Effects of Iron Deficiency on the Cognitive Functioning of Primary School Children in Southern KwaZulu-Natal

Mamoloko Florah Rangongo

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DECLARATION

I hereby declare that this whole dissertation, unless specifically indicated to the contrary, is my own original work.

MF Rangongo

TABLE OF CONTENTS

LIST OF TABLES

APPENDICES

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PREFACE

This study was a small component of a much bigger research study conducted by a multi professional team from the Department of Community Health (University of Natal - Medical School) in conjunction with the Human Sciences Research Council (HSRC). The purpose of the main study was to investigate the effect(s) of micronutrient deficiencies and parasite infections on the physiological and the psychological well-being of school children. The design was a double blind, placebo controlled study, with iron status (mild, moderate and severe deficiency), parasite status (whether children were infected or not) and micronutrient level (vit A and iron) as independent factors. Physiological/medical measures (i.e., urine, stool and blood specimen) and psychometric measures were taken twice at six months interval, i.e., before and after intervention with treatment or placebo. The main focus was to examine whether there would be any difference on the medical and psychometric measures before and after intervention with nutrient and vitamin fortified biscuits as well as treatment for parasites. Due to this overall aim and the sample size (n=810), both psychometric and medical tests had to be administered in group form. This was also to minimise the cost that would involve the use of individual testers including any time effects if such a large number of children were to be assessed individually. In addition, individual testing would have meant regular visits to schools, resulting in frequent disruption of the schools' teaching programmes. Thus, testing had to be adapted to group administration.

Researchers in this field of study, i.e., where they have to work with psychometric tests for African children in South Africa, have indicated that they are often faced with problems of lack of or insufficient psychometric tests that are standardised on such children. As a result they frequently have to compromise and modify some of the available tests to suit their specific research needs/situations. Psychometric tests that were selected for the current study, although unstandardised, were chosen because they are generally known to measure cognitive and other psychological functions that were being investigated in the study. It should also be noted that three of the four tests used can be administered either individually or in group form. In addition, two of them, viz. the Symbol Digit Modalities Test and Raven's Coloured Progressive Matrices, have been used on African children in South Africa in similar studies.

Furthermore, two pilot studies were conducted in an effort to assess and minimise problems arising from using unstandardised measures.

Studies on effects of parasite infections and micronutrient deficiencies have shown that children from underprivileged rural areas (such as Vulamehlo, the area selected for this study), tend to have high levels of parasite infections which result in high prevalence rates of iron deficiency. In fact, in the current study, of the 579 children who gave stool and urine specimen, about 53.7% of them were found to be infected with Trichuris trichiura, 22.6 % had Shistosoma haematobium and 2.6% were found to be infected with hookworm. Some of the children were infected by more than one parasite with others having all three parasites. These parasites are known to result in undernutrition and micronutrient deficiencies, specifically iron deficiency, through their cause of diarrhoea and loss of appetite or hampering the absorption of micronutrients from the gut of infected children. Thus, in cases such as these, the incidence of iron deficiency would be expected to be relatively high. The fact that very few children were found to be iron deficient (with even fewer of them falling within the anaemic end of the spectrum), despite the high rates of infection, suggests that there may be other factors either in the lifestyle or traditional dietary habits of these communities that may boost their iron levels. Although the results were unexpected and somehow may have complicated statistical analysis, it is still a comforting and pleasing fact that only about 23% of the children in the current study were iron deficient. Furthermore, estimations from previous research studies suggest that in an area like Vulamehlo, the number of iron deficient children can be expected to be at least 10% higher than what the study found. Thus, the fact that few children were iron deficient is a significant finding on its own, given what the literature indicates should be the case for communities with similar demographic variables.

ABSTRACT

The aim of this study was to assess the performance of the children in the study on some psychometric tests and to find out whether iron deficiency had any effect on cognitive skills as measured by the selected psychometric tests. The study also wanted to find out if there would be any gender differences on the psychometric tests.

A sample of 810 children was selected from eleven schools from the rural Southern part of KwaZulu-Natal. The children were of ages eight to ten years old, were all Zulu speaking and in standard one. Blood samples were taken from all the children to determine iron levels. Psychometric tests viz., the Symbol Digit Modalities Test, Raven's Coloured Progressive Matrices, Rey's Auditory Verbal Learning Test and Young's Group Mathematics Test, were all administered to measure cognitive performance.

