2, the birthweight range for boys was 2200 to 4255 and for girls 2300 to 3624. In Group 3, the birthweight range for boys was 1640 to 3900 grams and for girls 2140 to 3770. In Group 6, birthweights range for boys were 2000 to 4070 grams, and for girls 1369 to 4220 grams. The ranges observed in each group are wide, with weights of 1500 grams and below, designated very low birthweight (VLBW) and indicative of high risk for the children. Using a Fisher Exact Probability Test a comparison between Groups 1 ($n=4$), 2 ($n=0$), 3 ($n=0$) and 6 ($n=1$) on very low birthweight (VLBW) cases showed no significant difference between the groups ($p=.20$). Regarding the number of low birthweight (LBW) babies,

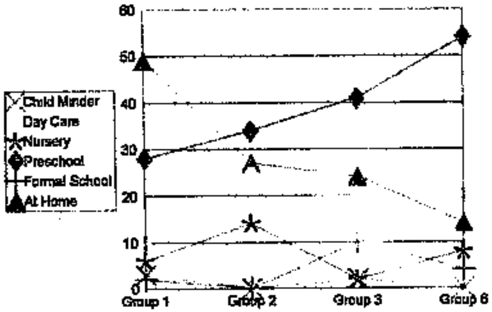

Figure 7.1 : Preschool Experience

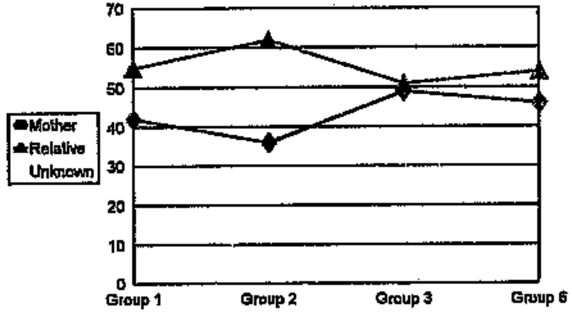

Figure 7.2 : Who the Child Lives With

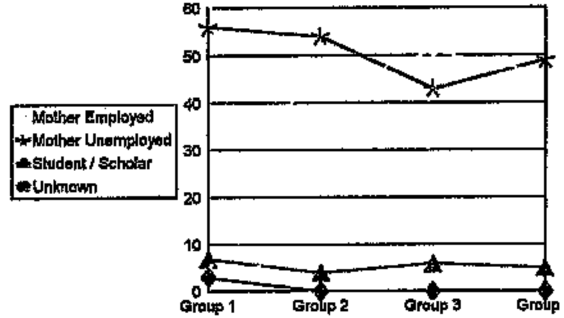

Figure 7.3 : Mother's Current Status

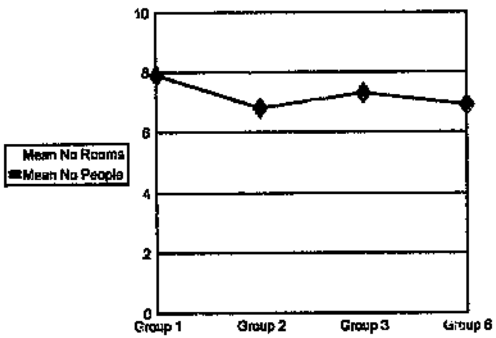

Figure 7.4 : Mean Number of Rooms and People

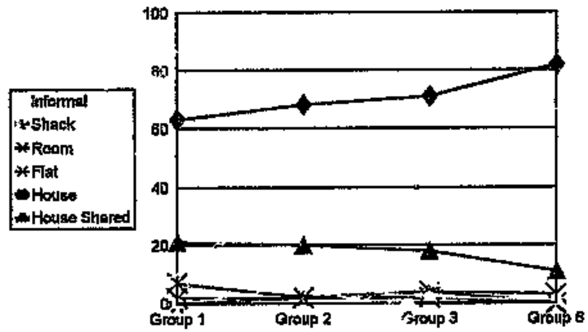

Figure 7.5 : Type of Housing

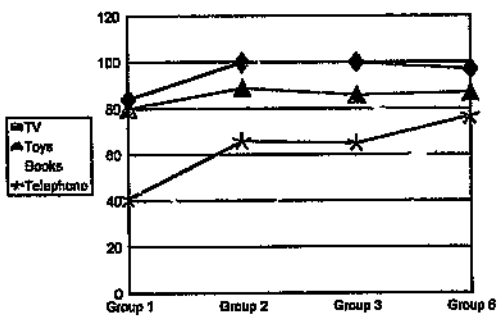

Figure 7.6 : Presence of Consumables

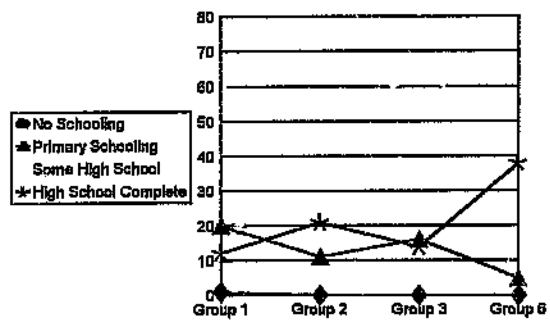

Figure 7.7 : Maternal Education

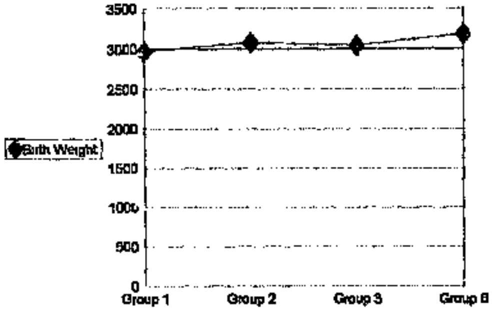

Figure 7.8 : Birth Weight

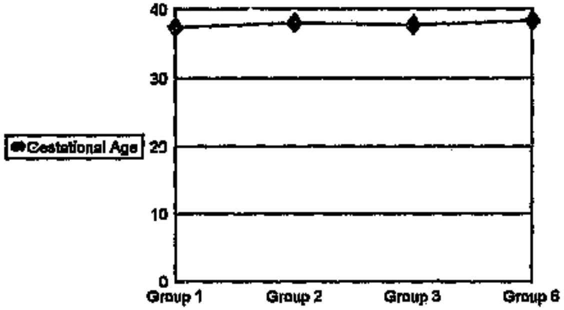

Figure 7.9 : Gestational Age

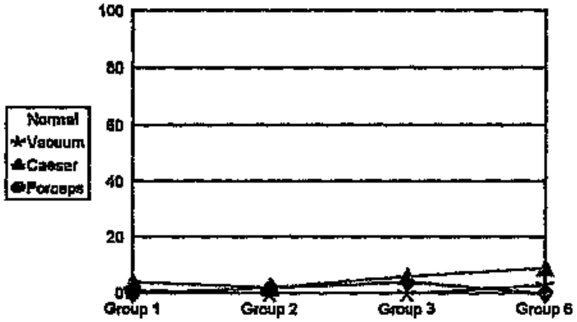

Figure 7.10 : Delivery Type

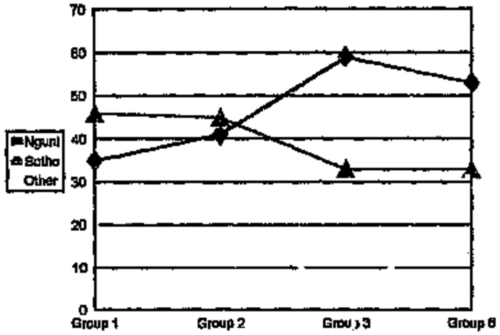

Figure 7.11 : Language Group

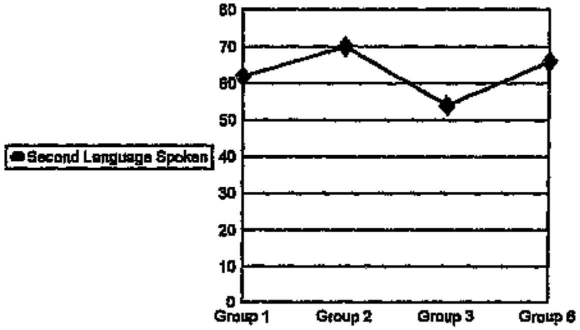

Figure 7.12 : Second Language Spoken

that is the babies whose birthweight was less than 2500 but greater than 1500, distributed across the groups. A Fisher Exact Probability Test was computed for Group 1(n=11), 2 (n=5),3 (n=7) and 6 (n=7),however no significant differences were found (p=.250). Figures 7.1 to 7.7 and Figures 7.8 to 7.12 on pages 239 and 240 portray the patterns on each variable across the four groups.

<u>Groups 4 and 5</u>

Comparison for Groups 4 and 5 was tested by the Mann Whitney test. Each variable was computed and compared. The z scores and probability values can be seen in Table 7.8. No significant differences were found between the two groups. Tables 7.9 and 7.10 contain the background factors for these groups.

Comparisons show no significant differences regarding background factors. The number of children living with mother or a relative is similar. Although no significant difference was observed, the number of employed as opposed to unemployed mothers is higher in Group 5. In terms of consumer goods, the presence of TV, toys and books are similar although the percentage of telephones is higher in Group 5 (82%) than in Group 4 (57%). In Group 5, 55% were Nguni speakers and 36% were Sotho while in Group 4, 49% were Sotho and 39% Nguni.