The results showed no significant iron level effects on most of the measured cognitive skills. There were some significant gender effects on all the psychometric tests except for the Maths test. There was general low performance on all the psychometric tests.

Therefore, the results highlighted the importance of designing more tests that can be standardized and thus be applicable to Zulu speaking children and other children with similar backgrounds. The tests should also be able to tap into the cognitive skills that may be affected by iron levels. There is also a great need for studies looking at the lower end of iron deficiency.

CHAPTER 1

INTRODUCTION

The importance of education, especially that of young children who are in primary schools, can be highlighted by the fact that:

> Children are the future and one must judge their needs today by roles they will need to fulfil as adults and by the structure and vision of the future society in South Africa for which they will be the leaders and the professionals, the parents and the citizens (UNICEF: SA, 1994, p. 18).

Thus, it becomes imperative to look into factors that may compromise children's learning capacity and reduce them as much as possible.

1.1 BACKGROUND INFORMATION

In 1990, the World Summit for Children held at the UN headquarters in New York, set a target of achieving basic primary education for at least 80% of children by the year 2000 (Nokes and Bundy, 1994). Moreover, organisations such as UNESCO, UNICEF and the World Bank had previously launched an initiative of "education for all" (UNESCO, 1989). Additional goals of UNICEF in South Africa, include addressing and eliminating problems of iron deficiency amongst both children and women, pursuing human, economic and organisational support for a national nutrition plan, and increasing access to primary school education (UNICEF: SA, 1994).

However, it was realised that all these initiatives will only result in significant improvement in education if children are healthy enough to be able to benefit from the schooling available to them, i.e., children needed to be helped in order to be able to take full advantage of the education they are offered (Bruer, 1994; Nokes & Bundy, 1994). It was considered that "there is little point in providing excellent educational facilities if the ability of children to attend school, or to learn while there, is compromised by ill-health" (Nokes & Bundy, 1994, p. 14).

Thus, in South Africa programmes such as the Primary School Nutrition Programme were developed, which link with the UNESCO project to improve primary school performance through improving nutrition and health in order to increase the development capacity of underdeveloped countries. It is designed in such a way that there is emphasis and belief that "more investment in child health and nutrition will pay off well for education" (Jamison & Leslie, 1990, p. 204). According to Nokes and Bundy (1994) it is important to improve primary school education because "for many children in the developing world, those few years of basic education may be the only education they ever receive" (p.18).

1.2 THE PROBLEM

"Within the Reconstruction and Development Programme (RDP) there is special recognition of the importance of improving the conditions of children: ... the needs of children must be paramount throughout all programmes aimed at meeting basic human needs and socio-economic upliftment" (UNICEF: SA, 1994, p. 18). Thus, in South Africa, the goals for children and development followed this acknowledgement. As a result, the Primary School Nutrition Programme (PSNP), was introduced in KwaZulu-Natal in September 1994 by government. This also followed the realisation that in the present transitional phase there is a need for integrated early childhood development programmes promoting the intellectual, health, nutrition, social and emotional development of children. Thus, investment in children and in their education, health and well-being is an important requirement for laying the foundation for a more dynamic and politically stable economy in the twenty-first century (UNICEF: SA 1994).

The implementation of the PSNP in Kwazulu-Natal was aimed at improving the children's active learning capacity. Included amongst its objectives are the improvement of the quality of life of school children by including micro-nutrient supplementation, alleviation of temporary hunger, ensuring that pupils benefit optimally from the nutritional interventions and developing a nutrition education component as part of the general curriculum. It is particularly focused at primary schools in disadvantaged areas, i.e., the rural and peri-urban areas, including informal settlements where poverty levels are high. The programme is linked with other health and RDP (Reconstruction and Development Programme) initiatives. Studies are thus needed to inform the implementations in order to achieve the objectives (Nutri Digest, 1995).