In Group 4, the birthweights ranged from 2600 to 3850 for boys and 2690 to 3860 for girls. Gestation ranged from 36 to 40 weeks for boys and girls. The birthweight in Group 5 ranged from 3100 to 3505 for boys and 2550 to 3630 grams for girls. The gestation periods ranged from 36 to 40 weeks for both boys and girls.

Figures 7.13 to 7.19 on page 245 and Figures 7.20 to 7.24 on page 246 portray the graphs comparing the patterns of variables for the two groups.

Table 7.8 Comparison Between Groups 4 and 5 (Mann-Whitney)

Variable	z	p
Birthweight	1.00	.32
Gestation	.49	.59
Delivery type	.26	.48
Mother's education	1.04	.27
Live with ...	.06	.94
Preschool experience	.40	.67
First language	.73	.44
Second language	.93	.33
Mother employed	1.06	.22
Home type	.03	.96
Number of rooms	1.38	.15
Number of people	.45	.64
TV in the home	.43	.11
Telephone	1.18	.15
Toys	.09	.83
Books	.35	.53

Table 7.9 Background Profile of Group 4

	n=28 Total		n=14 Males		n=14 Females			n=28 Total		n=14 Males		n=14 Females	
Item	N	%	N	%	N	%	Item	N	%	N	%	N	%
Lives with:													
Mother	9	32	6	43	3	21	Toys Yes	25	89	4	80	6	100
Relative	19	68	8	57	11	79	Teleph Yes	16	57	7	50	9	64
Preschool													
Child minder	0	0	0	0	0	0	Books Yes	25	89	12	86	13	93
Day care	8	29	4	29	4	29	Mean Number of rooms	3.8~	(2.8)^	3.7~	(2.6)^	3.9~	(2.1)^
Nursery school	6	21	1	7	5	36	Mean number of people	6.5~	(2.8)^	6.7~	(3.3)^	6.2~	(2.3)^
Preschool	10	36	7	50	3	21	Birthweight	3191.4~	(354.2)^	3203.6~	(375.1)^	3179.2~	(345.8)^
Formal school	1	4	1	7	0	0	Gestation period	38.3~	(1.2)^	38.6~	(1.2)^	37.8~	(1.1)^
At home	3	11	1	7	2	14	Normal delivery	27	96	14	50	13	93
Mother													
Employed	17	60	9	64	8	57	Caesar	1	4	0	0	1	7
							Language						
Unemployed	10	36	4	29	6	43	Nguni	11	39	5	36	6	43
Student/Scholar	1	4	1	7	0	0	Sotho	12	49	7	50	5	36
Housing													
Informal	1	4	0	0	1	4	Other	5	18	2	14	3	21
Shack	1	4	1	4	0	0	CSL#	23	82	12	86	11	79
							Motner's education						
Room	2	14	2	14	0	0	No schooling	0	0	0	0	0	0
House	22	78	10	71	12	86	Primary	1	4	1	7	0	0
House shared	2	14	1	4	1	4	Some high school	13	46	6	43	7	50
TV Yes	28	100	14	100	14	100	High school completed	14	50	7	50	7	50

#CSL = second language spoken

~ Mean ^ Standard Deviation

Table 7.10 Background Profile of Group 5

	n=11 Total		n=4 Males		n=7 Females			n=11 Total		n=4 Males		n=7 Females	
	N	%	N	%	N	%		N	%	N	%	N	%
Item							Item						
Lives with:													
Mother	4	36	2	50	2	29	Books Yes	9	82	2	50	7	100
Relative	7	64	2	50	5	71	Mean Number of rooms	3.8~	(2.4)^	3.5~	(2.4)^	4.1~	(2.4)^
Preschool													
Child minder	0	0	0	0	0	0	Mean number of people	6.5~	(3.0)^	7.0~	(3.4)^	6.0~	(2.7)^
Day care	3	27	1	25	2	29	Birthweight	3191.4~	(354.2)^	3261.3~	(184.0)^	2951.4~	(342.7)^
Nursery school	1	9	0	0	1	14	Gestation period	38.3~	(1.2)^	38.5~	(1.9)^	38.4~	(1.4)^
Preschool	5	46	1	25	4	57	Normal delivery	10	91	3	75	7	100
Formal school	2	18	2	50	0	0	Forceps	0	0	0	0	0	0
At home	0	0	0	0	0	0	Caesar	1	9	1	25	0	0
Mother							Language						
Employed	4	36	2	54	2	29	Nguni	6	55	3	75	3	43
Unemployed		64	2	46	5	71	Sotho	4	36	1	25	3	43
Student/Scholar	0	0	0	0	0	0	Other	1	9	0	0	1	14
Housing													
Room	4	36	1	25	0	0	CSL#	7	64	3	75	4	57
							Mother's education						
House	7	64	0	0	7	100	No schooling	1	9	0	0	1	14
TV Yes	10	91	4	100	6	86	Primary	0	0	0	0	0	0
Toys Yes	10	91	3	75	7	100	Some high school	8	73	3	75	5	72
Telph Yes	9	82	4	100	5	71	High school completed	2	18	0	0	1	14

#CSL = second language spoken
~ Mean ^ Standard Deviation

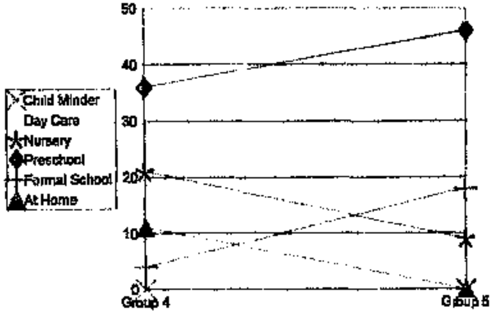

Figure 7.13 : Preschool Experience

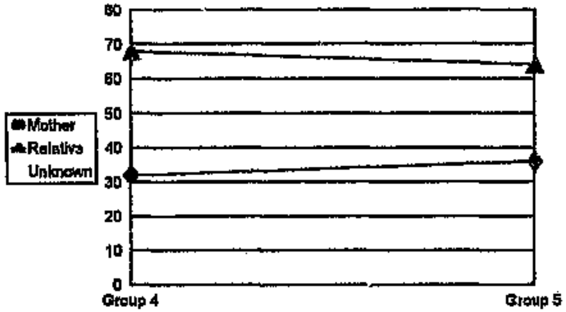

Figure 7.14 : Who the Child Lives With

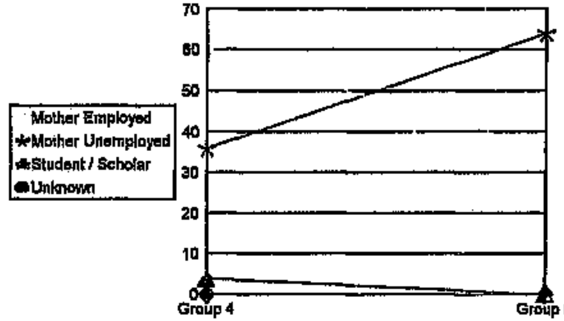

Figure 7.15 : Mother's Current Status

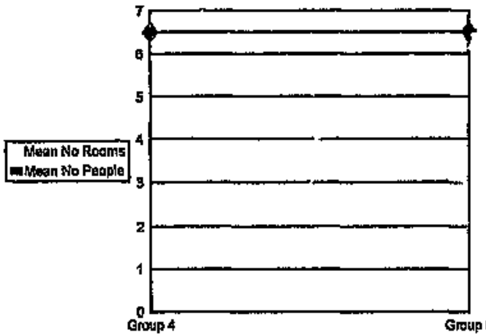

Figure 7.16 : Mean Number of Rooms and People

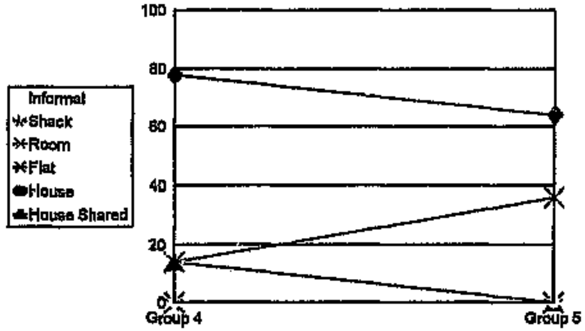

Figure 7.17 : Type of Housing

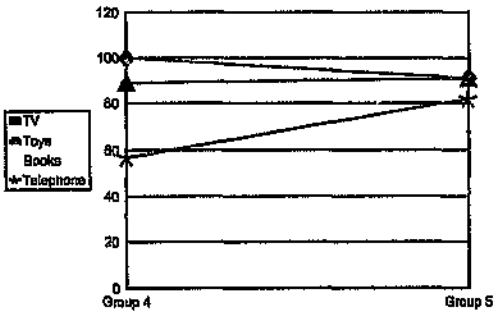

Figure 7.18 : Presence of Consumables

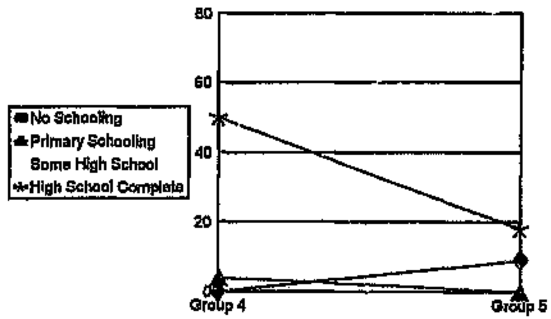

Figure 7.19 : Maternal Education

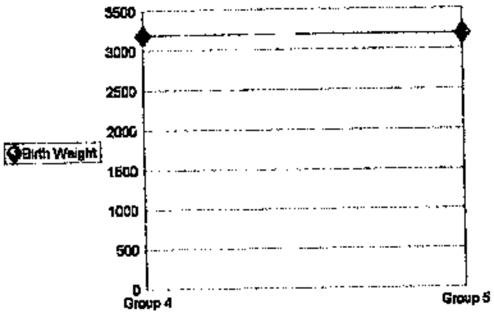

Figure 7.20 : Birth Weight

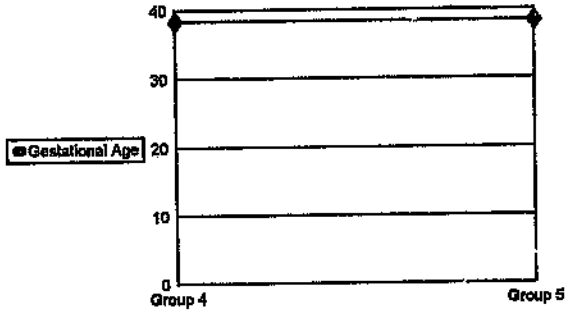

Figure 7.21 : Gestational Age

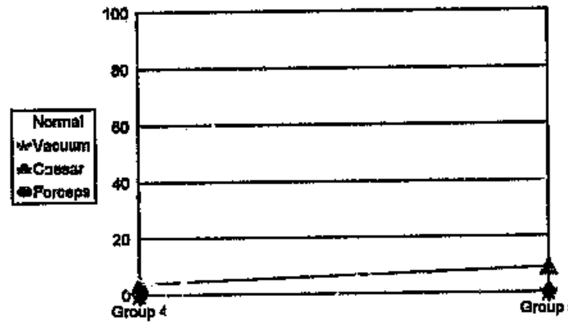

Figure 7.22: Delivery Type

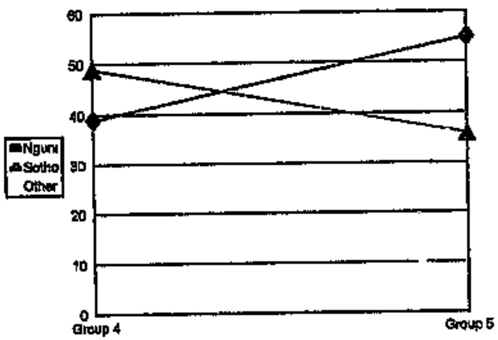

Figure 7.23 : Language Group

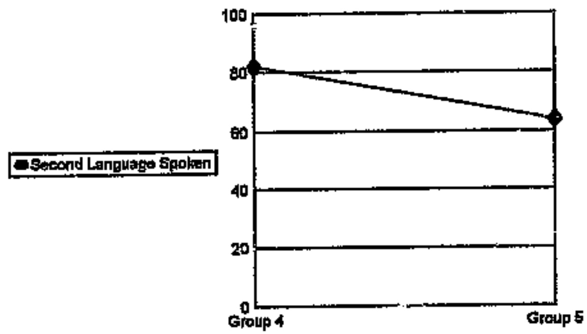

Figure 7.24 : Second Language Spoken

Interrelationships Between Variables

The relationship between background factors and cognitive skills was examined by computing partial correlations. Thus, relationships were examined between those variables describing background and environment (for example, housing, preschool experience, first language, second language, consumer goods, mothers education) and those describing cognitive skills and motor preferences (for example, mental processing types, verbal skills, handedness consistency etc). The correlation table (Table 7.11) appears on page 249. The r values (e.g. .29) and levels of significance (e.g. *$p < .05$ or ***$p < .001$) are indicated in the table.

Examination of Table 7.11 shows 58 significant correlations out of a total of 255, that is 23% of the correlations were significant. A number of relationships observed in the large - sample are weak, accounting for very little of the variance, generally the magnitude of the correlations is low. It might be meaningful to examine the background factors that account for the largest number of correlations so that the presence of specific trends might be extracted. The background variable with the highest number of correlations is preschool experience (14%) followed by the presence of books in the home (12%), gender (10%) and second language (9%). The majority of the correlations for preschool experience are negative. This could be explained in view of the levels of experience involved which extend from staying at home to formal schooling. Thus, absence or lack of a structured preschool environment might explain the negative association with verbal fluency, knowledge of size, mental age, IQ, sequencing skills, simultaneous skills and mental processing skills. Preschool experience was positively related to Alphabetic knowledge. However, the latter variable also contains levels of knowledge ranging from high to low, and the possibility is that the level of preschool experience may be positively related to the level of knowledge. For example, lack of preschool stimulation would be positively correlated with low alphabetic knowledge.

The presence of books showed high correlations with IQ ($r=.22, p<.0001$), sequential processing ($r=.17, p<.01$), simultaneous processing ($r=.27, p<.0001$) and mental processing composite score ($r=.27, p<.0001$). On the other hand, the presence of a second language was negatively correlated with IQ, simultaneous processing, mental processing and knowledge of shape, but positively correlated with Alphabetic knowledge. In this instance, the positive relationship may be suggested by the nature of alphabetic knowledge, which is basically linguistic. In terms of motor skills development, right and left pegboard speeds were significantly correlated with household size and negatively correlated with the number of rooms. Hand consistency was shown to correlate significantly with the child's first language. The cognitive variable that appeared to correlate most frequently with background variables was the Mental Processing Composite scale score. Nine (or 16%) significant correlations were observed which included household size, preschool experience, second language, which were negatively correlated. Television in the home, the presence of a telephone, toys, books together with gestation period and birthweight comprised the positive correlations.

It may also be enlightening to examine the lack of correlations between cognitive and background variables to determine whether trends can be observed. For example, information on who the child lives with, mother's employment status, and mother's education showed no relationship with cognitive or motoric variables. While variables such as birthweight and gestation period showed largely positive significant correlations with the two processing styles, delivery type yielded no correlations. As previously noted, overall the correlations are of low magnitude and explain little in terms of causality. In order to examine the predictive power of the background variables in the two processing behaviours, the employment of regression models is discussed and described below.

Table: 7.11 Correlations between Cognitive and Environmental Factors

	House hold size	Lives with	Pre-school	First lang.	Second lang.	Employ-ment status	Gender	Type of home	No. of rooms	T/vision	T/phone	Toys	Books	Ges-tation	De-livery type	Birth weight	Mother's educa-tion
Naming	.02	-.00	-.11	-.04	-.09	-.04	.14*	.04	.04	.06	.05	.11	.15**	.13*	-.05	.04	.09
Verb. Fluency	-.10	-.01	-.19***	-.11	-.03	.02	.17**	.03	.15**	.15**	.09	.12*	.11	.01	.01	-.03	.01
Alphabet	.07	.00	.29****	.03	.18***	-.03	-.19***	-.04	-.05	.02	-.20****	-.11	-.09	-12*	.01	-.09	-.01
RPEG	.18**	-.06	.05	-.06	.02	-.01	-.14*	.11	-.17**	-.03	.06	.02	-.09	-.01	.11	-.03	.03
LPEG	.18**	-.08	.02	.01	.10	.03	-.11	.15**	-.13*	-.05	.02	-.03	-.11	-.11	.10	-.08	.00
Shape	-.06	.05	-.09	-.00	-.12*	-.01	-.01	.10	.05	-.00	.01	-.01	.06	.06	.07	-.00	.04
Size	-.14*	.04	-.17**	-.02	-.10	.03	-.02	-.02	.01	.00	-.01	.06	.13*	.09	-.02	-.00	.01
Mental Age	-.02	.11	-.12*	-.01	-.07	.02	.12*	-.04	.10	.14*	.02	.09	.16**	.05	-.01	.07	-.05
IQ	.06	.10	-.18***	-.05	-.16**	-.02	.17**	-.08	.02	.13*	.08	.11	.22****	.08	-.03	.13*	-.07
SEQS	-.08	-.03	-.15**	-.01	-.07	.01	.08	-.03	-.07	.10	.21****	.12*	.17**	.12*	.05	.09	-.02
SIMS	-.18**	.06	-.24****	-.08	-.20****	-.10	.00	-.05	-.05	.15**	.17**	.15**	.27****	.19**	.02	.18***	-.02
MPS	-.15**	.01	-.23****	-.08	-.17**	-.07	.03	-.04	.03	.15**	.22****	.15**	.27****	.18**	.03	.17**	-.05
LQ3	-.03	.09	.01	.06	.05	.00	-.05	-.06	-.08	.06	.06	.02	-.08	-.06	-.00	.14*	-.04
LQ5	-.05	.02	-.01	-.00	.07	.00	.00	.03	-.05	.01	.05	-.02	-.06	-.10	-.00	-.10	-.02
Hand Consist.	-.05	-.01	-.06	.16**	-.08	-.01	-.06	.00	-.01	.06	.02	.03	-.07	.04	-.01	.01	.00

* p<.05 ** p<.01 *** p< .001 **** p<.0001

Note: Data incomplete for 4 cases

The Role of Background Factors and Mental Processing

Two regression analyses were computed in which both processing types, simultaneous and sequential, were the dependent variables. The purpose was to try and ascertain the background variables that would predict the levels of mental functioning. The rationale in separating the two processing styles is that developmentally they could be influenced by different environmental factors. Nineteen background variables were entered into a stepwise analysis (CSS Statistica programme). Table 7.12 shows the results of the analysis with simultaneous processing as the dependent variable.