Leslie and Jamison (1990) emphasised the importance of advancing understanding of the relationships between psychology, education and medicine (public health), in assessing the efficacy of interventions for addressing the problems, and developing and implementing action programmes based on cost-effective interventions. Additionally Bruer (1994), stated that the interaction between infections, micronutrient deficiencies and cognitive function - body and mind - represents an important, emerging research area where psychologists (and possibly neuroscientists) can collaborate productively with physicians and public health authorities. This kind of collaboration can be in a way that children who have been identified by physicians as iron deficient can be assessed by psychologists and/or neuroscientists to determine the effects of iron deficiency on neurological and/or mental/cognitive functions, with the resultant recommendations to public health authorities for policies and implementation of suggestions. Although it is known that iron deficiencies impair cognitive development and the ability to learn, much more is known about their physical than about their mental effects. Moreover, if learning is impeded at school, there is a need to know more about which skills, if any, are affected and, where possible, at which level (Bruer, 1994). Thus, it is important to investigate the specific aspects of cognition that are adversely affected by iron deficiencies and the implications for the scholastic achievement and health of children (Bundy & Nokes, 1995).

Iron deficiency anaemia has consistently revealed a negative effect on selective cognitive processes rather than on global mental ability such as intelligence and school performance, more especially through it causing lack of concentration or interest, apathy and/or sleepiness (Soewendo, Husaini & Pollitt, 1989; Leslie & Jamison, 1990). A study done by Soewendo et al (1989), on preschool children in Bandung, Indonesia revealed that iron deficiency anaemia produces alterations in visual attention and concept acquisition. The same results, indicating that anaemic children tend to perform poorly on cognitive tasks, were also shown by Soemantri, Pollitt and Kim (1985); and by Seshadri and Gopaldas (1989), in their studies of Indian children of ages 5-8 years, where they found that after supplementation with iron, children's IQ scores, as measured by Wechsler's Intelligence test for Children (WISC) improved significantly. Therefore, as indicated through research, iron deficient children tend to be less attentive with reduced alertness, exhibit less motivation and a low level of engagement with their immediate environment, their problem-solving skills are affected, as is short-term memory and they are slow to react to stimuli. All of these skills impinge upon learning and school achievement (Levinger, 1992).

However, numerous problems are still encountered when parameters that include problem-solving skills, information processing and mental alertness need to be assessed (UNESCO, 1989). This is due to the fact that the norms of the tests that are available and often used, are mostly only relevant to specific populations and not to all populations that need to be tested. This problem was also encountered by Frets-van Buuren, Letuma and Daynes (1990), during their attempts to assess Zulu children with the conventional tests which were either "too closely linked to the European way of life" (p. 144), or just proved to be inappropriate. As a result, very few tests can provide the answer for black South African children who cannot speak English. Therefore, "we need batteries of culturally appropriate tests that tap the range of cognitive functions that contribute to skilled performance on school tasks" (Bruer, 1994, p. 9). Thus, this study will also gather some preliminary data that may be used to inform efforts to develop appropriate norms in the future.

1.3 THE RATIONALE AND IMPORTANCE OF THE STUDY

According to Pollitt et al. (1978) and Levinger (1983) (cited in Richter, Rose and Griesel, 1994), there have been claims that supplementing nutrition with micronutrients can improve academic performance but "few good controlled studies have been reported which demonstrate these effects unambiguously" (p. 18). Moreover, effects of micronutrient supplementation on learning still remain unclear (Richter et al., 1994). Levinger (1994) further stated that "data on the prevalence of micronutrient deficiency disorders ... is still incomplete. It is difficult if not impossible to target communities on the basis of what is currently known" (p. 35). Therefore, it is hoped that data from this study will provide guidelines for further research and informed intervention programmes for primary school children.

The additional use of the selected psychometric measures, will potentially help those people involved in this area of work and research. This need is further highlighted by the fact that

> in South Africa, although the state-funded agencies like the National Institute of Personnel Research and the Human Sciences Research Council (and their predecessors) focused considerable attention during the 1950s and 1960s on the development of tests of intelligence, aptitude and ability to assist in the educational and career placements of white children, no comparable measures were constructed for other children (Dawes & Donald, 1994, p.7).

This supports the necessity for more research on the impact of micronutrient deficiency on cognition, and developing and refining test procedures for assessing the impact of micronutrient deficiencies on cognition (Nokes & Bundy, 1994).

1.4 THE FOCUS OF THE STUDY

This study is focused on the effects of the various levels of iron in the body, namely iron replete, iron deplete, moderate iron deficiency and severe iron deficiency (see a later section for their definitions) on cognitive functioning. The cognitive functions that will be looked at include attention, memory, problem-solving and learning as measured by selected psychometric tests. These tests are viz, the Rey Auditory Verbal Learning Test (RAVLT), the Symbol Digit Modalities Test, (SDMT), Raven's Coloured Progressive Matrices (CPM) and Young's Group Mathematics Test (GMT) (All discussed in a later section).