The results of the equation show that the value of R_2 accounts for 21% of the variance. Table 6.20 on p.206 shows that the cognitive/motoric model presented a viable predictor for simultaneous processing, accounting for 37% of the variance. In the current model the background variables in Table 7.12 show that the most significant predictor was the presence of books in the home. Weaker but significant predictors were preschool experience, the child's birthweight, the presence of television in the home,second language, the number of people living with the child and the presence of a telephone, this latter variable possibly indicating level of wealtn within the child's environment. The implications of the analyses point to the following :The presence of consumable items;the quality of the housing;the household size;the child's birthweight;the absence of a second language and the amount of preschool stimulation together form influential factors in the development of simultaneous processing skills. Since the R_2 values indicate the percentage of variance in the tests and background factors used in the study, the model that explains the greatest percentage of the variance is the most suitable. It would seem probable that the background factors alone are unsatisfactory in their predictive power. It might be more meaningful to combine the background and cognitive variables in the regression equation to determine a set of predictors. Table 7.13 shows this combination which includes factors related able 7.12 Multiple Regression with Simultaneous Processing as the Dependent Variable: Background Variables

Multiple R	.46
R_2	.21
Adjusted R_2	.18

Analysis of Variance

	df	Sum of Squares	Mean Square
Regression	9	8586.23	954.03
Residual	304	32616.30	107.29

F=8.89, ******p<.000000

Variables in the Equation

Variable	BETA	SE B	*B*	T(304)
Books	.20	.05	.60	3.84***
Preschool	- .11	.05	- .88	- 2.04*
Birthweight	.12	.06	.002	2.03*
TV	.12	.05	2.32	2.18*
Second language	- .12	.05	.13	- 2.21*
Number of people	- .12	.05	- .43	- 2.32*
Telephone	.11	.05	.43	2.06*
Gestation period	.10	.06	.56	1.63
Mother's education	- .05	.05	- .04	1.04

*p<.05, ***p<.001

to the child and environmental influences. Overall, 9 variables were significant predictors, three of which were cognitive variables, two were handedness variables, one, a predetermined factor, gender, one a birth risk factor, and two background factors. R_2 accounted for 45% of the variance.

Examination of the variables in the equation show that the first two, IQ and knowledge of size, are highly significant predictors followed by gestation period, a birth risk factor, the presence of books in the home, and a telephone, both environmental factors. The last four predictors in order in the equation were right peg board speed (RPeg), gender, verbal fluency and the degree of handedness at five years (LQ5) and both RPeg and gender are negative predictors. The predictor variable IQ accounts for most of the variance, 31%, with the eight remaining variables contributing the remainder. For example, the addition of the variable, knowledge of size, increases R_2 to .34, adding the variable gestation, increases the variance to 36%.

The same independent background variables were subjected to regression analysis with sequential processing skills as the dependent variable (Table 7.14). In this equation consumables (telephone, books) and an environmental variable (number of rooms in living abode) emerge as the predictors in the acquisition of sequential processes. R_2 accounted for 11% of the variance. In Table 6.19 in Chapter 6 it was observed that the variance accounted for by the cognitive regression model for sequential processing, was 25%. In Table 7.14, R_2 has less predictive power than the cognitive/motoric model. Only two significant predictors were found, the presence of a telephone and the presence of books in the home. The question once again is whether a combination of background and cognitive factors might provide a more meaningful set of descriptors. A further regression was computed and both cognitive and background variables

Table 7.13 Multiple Regression with Simultaneous Processing as the Dependent Variable: 'Background and Cognitive Variables

Multiple R	.67
R_2	.45
Adjusted R_2	.42

Analysis of Variance

	df	Sum of Squares	Mean Square
Regression	13	18230.69	1402.36
Residual	298	22370.59	75.07

F=18.68, ******p<.000000

Variables in the Equation

Variable	BETA	SE B	*B*	T(298)
IQ	.41	.05	.44	8.38******
Size	.14	.05	4.68	3.07**
Gestation period	.12	.05	.67	2.32*
Books	.12	.04	.33	2.57*
Telephone	.10	.05	.40	2.31*
RPeg	- .12	.04	-.34	- 2.53*
Gender	- .11	.04	-2.52	- 2.46*
Verbal fluency	.11	.05	.34	2.41*
LQ5	.15	.05	.64	2.96**
LQ3	-.10	.05	-.35	-1.89
TV	.07	.04	1.31	1.46
Birthweight	.06	.05	.001	1.21
Mother's employment status	-.04	.04	-.85	-1.02

*p<.05, **p<.01, ******p<.000000

were combined. The same 19 variables, used in the computation of a regression equation for the dependent variable simultaneous processing, were placed in a stepwise regression model for the dependent variable sequential processing. Table 7.15 shows this result. The combinations of both cognitive and background variables resulted in seven significant independent variables. The variables were IQ, knowledge of the alphabet, knowledge of size, a telephone in the home, the number of rooms, right pegboard speed, and naming skills. The R_2 value, .32, was higher than the resultant R_2 values for either the background or the cognitive/motoric model alone. The predictive model incorporates housing space, consumables available, cognitive skills and handedness proficiency. However, the R_2 value of IQ was highest, .17, the value was increased by alphabetic knowledge to .22, and knowledge of size to .23. Thereafter, the contributions of the remaining predictors were small.

Generally, the analyses show that there are background and cognitive factors contributing to the level of sequential and simultaneous processing. It might be meaningful to pose the question regarding the overall prediction of mental processing skills for the current sample. A combination of variables, cognitive and environmental were entered into the regression equation. Variables associated with cognitive ability were verbal skills, knowledge of shape and size, alphabetic knowledge. Variables associated with environment were who the child lives with, household size, mother's employment level, mother's education, presence of specific consumables (TV, Telephone, books). Variables associated with the child's environmental experience were gestation period, birthweight, preschool experience, language grouping. Finally variables associated with motoric development, handedness at 3 and 5 years and hand skills. Twenty-seven variables were entered into a stepwise regression equation. The dependent variable was composite Mental Processing scaled score. Results can

Table 7.14 Multiple Regression with Sequential Processing as the Dependent Variable: Background Variables

Multiple R	.34
R_2	.11
Adjusted R_2	.09

Analysis of Variance

	df	Sum of Squares	Mean Square
Regression	8	3361.81	420.23
Residual	305	26535.5	87.00

F=4.83, *****p<.000013

Variables in the Equation

Variable	BETA	SE B	*B*	T(305)
Telephone	.20	.06	.66	3.49***
Books	.14	.06	.36	2.57*
Number of rooms	- .11	.05	.27	- 2.00
Gestation period	.11	.05	.53	1.94
Preschool	- .09	.06	- .62	- 1.63
Mother's employment status	.08	.06	1.26	1.39

*p<.05, ***p<.001

Table 7.15 Multiple Regression with Sequential Processing as the Dependent Variable: Background and Cognitive Variables

Multiple R	.56
R_2	.32
Adjusted R_2	.29

Analysis of Variance

	df	Sum of Squares	Mean Square
Regression	13	9432.39	725.57
Residual	298	20427.91	68.55

F=10.58, *****p<.000000

Variables in the Equation

Variable	BETA	SE B	*B*	T(298)
IQ	.27	.05	.25	3.84*****
Alphabet	- .15	.05	-1.57	- 2.945**
Size	.12	.05	3.45	2.36*
Telephone	.17	.05	.58	3.42***
Number of rooms	- .16	.05	-.79	- 3.16**
RPeg	- .14	.05	-.36	- 2.77**
Naming skills	.11	.05	3.04	2.19*
Verbal fluency	.09	.05	.24	1.79
LQ3	-.07	.05	-.22	-1.48
Gender	-.06	.05	-1.15	-1.17
Gestation period	.06	.05	.31	1.25
Mother's employment status	.06	.05	1.04	1.27
Delivery type	.05	.05	.71	1.12

*p<.05, **p<.01, ***p<.0[illegible], *****p<000001

Table 7.16 Multiple Regression with Mental Processing as the Dependent Variable: Background and Cognitive Variables

Multiple R	.69
R_2	.47
Adjusted R_2	.44

Analysis of Variance

	df	Sum of Squares	Mean Square
Regression	17	16487.78	969.87
Residual	294	18511.68	62.96

F=15.4, ******p<.000000

Variables in the Equation

Variable	BETA	SE B	*B*	T(294)
IQ	.50	.07	.51	7.4******
Telephone	.13	.04	.45	2.78**
Books	.12	.04	.32	2.69**
RPeg	- .12	.04	-.33	- 2.64**
Size	.10	.04	3.13	2.3*
Gestation period	.11	.04	.60	2.6**
Verbal fluency	.10	.05	.28	2.14*
Gender	- [illegible]	.04	-2.41	-2.55
Alphabet	-.09	.05	-1.02	-1.96
Mental age	-.12	.06	-.14	-1.85
Household size	-.08	.04	-.25	-1.75
LQ5	.11	.05	.42	2.09*
LQ3	-.08	.05	-.26	-1.48
TV	.06	.04	1.22	1.47
Child lives with	-.06	.04	-.44	-1.35
Language group	-.06	.04	-.89	-1.33
Second language	-.05	.05	-.12	-1.15

*p<.05, **p<.01, ******p<000000

be observed in Table 7.16 Seventeen variables remained in the equation, however, nine of these were significant. The child's IQ emerged as a highly significant factor, followed by the presence of a telephone and books. Hand skills,the degree and direction of handedness at five years,knowledge of size and verbal skills emerged as significant predictors together with gestation period. Finally the child's gender would seem to be a significant variable associated with mental processing ability. The R_2 value accounts for 47% of the variance. The implication of these findings will be discussed in the next and final chapter.