1.5 DEFINITION OF TERMS

Due to the technical nature of some of the terms used in this study, it becomes essential to define them. These definitions are primarily related to levels of iron in the body. Reductions in body iron have been grouped into three stages of progressively increasing severity, based on iron metabolism and defined appropriate laboratory criteria and/or tests. These stages, also known as compartments are viz, storage iron, transport iron and red cell iron (i.e. iron found circulating in blood). The most widely employed tests include serum ferritin for the storage compartment, transferrin saturation for iron transport and haemoglobin for red cell measurements. Following, are brief definitions of different iron levels according to the stages.

1.5.1 **Iron replete/sufficient** denotes a normal total body iron content, i.e. an adequate reserve of storage iron to cope with normal physiological functioning.

1.5.2 **Iron deplete or mild iron deficiency** has been used to designate a decrease in body storage iron (e.g serum ferritin below 12 ug/l) without any effect on other functional iron compounds.

1.5.3 **Iron deficiency without anaemia or moderate iron deficiency** denotes a further decrease in the supply of iron, showing a decrease in transport iron without any detectable effect on red cell iron (i.e. serum ferritin < 12 ug/l, transferrin saturation < 16% with normal haemoglobin levels).

1.5.4 **Iron deficiency anaemia or severe iron deficiency** is a more advanced stage of iron lack resulting from a further diminution in total body iron. There is a drop of serum ferritin to below 12 ug/l, transferrin saturation < 16% and haemoglobin < 11 ug/dl. This is a late manifestation of iron deficiency and reflects the severe end of the spectrum of iron deficiency. Anaemia is usually defined on the basis of arbitrary threshold criteria for haemoglobin concentration. It is defined as a reduction in haemoglobin concentration to below that which is optimal for that individual. Anaemia can also be divided into different levels according to its severity. These will not be discussed as they are not part of the focus for this study.

Thus, iron deficiency is first noticed in the storage compartment, followed by deficits in transport and then in the red cell compartment. A more detailed discussion of the iron levels will be dealt with in a later section.

1.6 THE DELIMITATIONS OF THE STUDY

(I) The study will be limited to school children of ages 8 - 10, currently in standard one in eleven schools in the Vulamehlo area, a rural magisterial district in the southern part of Kwazulu-Natal.

(ii) Due to the size of the sample, only group administration could be conducted which meant that qualitative observation of the individual children was not possible. The Rey Auditory and Verbal Learning Test (RAVLT), which is normally administered on an individual basis was adapted to group administration. This test was also translated into Zulu.

1.7 THE OUTLINE OF THE STUDY

The composition of the chapters of the study are illustrated as follows:
Chapter one has presented the introduction and background information of undertaking the study. Chapter two will focus on the literature review of cognitive functions which are of interest in this study, and on iron deficiency, its assessment and its effects on cognitive function. The third chapter explains the methodology and the instruments selected for use in this study. The fourth chapter focuses on the results, and the final chapter deals with the discussion of results and conclusion. Then references and appendices are attached.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The physical and psychological development of children from disadvantaged communities is influenced by several factors. Some of these factors may be biological in nature while others are more social in nature. There is a complex matrix of factors where nutritional deficits, socio-economic and environmental conditions, and behavioural variables affect child development and are also affected by one another (Kvalsvig & Connolly, 1994).

Problems that are encountered by people from underprivileged communities include poverty which may result in micronutrient deficiencies. Research indicated that iron deficiency, together with other micronutrient deficiencies, have deleterious effects on children's cognitive skills/processes, behaviour and psychological functioning, and ultimately on educational achievement (Lozoff & Brittenham, 1987; Simeon & Grantham-McGregor, 1990; Pollitt, 1993; Kvalsvig & Connolly, 1994). As a result, more attention needs to be given to the effects of micronutrient deficiencies on children's health and cognitive functioning in order to ultimately enhance better academic performance (Clarke, Grantham-McGregor & Powell, 1991). In South Africa, this may ultimately alleviate the problem, stated by Dawes & Donald (1994), that there appears to be an increasing population of young people "who are poorly educated, who are socialised in a violent environment, and whose families are often too caught up in stresses of poverty and survival to offer what western middle-class society would call a normal childhood" (Dawes & Donald, 1994, p. 8).

The literature review will first focus on the cognitive skills that may be adversely affected by iron status in the body. The cognitive processes that will be discussed include, memory, attention, learning, problem-solving and reasoning. Then indicators and measurement/assessment of iron will be presented, followed by a discussion of risk factors and mechanisms through which iron levels affect cognitive skills. The final focus will be on the effects of iron deficiency on cognitive skills as indicated by research studies.

2.2 COGNITIVE PROCESSES

Cognitive processes consist of internal psychological mechanisms that are involved in making sense of the world. They relate to those functions which are more concerned with conscious processes and voluntary responses to information and stimuli. These processes are important in attention, perception, learning, memory, language, concept formation, problem-solving and thinking (Morgan, King & Robinson, 1981; Eysenck, 1993; Malim, 1994). Levinger (1994a) stated that processes associated with cognitive function also include short-term memory, the development of sensory-integrative capacity, mental and physical activity, interest in and motivation to tasks at hand. The information a person has to work with at any given moment comes from current circumstances which usually include some focal source of stimulation; memory which has information about past experiences and functional skills; and feedback contingent upon action, i.e., information that is derived from sensing one's own activity (Bourne et al., 1986).

There are several definitions of cognitive function. According to Levinger (1994a) cognitive function is defined as:

> the ability to learn categories, to process and structure information, and to learn and react to social and environmental cues. Cognitive function also includes the ability to ask appropriate questions and provide appropriate answers within a given environment and to identify and solve relevant problems. Furthermore, it embraces general conceptual ability, appropriate actions within a given culture, and the mental agility needed to entertain new categories and see new possibilities (p. 9).

Reed (1988) stated that "cognitive psychology refers to all processes by which the sensory input is transformed, reduced, elaborated, stored, recovered and used" (p. 3). There is acquisition of knowledge which involves many mental skills. These skills are encountered by people in their daily lives and include perception/pattern recognition and attention, memory, problem solving, and decision making. Cognition starts with our contact with the external world. The information that is received from the environment is actively constructed through both reduction and elaboration. Only a small amount of the information that is perceived will be stored (Reed, 1988).

"Cognitive processes are thus the mental processes involved in knowing about the world, and as such they are important in perception, attention, thinking, problem solving and memory" (Morgan, King & Robinson, 1981, p. 148). Thus, this section of the literature review will discuss these cognitive processes, i.e. memory, problem-solving, reasoning, learning and attention..

2.2.1 Memory

Memory covers a complex collection of abilities, processes and mental systems. Memory is the capacity to retain and retrieve information, it confers competence and helps people to negotiate their daily tasks. It also confers a sense of personal identity as people are each a sum total of their own recollections and experiences. Memory preserves the past and guides both the present and the future (Wade & Tavris, 1993).

There are two concepts in understanding human memory. The first is activation which controls the speed and reliability of access to the memories. When memories are in an active state, they can be accessed quickly and reliably. The second concept is strength which determines the degree to which we can reactivate old memories. Memories that are currently active are often referred to as working memory because they are the knowledge which we can currently work with (Eysenck, 1993). Atkinson and Shiffrin differentiated between three kinds of memory store viz: modality-specific stores/sensory memory, the short-term memory/working memory and the long-term memory. This model is also known as the information-processing theory or the multi-store model of memory. According to this model, the memory process is viewed in terms of discrete stages each of which has its own characteristics. They differ in terms of how long information is stored in them, their storage capacity and the way in which information is forgotten. Basically, information from the environment passes through sensory store where it is preserved for a few hundred milliseconds; to short-term memory (STM) where it will be lost within 15 to 30 seconds if it is not rehearsed; and finally to long-term memory (LTM) for more permanent storage (Eysenck, 1993). Thus, information is received from the environment, processed in steps or stages and then an output is produced (Morgan, King & Robinson, 1981; Wade & Tavris, 1993). The following is a discussion of memory according to the three stores/stages.

(1) Sensory memory

An enormous amount of information is received by an individual at any given time. This information must first be registered perceptually (i.e,. through the senses) for it to be processed any further. The perceptual system will then process this load of information, received from the environment, in such a way that it makes sense. As stimuli are presented for a very brief duration, in order to recognise them, there is need for a system of holding the information for a while until it can be analysed. This system is in the form of a sensory memory/ modality-specific store. This short-term store is regarded as primitive, has a very limited capacity of six or seven items and contains information that is in a fragile state. This information is highly susceptible to interference and lasts for short periods of time, only up to a second or two (Bourne et al., 1986; Reed, 1988).