CHAPTER 8

REVIEW OF THE ANALYSES AND RESULTS,DISCUSSION AND CONCLUSIONS

Studies that set out to examine neurodevelopmental, or more specifically neuropsychological trends,in children are faced with potential pitfalls. At th outset childrens' developmental patterns, no more than adult brain injury patterns, do not follow simple brain-behaviour isomorphisms. This view is encapsulated by Fletcher and Taylor (1984).

> *The common theme is that progress in understanding how brain status relates to behaviour is partly dependent on how behavior is studied. This theme is especially pertinent to children, where behavioral relationships change with time. Addressing the processes of change that occur among behavioral variables is necessary for any truly developmental neuropsychology. These processes are intrinsic to children and separate applications of neuropsychology*

through for example adult models, from approaches specific to development in children. p.49.

However, several issues in this statement require consideration in view of the new approaches in integrating developmental psychology with developmental neuropsychology (Segalowitz & Hiscock, 1992). Firstly, an approach to exploring neuropsychological developmental patterns in a population of children does not necessarily imply pathology or brain damage but rather a framework in which normal brain structure development can take place. '*From a neuropsychological standpoint, it is apparent that we cannot understand completely the child's behavioral growth unless we understand the growth of the biological substrate of behaviour.* '(Segalowitz & Hiscock, 1992,p.45). Within such a framework,Fletcher and Taylor (1984) agree that the social and environmental context is a crucial factor in understanding behaviour and test performance.Secondly,although much of the theory in neuropsychology has been guided by adult models, it would be retrogressive to separate out or ignore these models without considering the possibility as to how they might be adapted and understood within a neurodevelopmental framework. As an example,Segalowitz and Hiscock (1992) argue that localization of function within the brain can be demonstrated in young children by relatively non-intrusive procedures such as patterns of lateral preferences. As a form of localization,lateralization is posited as a relatively popular approach to demonstrating laterality in children at varying age levels (p.53). The fact that efforts to demonstrate differences have yielded both positive and negative results may be due to other factors,such as the absence of hemispheric specific tests, and not to the absence of laterality of function. More specific items such as memory deficits can be linked to unilateral lesions (Walsh, 1994) which raises the possibility that linkage of cognitive functions and hemispheric specialisation patterns is a viable goal that as yet remains unproven (Segalowitz & Hiscock, 1992). In this final chapter these issues will be addressed as the findings are reviewed, part of this discussion will involve the flaws and limitation of the study, followed by the conclusions. However, an initial and necessary task is to review and reiterate the findings of the three chapters that contain the analyses and results, that is Chapters 5, 6, and 7.

Review of Chapters 5,6 and 7

In Chapter 5, the analyses of the study of lateral preferences,assessed at two stages, three years and five years were described. It will be recalled that a significant difference between the Laterality Quotients was found, reflecting the hypothesized rightward direction. Despite the significant change, the patterns of handedness show a large proportion of children are mixed-handed, the degree to which they show manual dominance is less than that reported in other studies (e.g.Brito et al., 1992).It could be argued that the applications of right and left handedness (see Chapter 5, Table 5.2, for example), based on the Laterality Quotient scores were overly stringent. However, the assessments were performed over two developmental stages and the strict criteria were applied over the same number of tasks at each assessment. Thus, the emphasis was on development of manual preference over a range of tasks in addition to establishing more static categories of handedness. It would seem that the tasks that show the most improvement are those activities that the children are probably exposed to in daily life, using a spoon or picking up a sweet. It seems clear that the choice of activities for evaluating manual preferences in young preschoolers can lead to variations in findings. Nevertheless, the use of handedness inventories with young children as previously described (e.g. Brito et al., 1992;De Agostini et al., 1992) may present problems in terms of the materials and the items employed.

The assessment of foot and eye preferences showed that the trend towards rightwardness has been established in these areas. The employment of balance was a weak measure of footedness in the present study although the changes observed in Table 5.4 were the most significant.

Eyeness also showed a significant change over the two assessment periods although the direction varied. Leftwardness in eyeness increased significantly (McNemar's test) from 92 children in 1993 to 128 in 1995. Mixed-eye preference as assessed in 1993 decreased significantly (McNemar's Test) from 46 to 17 children in 1995 (see Table 5.4, Chapter 5). However, the congruence between right-hand and right- foot was more firmly established, especially for girls as shown by the McNemar test (see Chapter 5). The frequency of right-hand and right-eye congruence was less but no gender differences were found. The demonstrations of proficiency with the peg-board task yielded times that were slower than those documented for children in a British sample (Annett, 1985). It was also noteworthy that the issue of handedness consistency over the two age periods showed that girls who demonstrate early consistency produced faster pegboard times;boys did not show a similar trend. The role of factors such as familial handedness and birth risk did not reflect any particular patterns in handedness distributions. As isolated elements they appear unremarkable in the current findings, however, when combined they would seem to have a significant effect. For example ,the regression model at three-years showed that the combination of parental handedness and birth risk are predictors of the direction of handedness. At five years birthweight does not emerge as a significant predictor although maternal handedness remains a influential factor.

The analyses and results in Chapter 6 focus on the two modes of processing information. In the first instance the internal consistency measures for the three processing scales, Simultaneous, Sequential and Mental Processing composite, were satisfactory. It has been suggested that an alpha exceeding . 70 is a recommended level for employing a measuring instrument in research (Watkins & Mboya, 1997). A two factor solution was supported (see Table 6.4, Chapter 6) and is consistent with the division of the mental processing subtests into the sequential and simultaneous modes of processing. Giordani and his coworkers (1996) noted that although the processing modes are distributed in diverse samples there may be variations in their presentation (p.22). Thus, it is important to continue collecting data from a wide variety of groups especially in nonwestern environments (Giordani et al., 1996).

Comparison scores for the entire group on the two processing modes showed no significant differences. Comparison of cognitive measures, verbal skills, knowledge of shape and size, alphabetic knowledge, mental age and IQ were examined with MANOVA. In Table 6.2. it will be recalled that significant main effects were found for gender on verbal fluency, mental age, IQ, and alphabetic knowledge. Girls mean scores were higher for all the tasks. Computation of the Kruskal-Wallis ANOVA also showed a significant difference for Naming skills in favour of the girls in the group. Correlations (Pearson correlations) were found between cognitive and processing modes but particularly between the mental age and IQ markers with the two processing scales plus the composite mental processing score (see Table 6.3). In the regression models, variation in predictor variables appeared. For example, Simultaneous processing was predicted by IQ, knowledge of size, right-hand proficiency and verbal fluency (Table 6.20). Sequential processing was predicted by IQ and alphabetic knowledge (Table 6,19). The low values of R squared in both these models suggest that variables other than the cognitive predictors require consideration in the development of the two processing modes.

The variations in the two processing modes, as reported by previous researchers (e.g. Kirby & Das, 1977; Morris & Bigler, 1987) were employed to divide the groups. A substantial number of children's scores were below the group mean. In addition, discrepancies were found between the two processing modes with either simultaneous or sequential below the mean for the group. Three groups out of the six had scores where both modes of processing were above the group mean. Of particular interest was the mental profile and IQ scores which increased or declined in keeping with the sequential-simultaneous profiles (see Tables 6.12 to 6.15). An ANOVA between the four most comparable groups showed a significant main effect for group in simultaneous processing and mean number span. IQ and verbal fluency showed a significant main effect for both group and gender (see Tables 6.6 to 6.11). Tasks compared with a Kruskal-Wallis ANOVA (see Table 6.5) were highly significant and included sequential processing, mental processing composite score,mental age,alphabetic knowledge,and knowledge of shape and size.

Measures of handedness direction,handedness consistency and handedness proficiency (as measured by the pegboard task) were included in each processing profile table and explored for variations in patterns across the groups. There was no compelling evidence for differences in consistency or direction, however, a significant difference was found for proficiency (Kruskal-Wallis ANOVA for Groups 1 2 3 and 6) for both the right and left hands (Table 6.11).

The two groups explored separately, Groups 4 and 5, showed highly distinctive processing profiles. Both groups scored above the group mean on all tasks. The processing differences gave rise to variations in cognitive scores and several lateralizing trends. For example,girls who scored highly on sequential processing also demonstrated high verbal fluency. Alphabetic knowledge was significantly higher in the HIGH SEQ > HIGH SIM group. Mental age was not significantly different between the two groups.Laterality Quotient differences showed a significantly strong right-hand direction for boys who scored highly on sequential processing (Group 5,see Tables 6.16 and 6.17).

The analyses and results in Chapter 7 explored the groups established and described in Chapter 6 in terms of background variables and levels of poverty. Correlations between cognitive and background variables were in general of low magnitude. However, the mental processing composite score correlated significantly with a sizable number of background variables, including television, toys, books and a telephone in the home, gestation period and birthweight but negatively with preschool experience,household size. In Groups 1, 2, 3 and 6 the computation of the Kruskal-Wallis

ANOVA resulted in significant differences. The lowest scoring group (Group 1) contained the highest number of children who remained at home prior to starting school, and whose mothers were described as having little or no education. Group 1 also contained low numbers of consumable items such as TV, and a telephone, suggesting greater levels of poverty. The highest number of children with gestation periods of 37 weeks and less were also found in Group 1. Comparisons between groups 4 and 5 did not show any significant variations in the children's backgrounds. Regression models computed to incorporate both cognitive and background independent variables were found to be the most satisfactory predictors of both sequential and simultaneous processing.The implications of the findings described in the three chapters will be explored below.