Some of the information in the modality-specific stores is attended to and receives further processing, while the other information will rapidly decay and get lost. Information that is registered in the sensory memory is meaningless until identification or recognition is achieved, i.e., an event must be recognised and encoded, given meaning and converted into a more durable form that can be stored. This is done through the aid of past experience and knowledge (Morgan et al., 1981; Bourne et al., 1986). Sensory memory is made up of separate memory subsystems known as sensory registers and they are as many as there are senses. Visual sensory information is perceived and processed by the iconic memory, and auditory information by the echoic memory. Encoded information that is more durable is passed from sensory memory to short term memory (Reed, 1988; Anderson, 1990; Wade & Tavris, 1993).

(2) Short-term memory

Short term memory (STM), also known as working memory, is comprised of the material that we are aware of at any given moment. It is what individuals employ in their current functioning with the inclusion of the temporary maintenance of information that is necessary for performing many cognitive/mental tasks. It is an active form of memory, consisting of information that has just been encoded from sensory memory or information that has been retrieved from our general store house of knowledge, i.e., long-term memory. Its storage capacity is very limited, it contains those items to which we are attentive at the moment. The storage capacity can be increased, however, by a process known as chunking. Chunking entails combining several items into a "chunk", and then several of these chunks are retained in STM. STM incorporates attentional systems and processes concerned with maintaining and manipulating all information including verbal, auditory and visuo-spatial information (Eysenck, 1993; Wade & Tavris, 1993; Baddeley, 1995).

As there is a continuous flow of information from the environment, information that is contained in STM is subject to a great deal of competition and interference. Information fades out of STM in a short period of time if it is not processed. Much of the data is lost because it is displaced by incoming items of information. Rehearsal is one form of processing that is important for maintenance of information over time, and/or converting or elaborating information into an even more stable form, for storage as a part of our general knowledge about the world. Rehearsal happens in a special part of the short-term store known as the rehearsal buffer. There are two kinds of rehearsal systems, viz: maintenance rehearsal which involves a repetition of material or a process which has already been carried out, e.g., repeating a word over and over again; and elaborative rehearsal which involves deeper processing of the stimulus material that is to be learned by giving this material organisation and meaning. Memory improves the more it is elaborated. Elaboration is an active process that provides redundant retrieval routes for recall and helps the individuals to infer what they can no longer actually remember. Elaborative rehearsal is also part of an alternative conception of memory called the levels-of-processing view which also relates to the organisation of memory (Morgan et al., 1981; Anderson, 1990). Deep processing is one strategy related to rehearsal and promoting retention of information. It involves analysing the meaning of what a person is trying to remember and also associating new items of information with items that have already been stored or with other new items. Deep processing can also include analysing the various physical or sensory features of an item (Wade & Tavris, 1993).

The use of either one of the two rehearsal systems depends on the kind of information that needs to be rehearsed and stored. Rehearsal enhances the maintenance and transfer of information from STM to long-term memory for storage. If a person is distracted during rehearsal, information will be lost rapidly. Unrehearsed items are displaced from memory and thus get forgotten (Bourne et al., 1986; Eysenck, 1993). The occurrence of rehearsal in STM has often been used to explain the serial position effect. When a person is asked to recall a list of presented items, recall is best for items at the beginning of the list (i.e., primacy effect) and at the end of the list (i.e., recency effect) (Wade & Tavris, 1993).

Working memory consists of an attentional system that plays a part in determining whether or not the rehearsal systems are used. This system includes the articulatory loop, the visuo-spatial sketch pad and the phonological loop. An articulatory loop is regarded as a verbal rehearsal system and information such as words are typically rehearsed and kept active by saying them over and over again. It resembles an inner voice. The articulatory loop has very limited capacity, which is equivalent to the amount of verbal information that can be articulated in approximately two seconds. The visuo-spatial sketch pad is mainly for rehearsing images, it is a visual and/or spatial rehearsal system and resembles an inner eye. The phonological loop maintains acoustic information by subvocalization and converts the presented information to a phonological code. It seems to be particularly important in the acquisition of vocabulary (Anderson, 1990; Eysenck, 1993; Leahey & Harris, 1993). Information that is processed and encoded is transferred from STM to long-term memory for storage and later use (Reed, 1988).