Discussion

The point of departure adopted by the current study was the developmental patterns of lateral preference but especially handedness and mental processing styles. Lateral preferences were examined with three goals in mind (i) the patterns of development within an environmental and cultural context.(ii) the hypothesized relationship with cognitive deficits (iii) the hypothesized relationship with cerebral organisation.

Lateral Preference:Patterns of Development

Michel (1983) points out that human handedness and its developmental course is a complex process subject to variations and changes. Knowledge of the developmental trends and transitions should ideally be sought in culturally different environments. It is the environmental conditions that can bring about changes in degree, direction or proficiency of handedness and indeed other limb behaviours (Michel, 1983). The changing handedness patterns in young preschoolers have posed difficulties in that indices have been gathered and focused on preference and skill. The reliability of preference is dependent on measurement procedures based on a demonstration of hand use. As observed in Chapter 2, Brito and associates (1992) noted that the range of tasks require consideration from several perspectives. First, tasks of novel content may not elicit hand preference but may result in a mixed-handedness response, reflecting exploratory behaviour rather than true preference. Second, the procedures or measurement tasks used should ideally be comparable with other research findings. So far studies with younger children (e.g. Brito et al, 1992; De Agostini et al., 1992;McManus et al., 1988) have employed a variety of measures supporting the view that selection of assessment devices for handedness in particular have been guided by the researcher's personal predilection (Bishop, 1990). In the current study a major concern was the selection of tasks that would be reasonably familiar but lacking in requirements for extensive skilled based experience. An attempt was made to give concise details of the objects and procedures used as set out in the section Measuring Instrument in Chapter 4 for replication with similar samples. The result could be described within a continuum of skilled-unskilled behaviours which weighs more towards the unskilled area of the handedness behaviour continuum. The question is whether the emphasis on unskilled tasks will increase the incidence of mixed-handedness in preschoolers. An answer might be found in a study which compared Soweto three-year-olds (not involved in the Birth to Ten study) with a group of suburban (white) three-year-olds and reported a higher number of mixed-handers in the black sample (Nohr, 1995). Of interest is the fact that the measures (Soper et al.,1986) were the same as those used in the current study. Although the number of children in Nohr's study was small (26 children in each of the black and white groups) the prevalence of mixed-handedness in Soweto children would appear to show some support for the present research patterns. In the current sample, African preschoolers also show the same rightward patterns as children portrayed in a variety of studies. Thus, the direction or rightwardness of handedess is developmentally no different. However, the degree of that rightwardness is not well established within the group. The shift from mixed to rightwardness appears to be slower,and although girls show a greater degree of, specifically rightwardness,there would seem to be a developmental lag.It has been established that children who are lacking in strongly defined hand preference in childhood may require motor skills instruction (Gabbard, Hart & Gentry, 1995;Herbst et al., 1993). In the current study,direction of handedness appears to be strongly influenced by familial factors as shown by the regression analysis in Table 5.11 (Chapter 5). Although degree of handedness may also be influenced by familial factors,as shown in Table 5.11,the environmental influences cannot be ignored. The background factors described in this study reflect variations of poverty and overcrowding, and if degree of handedness is a function of a child's learning experiences in an asymmetric world then this is reflected in the large number of children who remain with mixed-handedness prior to entering school. If this assumption is correct then further follow-up with this group should show increased right-handedness with exposure to writing and reading skills. It could be also argued that ethnic or traditional experiences act as the desired learning experience although this was only reflected in a strong rightward shift for girls, as observed in Table 5.9, Chapter 5. However, it would be impossible to ignore birth risk factors and the consistent manner in which they emerged as significantly influential variables in the current study. For example, regression analyses in Table 7.13 (Chapter 7) shows gestation period as a significant predictor of simultaneous Processing. In addition, regression analysis (Table,5.11, Chapter 5) shows birthweight to be a significant predictor of handedness at three years but not at five years. It would seem likely that as the child develops the effects of environmental factors become more potent determinants of handedness.

The tasks that elicit handedness proficiency are usually tests of hand skills with preferably,little opportunity for prior practice on a particular task (Harris, 1992). The variety of measures available include peg-moving (Annett, 1985) or square drawing (Bishop, 1990) and it is unlikely that in western environments, children would have not have been exposed to similar kinds of activities.

Thus, the requirement of underexposure to the task could be seen in a different context when African children's performance is evaluated as there is a strong possibility that the children may not be exposed to similar tasks or activities. Liddell et al., (1994) argue that the cultural context of development is frequently overlooked, so that the similarities between Western and African children are limited. For example, household density and household size, in combination with other poverty factors found in African environments have emerged as contributing to the prediction of cognitive and motor activities as revealed in the current research as shown in Table 7.12 in Chapter 7. In Table 7.12 the predictor variables associated with simultaneous processing included household size, the presence or absence of consumer items, a telephone and television and the kind of preschool experience that the child has been exposed to. However, the selection of the Annett peg-moving task for the current study was also dictated by several needs. First, language requirements were minimal, the task could be successfully demonstrated nonverbally, and secondly, normative data at the required age level was available. The overall speed for hand-skills as measured by a pegboard task, was slower than the non-African reference normative group. There is a lag in the level of hand proficiency which follows the trend in the degree of lateralization observed in the current sample.

Despite the fact that a sizable number of mixed-handers were found at five years, the patterns of congruence across tasks for hand, foot and eye again showed expected developmental trends. The value of congruence measures is difficult to evaluate in preschoolers although the emergence of eye-hand coordination is an important benchmark of sensory integration (Dean & Rothlisberg, 1983). Bishop (1990) argues that items such as footedness have little in common with the skills associated in handedness measures. Dean and Rothlisberg's (1983) findings confirm this view. Incongruence between foot and hand measures were found to have no relationship to performance on sensory integration procedures whereas incongruence of hand, eye and ear resulted in poorer performance on tasks (p.289). As the results were based on data collected from 48, white, grade four boys, replication with a larger sample of school-going children would be required to confirm the trends reported.

The present picture that emerges on handedness patterns is not inconsistent with the overall views (e.g. Curtiss, 1985) on developmental handedness in preschoolers although the pace of development is slower in the current sample. At present, knowledge of the developmental trends in lateral preferences but especially handedness, in Black preschoolers, is limited, however, the degree of handedness at five years, as shown by the laterality quotient, emerges as a significant predictor associated with efficiency in mental processing skills (Table 7.17, Chapter 7). As noted with previous research findings (e.g. Hynd et al., 1981) this association is weak and may be a product of the variation in developmental differences observed in the degree of handedness in this particular group. Thus, the rate of development, together with concomitant risk factors, would require further verification in a greater diversity of Black South African preschool populations.

Lateral Preference: Relationship with Cognitive Deficits

The administration of Sequential and Simultaneous scale processing tasks and the ensuing division, based on performance characteristics of processing styles, saw the emergence of six groups. The results of additional cognitive tasks and handedness information were appended to each group. In this way it was hoped that an overall picture of processing skills together with cognitive and motoric preferences could be scrutinized. The portrait of differential developmental rates was observed in the groups. In seeking handedness trends and patterns of cognitive deficit, four comparable groups were surveyed on (i) patterns of consistency and inconsistency and (ii) handedness direction based on laterality quotients at three and five years and (iii) pathological left-handedness (PLH) and cognitive deficit.

It has been suggested that the prevalence of mixed-handedness represents a defic ... .ving bilateral brain damage that prevents the establishment of hand dominance (Soper et al.,1986). In the current study,the notion that the factor of lower mental function, as observed specifically in the largest group (n=115, Table 6.12,Chapter 6) will contribute to less lateralized patterns or greater mixed-handedness were not clearly observed in this sample. Thus, the number of children who demonstrated consistency of handedness as opposed to the number who showed handedness inconsistency did not reflect compelling statistical evidence to support this perspective. In fact,the number of inconsistent handers in Groups 1, 2 and 3 is reasonably high, and it is noteworthy that Groups 2 and 3 also showed deficiencies on either Sequential or Simultaneous processing skills (see Tables 6.12, 6.13,and 6. 14 for comparisons). The lowest number of inconsistent handers can be found in Group 6, where the processing profile showed average scores on the two processing styles (see Table 6.15,Chapter 6). Although non-significant, the trend in the present research does appear to follow a greater handedness consistency pattern with higher cognitive scores. Bishop (1990) proposes that inconsistent handedness is a function of lack of motor maturation although this is an unlikely explanation given the previous observations (Cameron, 1993;Mwamwenda 1995) regarding the precocious development of motoric behaviours in African infants and toddlers. However, the answer may be partially explained in the reported early motoric advances and decline after the first 12 months so that the physical gains reported for African children diminish over the ensuing developmental period, perhaps due to the effects of environmental adversity, such as poor nutrition (Cameron, 1993;Dawes & Donald, 1994). Handedness inconsistency may also be related to the kind of measurements involved as some tasks might be more susceptible to change. For example, observation of the tasks described in Table 5.3 (Chapter 5) shows that the item, sweet,increased in rightwardness and decreased in leftwardness over the two assessment periods. Not all tasks showed the same shift and the possibility of greater cultural pressures being brought to bear may be a covert factor. It has al eady been observed that some ethnic groups in South Africa adopt a stringent approach to discipline and the maintenance of custom and etiquette in handling gifts or food (Chierian, 1994). A further plausible hypothesis is the prevalence of birth risk factors within this sample and among the groups (see Chapter 7). The laterality quotients were explored with the aim of determining whether lower LQs at three and five years, reflecting greater mixed-handedness, could be determined on a group mental processing basis. However, the four comparison groups did not show any differential patterns in direction or degree of handedness. The manner in which cognitive deficit and laterality did appear to link up was in the number of specifically male left-handers found in the weakest group as reported in Chapter 6. The greater birth risk factors observed in this group provide tentative support for the theory of pathological left-handedness (PLH). However, this relationship is highly complex given the number of left-handers who appeared in higher scoring groups, and supports the notion that the specific factors contributing to PLH must be taken into account. Thus, the current findings concur with those of Saling (1983) in that PLH would seem to occur in those circumstances where pregnancy and birth risk raise the possibility of non-righthandedness in those individuals with a familial history of sinistrality. The presence of cognitive deficit and PLH is a direction which would profit from further verification in a larger left handed sample.