(3) Long-term memory

Information that is transferred to long- term memory (LTM) is in its most lasting form. The vast amount of information in LTM constitutes our representation/knowledge of the world and builds a sense of identity and personal history. LTM contains diverse and huge amounts of information and has unlimited capacity. Much of what is in LTM consists of knowledge about what words mean, about the ways they are related to one another and about the rules for using them in thinking and communication. Rehearsal improves storage, structuring and organisation of information in LTM (Morgan et al., 1981; Anderson, 1990).

Information in LTM is organised in such a way that it fits into existing categories, is grouped in some logical manner, or is arranged in some other way that makes sense. Organisation of information in LTM depends on the kind of material that is stored there. There is a distinction between procedural knowledge, i.e., knowledge of skills or habits ("knowing how"); and abstract or representational knowledge, known as declarative knowledge ("knowing that"). Procedural knowledge, also known as implicit memory, involves e.g., knowing how to drive your car. It is reflexive in nature, and is built out of extensive knowledge which has become automatized through prolonged practice. Implicit memory also includes our unconscious remembering of how to do things and it affects our current thoughts or actions even though we are no longer aware of the original information or event. Declarative memory, also known as explicit memory, takes the form of conscious recollection of knowledge about facts and things (Bourne et al., 1986; Anderson, 1990; Eysenck, 1993). In short, "implicit memory is revealed when performance on a task is facilitated in the absence of conscious recollection; explicit memory is revealed when performance on a task requires conscious recollection of previous experience" (Eysenck, 1993, p. 76).

Explicit memory comes in either one of two forms, viz., semantic or episodic memory. Episodic memory is thought to be memory of personally experienced events that have happened to a person and the context in which they occurred, i.e. knowledge of one's personal history. Therefore, episodic memories are dated and have biographical reference. Semantic memory consists of the permanent, organised store of knowledge that we possess about language and about the world, i.e. one's general factual knowledge of concepts that one knows without necessarily knowing how or when these were first acquired. It is considered to be stable and encompasses knowledge of facts, rules, concepts and propositions. It is highly structured, which facilitates the great efficiency with which it operates, and it can thus be accessed rapidly and with relative ease. Semantic knowledge lacks specific information about time and place that typically characterise episodic memory. However, the two memories are not entirely separate from each other and are in fact highly related and inter-connected (Bourne et al., 1986; Eysenck, 1986, Wade & Tavris, 1993) (see Appendix A (1) for a summary illustration of LTM).

More information is encoded and stored in memory than can be retrieved and recalled. All the information that is in LTM is available, but only some is accessible. The strategies we employ in order to store information, i.e., attentive rehearsal and meaningful organisation, will influence the ease or otherwise with which we can later retrieve and recall information. Retrieval of information from memory is not random and is facilitated by retrieval cues which the person receives from the environment or which he/she produces. There are two retrieval theories, viz, search retrieval and reconstruction retrieval. The search retrieval involves searching for the specific bit of information through memory, based on that material's coded image. The reconstruction retrieval states that "the person does not have correlates (or copies) of previous experiences in his memory, but only traces or fragments of information which have previously been conceptually categorised" (Jordan & Jordan, 1989, p. 563). Thus, an image is reconstructed on the basis of the information that is currently available (Jordan & Jordan, 1989).

The storage capacity, memory and the ease with which we remember things can be improved through improving encoding strategies. One way is through the use of mnemonics, strategies which are products of conscious decisions to organize and chink information into larger and more meaningful units for the purpose of remembering it better. These strategies include, for instance, making up a little song to help you remember something. This gives you two ways of retrieving the information later, either remembering the words or remembering the tune and use that to reconstruct the words. Mnemonics are most useful when they impose meaning on a series of items that otherwise would have little or no meaning (Leahey & Harris, 1993). Forgetting, defined as "the inability to retrieve and recall stored information" (Jordan & Jordan, 1989, p.567), depends on many factors, including the way in which memory is measured. Many of the things we think we have forgotten were never stored in LTM in the first place; they were lost from STM before they could be transferred to the long-term store or the material was never encoded properly. This may have been due to inadequate elaborative rehearsal. There is a view that holds that once material is learned, it remains forever in one's memory, but for various reasons it may be difficult to retrieve it. There are a few theories of forgetting. The decay theory proposes that memory traces simply fade with time if they are not "called up" now and then. The decay of memory traces occurs especially if the material is not rehearsed. Thus information that is in constant and repeated use is kept active. The information that has not been used over a long period of time can be retrieved and recalled when the need for it arises. However, the mere passage of time does not seem to account well enough for forgetting in LTM (Jordan & Jordan, 1989; Wade & Tavris, 1993).