Laterality Patterns: Relationship with Cerebral Organisation

On this aspect the question posed is whether lateralization, as an integral feature of the human cerebral cortex, has important consequences for cognition. Handedness has been a focus of research and one of the factors considered in exploring the degree to which the cerebral hemispheres are specialised. For example, right-handers are thought to be more lateralized than left-handers and may have greater left hemisphere dominance. On the other hand the degree to which lateralization occurs in children is unclear. Thus, the selection of cognitive tasks depicting right and left hemisphere function is a significant factor. A further issue is the appropriateness of the measures for the age and the developmental level of the group concerned.

Because it is important to consider the tasks employed, the theoretical basis for the two processing scales adopted, Sequential and Simultaneous, as discussed in Chapter 3, was based on the theory of hemispheric functioning (Kaufman & Kaufman, 1983; Morris & Bigler, 1987; Shapiro & Dotan, 1986). Although the background factors associated with the two modes of processing show evidence for hemispheric differences in coding stimuli, a substantial amount of the evidence accumulated is based on the split-brain patient studies and experimental tasks carried out in laboratory conditions. More specifically the right hemisphere processing style is holistic and simultaneous while the left hemisphere processing style is analytical and sequential. The question is whether the split-brain studies and findings can be extrapolated to normal populations and more pertinently to child populations. As discussed in Chapter 3, the development of measuring instruments linked to neuropsychological theories is an exciting and welcome direction in child neuropsychology and signals new advances in the field. However, the search for the neurological correlates involved in the theories has yet to show progress. This is best illustrated by the Luria-Das perspective which adheres to the Luria three unit brain theory. There is debate (e.g. Kranzler & Weng, 1995b; Telzrow, 1990) regarding the validity of two constructs, Planning and Attention, in the four construct model (including Simultaneous and Successive Processes) linked to Luria's theory (Naglieri & Das, 1997). There is also difficulty in demonstrating brain-behaviour relationships within the Luria-Das/anterior-posterior perspective. The alternative approach, cerebral specialisation of the two hemispheres of the brain, has proven equally difficult to link to brain-behaviour relationships. The possibility is also raised that the two processes, simultaneous and sequential coding, require more than hemispheric processing so that other nonlateralizing systems are involved. In considering additional lateralizing tasks,language was chosen as it has been traditionally associated with left hemisphere function. Basic spatial tasks with non-verbal or right hemisphere function were also included. The inclusion of such tasks is essential as they are designed to tap these independent rather then complementary functions. Finally, while selection of tasks form an important part of determining hemispheric functioning,it has also been acknowledged that the kind of sample involved should show suitable variations in hemispheric performance tasks. This was reflected in a proportion (n=39) of the sample whose Simultaneous and Sequential scale scores were both above the mean with variations on each scale. With these issues in mind,the findings related to the third factor will be examined.

Both the degree and direction of handedness were explored in comparing performance on the cognitive tasks. The hypothesized high sequential bias and rightward direction of handedness was only observed in the smallest group (n=11) where Sequential scale scores were the highest (see Table 6.17.Chapter 6). In this group, there was a 12 point difference in favour of the hypothesized left hemisphere dominant preferred mode. A predominance of consistent right-handers was observed. This group also produced the highest mean verbal fluency score also suggesting the hypothesized left hemisphere bias. Although the evidence does not justify a strong negative conclusion these are meagre findings in terms of overall group numbers. However, consideration might be given to the following issues:

(a) the majority of the sample produced scores that were deficient in either both (Group 1, n=115, Table 6.12) or one form of processing (Group 2,n=56.Table 6.13;Group 3,n=49, Table 6.14)

(b) the second largest group produced scores that were low average with no differences in processing styles (Group 6,n=76. Table 6.15)

(c) the smallest proportion (Group 5, n=11 ,Table 6.16; Group 4, n=28, Table 6.17) produced scores that were above the mean with substantial differences in the processing styles. Thus,evidence suggests that deficiencies as observed in (a) may not necessarily be reflective of normal lateralization. Moreover,the test performance,including the assessment of mental age,is more likely to be judged as immature in functioning. In the case of (b) the flat profile for both scores again does not suggest variation in processing style. In this instance an assumption could be made on the basis that where there are no differences between the two modes of processing there should be no gross differences between hemispheric tasks. Perusal of the (n=76, Group 6, Table 6.15) group's scores would seem to substantiate this expectation. In terms of (c) these groups offer the clearest indications of processing variations. The largest group (n=28, Group 4,Table 6.16) present the greatest discrepancy, a low average to high average picture in favour of Simultaneous scale: the smallest group (n=11, Group 5, Table 6.17) present an average to high average profile in favour of the Sequential scale.

The large discrepancy seen in favour of the simultaneous direction (Group 4) may reflect more underlying sequential (or left hemisphere) difficulties as shown explicitly by low levels of alphabetic knowledge but implicitly in the greater trend in mixed-handedness. Where the Sequential scale is emphasised as in the smallest group (Group 5), gender differences are more apparent. Males seem clearly right-handed, girls demonstrate skills in verbal fluency but appear more mixed-handed. Despite the low numbers, this picture in consistent with the hypothesized trends in the literature (Shapiro & Dotan, 1986;Morris & Bigler,1987;Palmer & Corballis, 1996) and given the nature of the tasks used in this study,it does not seem likely that cognition and lateralization were confounded.

The current results raise the question of the role of environmental or background factors in the development and lateralization of hemispheric function. The more current views (e.g.Galaburda, Rosen, Sherman, 1990;Palmer & Corballis, 1996) suggest that left hemisphere growth predominates during the period of language acquisition,that is from two to four years. The period of right hemisphere growth follows but is more dependent on environmental influences. This picture was borne out by the current findings where simultaneous processing or the putative right hemisphere mechanisms,seem reliant on a wide variety of environmental factors such as preschool experience, bilingualism, household size, the presence of books and television (see Table 7.12, Chapter 7). By comparison, the background variables associated with sequential or left hemisphere systems were relatively few, the presence of the consumable items, books and a telephone. Thus,the present findings show a number of factors that could be related to the development of hemispheric lateralization in the present sample and could be explored as further avenues of research. As an example, the role of bilingualism, as an environmental factor, and brain lateralization would be an important area for consideration. From Table 7.12 (Chapter 7) it will be recalled that the presence of a second language emerged as a significant negative predictor in the regression model for simultaneous processing skills. It will be also be recalled from the discussion in Chapter 2 that the two major hypothesis concerning the development of cerebral lateralization for language have been Lenneberg's (1967) progressive lateralization theory and the developmental hemispheric invariance model (Kinsbourne & Hiscock, 1983). It was Lenneberg's (1967) view that the hemispheres are equipotential for language;hemispheric specialisation occurs with the advent of language development. The second model proposes that the hemispheres of the brain are specialised before birth. Language is present in (usually) the left hemisphere from the outset. There has been a lack of support for Lenneberg's (1967) model from a pragmatic perspective,as Harris (1992) suggests progressive lateralization also implies that the absence of hand differences could also be expected in early life with a gradual differentiation as development progresses. Currently this trend is not supported (Bishop, 1990;Harris, 1992). Over the years, there has been a tendency to integrate these two theories of developmental lateralization. Such an approach does not propose a rigid invariance which by implication tends to exclude for example,environmental influences that can affect language. The possibility that language development can be affected by environmental influences can be raised within the integrated model of developmental cerebral lateralization. This is probably best illustrated by Iaccino's (1993) view that brain lateralization may not be advanced in children who are second language speakers. He raises an intriguing possibility that "*...a Lennebergian type of equipotentiality might exist in this group of subjects up until the onset of puberty " (p.193)*. In this approach the role of the right hemisphere is implicated in the early stages of learning a second language which Iaccino (1993) proposes slows its development. However, Iaccino (1993) does not elaborate on how right hemisphere function might be involved. A slightly different view is that the acquisition of a second language requires a greater cortical area (Segalowitz & Hiscock, 1992). Both views converge on the notion that greater cortical space may be involved in acquiring a second language. Thus, the consequences fc· . child growing up in a high risk impoverished environment with wide exposure to multiple languages require clarification and warrant further investigation. The present findings endorse the view that the relationships between peripheral activities (such as handedness) and cortical laterlization is not a simple one and do not relate to each other in one-to-one fashion.

Mental Processing Profiles

Thus far the formal assessment of African children has been stunted by the lack of appropriate measuring instruments. The tendency has been to select instruments,especially for young preschoolers,that emphasize motor and behavioural development. This may in part explain why these tasks fail to predict performance on tests involving developing mental ability (Miller, 1976). Thus, assessment procedures that offer continuity over a number of years but especially at an early stage in the preschool period,are worthy of consideration. Although continuity of measurement over time is a highly desirable aspect in a test battery, test developers have, in recent years, also noted the increasing need for assessment procedures that can be applied to children in a wide variety of socio-cultural milieu. The question of whether tests can be meaningfully applied in such a universal manner is posed by Boivan and his colleagues (1996). *'Is the cultural context of daily social interactions and adaptations paramount in interpreting cognitive ability or development at any level, or is it possible to tap a common neuropsychological foundation in one's assessment that supports or mediates such contextual adaptations?' (p.597)*. Based on their experimental use of the Kaufman Assessment Battery for Children (K-ABC) and a number of neuropsychological tasks in a variety of cultural situations,Boivan et al. believe that the latter aspect is true. The K-ABC tasks tap into information processing or encoding strategies which appear to be influenced by environmental experiences. Processing styles can illustrate the developmental status of the two modes of processing within specific environments. Thus the two constructs, sequential and simultaneous, can be shown to be universally distributed, though in varying degrees, across cultures. There is also evidence to show that the K-ABC is highly correlated with other measures of intellectual abilities,such as the Wechsler Intelligence Scales, so that meaningful comparisons can be made across culture and social factors.

In the current sample the scores obtained on the two processing modes were compared to the scores of children based on American normative data standardized on parental education and African-American children's scores (Kaufman & Kaufman,1983). Comparisons with normative data based on parental education indicate that the scores in the current sample show little difference on the Simultaneous scale and are not grossly different for the Sequential scale. A similar picture emerges for comparisons with the African-American sample. Simultaneous processing scores were similar for the two groups while sequential scores are higher by 10 points in the American sample. The sequential difference may have been influenced by several factors including the split between the scales as manifested by 25% of the sample,and the low scores on both scales by 34% of the children. It will also be recalled that the factor solution for the two processing styles showed a stronger support for the simultaneous, but a weaker structure for the sequential process. The impression is that either the sequential tasks were less suitable for the children or that there is under development of sequential processes. In their research, Giordani et al., (1996) found robust factor analytical support for the presence of the two processing styles, sequential and simultaneous, in their sample. In terms of tasks it would be difficult to rule out the effect of translation of Word Order subtest into the child's home language. Yet ,it was also noted that Hand Movements, a non-verbal subtest, tended to load on both scales as shown in Table 6.4 in Chapter 6. This would tend to support Giordani and his co-workers' (1996) view that there may be variations in visual-spatial skills depending on task and environmental factors. Thus, the tendency to rely on non-verbal measures in the assessment of non-Western samples is not a satisfactory solution. There is a strong need for the development of verbally based measures in the assessment of problem-solving behaviours when assessing non-industrial or rural African samples. Although task difficulty would seem to provide a convincing argument for the low scores and subsequent poor performance on this scale the alternative argument is that sequential skills are inadequately developed within this sample. This aspect will be discussed further below.

Background and Cognitive Factors

Generally, the socio-economic situation in South Africa as reflected in areas such as Soweto is severely skewed so that the conditions for child development are not ideal. In a sample where overall low socio-economic conditions are pervasive how were differences in children's processing skills accounted for? It will be recalled that Table 7.16 in Chapter 7 shows that the dependent variable,mental processing composite score, was influenced by the child IQ,spatial and verbal abilities,handedness skill and handedness direction at five years, gender, gestation period, and consumable items, specifically access to books and a telephone, which may be indirect measures of income level. Thus, the question regarding the circumstances in which processing skills develop may best be answered in the following way. Optimal levels of processing skills are likely to be influenced (a) by intrinsic factors, mainly the basic intelligence level, which at five years would seem to be positively enhanced by the child's verbal skills, perceptual abilities and handedness direction but negatively affected by poorly developed motor skills: (b) by epigenetic factors, the period of gestation and the child's gender: and (c) by environmental factors, availability of consumable items (books and a telephone). However, when these indicators are distilled further down to the separate coding processes, it would seem that each type of processing skill is further hinged on both similar and distinctive cognitive and environmental indicators. For example, Table 7.13 in Chapter 7 displays the environmental variables which emerged as associated with simultaneous skills were those related to the presence of specific consumables (TV, telephone, books); the size of the household; the child's preschool experience. Cognitive variables included IQ, basic perceptual skills, verbal skills and hand skills plus an epigenetic factor, the child's birthweight. For the Sequential scale, Table 7.15 in Chapter 7, shows the environmental variables which included the availability of consumable items (books and a telephone), no epigenetic factors, the cognitive variable IQ, but more distinctly, alphabet knowledge.

The overall outcome suggests that simultaneous skills are more susceptible to environmental, epigenetic and cognitive influences which ultimately affect mental processing. However, these factors are distributed to a greater or lessor degree throughout the sample hence a slightly better simultaneous score. The indicators for sequential skills appear to be influenced by more specific cognitive requirements in addition to IQ, namely alphabetic knowledge, which was found to be generally low in the group. The alphabetic system is not well-developed in this sample of preschoolers, the question of how sequential skills could be affected by the alphabet system is an important one. It has been established that the alphabet "maps onto speech at the level of the phoneme". (Tzeng & Hung ,1994, p.275) and research with preschoolers has revealed that the use of the alphabetic system is one of the basic prerequisites for the development of phonological skills (Naslund & Schneider, 1996).Tzeng and Hung,(1994) reported that the alphabetic system was visually processed in a linear manner by a group of American children,implicating a Sequential processing mode. The sequential characteristics of the alphabetic system have also been seen as having a crucial role in the development of reading skills by a number of researchers (e.g. Frith, 1985; Pennington,Lefly, Van Orden, Bookman & Smith, 1987;Riccio & Hynd, 1995). Whether alphabetic knowledge influences or enhances the development of sequential processing skills or vice versa, is a question that cannot be answered within the scope of the current analysis. However, low levels of this knowledge would require further follow-up in this group for the implications inherent in reading and writing. Generally, the findings suggest that each processing scale was seen to require specific environmental and cognitive input combined with factors residing in the individual child.

The role of maternal education, emerged as a significant background factor between the four largest groups. Previous research (e.g.Richter & Grieve, 1991; Barbarin & Nkomo, 1997) has shown that maternal education is a pervasive and influential variable in African research. Yach and his associates (1993b) found increased benefits in terms of health awareness and higher attendance at primary health clinics were associated with higher levels of maternal education. However, the effect of the maternal education variable as reflected in the current study suggests the wider and deeper implication over the broader spectrum. As an example, Barbarin and Nkomo (1997) reported that in Soweto households where the mother was more educated,there was a greater likelihood of having a steady income,adequate food, greater quantity of consumables and better housing. Adequate food is a crucial prerequisite if hunger and malnutrition, as a consequence of po y and deprivation,are to be avoided (Barbarin & Nkomo, 1997). In the current study, it is likely that the efficiency and level of processing skills could be affected by a history of malnutrition or hunger over periods of time especially in the poorest groups. In cases where income and educational level is low, where the family size is large and the household structure comprises a single parent, the risk for childhood hunger and malnutrition is high (Richter & Griesel,1994). These factors were observed in lower scoring groups in the current study. For example,it will be recalled that in Chapter 7 there were significant differences between the four groups on consumer items. The lowest scoring group, Group 1, having the lowest number of televisions sets and the lowest percentage of telephones. As previously noted, consumable items are indirect markers of the level of wealth within a household (Barbarin & Nkomo, 1997). Poverty also increases birth risk factors, for example the nutritional status of the mother or lack of antenatal care may be reflections of poor socio-economic conditions (Richter & Griesel, 1994). It will be recalled that in Chapter 7 comparison across groups showed that Group 1 contained a significantly higher number of children with gestation periods below 37 weeks. The current findings suggest that children in Group 1 may be considered as a high-risk group.

Mother's educational level may also be reflected in the number of books and reading material reported in the household and available to the child. Richter and Grieve (1991) noted in their study that the educational level of the mother was significant in terms of the amount of reading material in the household and the amount of time spent reading. Thus, the benefits accruing to the child might be seen in better nutrition,availability of consumables, and a more enriching preschool and educational experience. However, there are possible factors for which maternal education is not influential and these reside within the child. For example,the basic level of intellectual function can be set at a level whereby the effects of environmental influences may be limited. These factors may be governed by events such as gestation duration, birthweight or delivery. Under these circumstances the development of processing skills may be seen from a 'top down' perspective starting with the child's intellectual level, as observed in the present study. However, it is clear from the current findings that the crucial role supplied by environmental variables in the development of cognitive skills is underpinned by the factor of maternal education.

Critical Considerations

As a longitudinal study the focus was placed on a small but important slice of development within a neuropsychological framework. It could be argued that the developmental period is narrowly defined, however, a research focus towards early understanding of basic processes, the implications for later development, the role of environmental factors and appropriate early interventions has emerged in recent years. Further follow-up with this group of children is inevitable and the prospect of determining the relevance of the current results to future findings is exciting and worthwhile.

In terms of perspective, considerations of childhood and development invariably invoke the need for a range of professional input including language pathologists, pediatric neurologists, developmental psychologists and occupational therapists. The inclusion of a child neuropsychologist in the disciplinary team should not be surprising. The role of the child neuropsychologist differs because of the kind of questions asked, the test instruments used and the test strategies adopted (Segalowitz & Hiscock, 1992). Thus, the contribution to the pool of information hopefully reflects on brain growth and maturation in a way which enlightens understanding of language development, motoric development and cognitive processing together with the environmental influences which are thought to be influential in this sample.