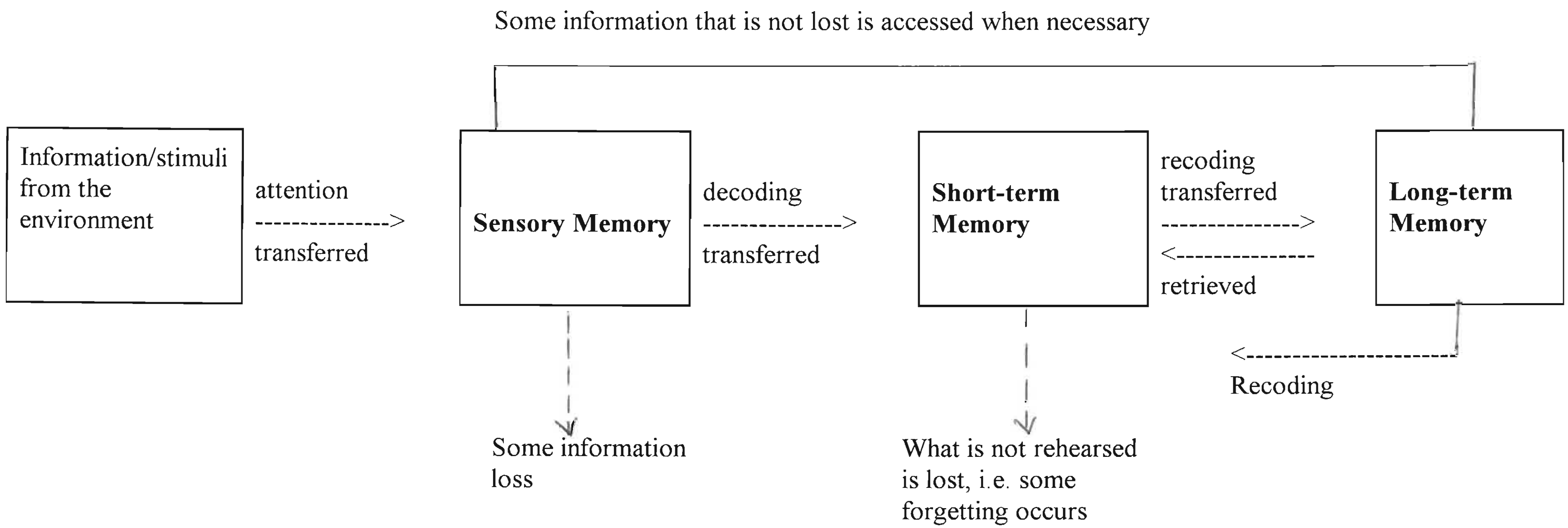
Interference theory proposes that memory for other material, or the performance of another task interferes with information that is already stored in memory and results in forgetting, i.e. similar items of information can interfere with each other in either storage or retrieval. This type of forgetting, which is divided into retroactive and proactive forgetting, is especially common when one has to recall isolated facts. Retroactive interference results from interference by information that occurs after an event, e.g., what a person learns later interferes with previously stored material. Proactive interference occurs when stored memory interferes with new events that have to be learned, i.e., our memory for what we are currently learning may be disrupted or interfered with by what we have previously learned and stored in memory (Reed, 1988; Jordan & Jordan, 1989; Malim, 1994). In summary, "when previous learning interferes with later learning and retention, this is known as proactive interference, and when later learning disrupts earlier learning we have retroactive interference" (Eysenck, 1993, p. 94). However, interference theory has very little to say about the internal processes that are actually involved in learning and memory as not all forgetting can be attributed to interference (Reed, 1988).

Another type of forgetting, which is a process of keeping dangerous, unpleasant or anxiety-provoking memories out of consciousness, often described in relation to the Freudian theory of repression, is known as motivated forgetting. It is claimed that this kind of forgetting can be “motivated” by the need to “hide” certain memories including embarrassment, guilt, shock and a desire to protect one’s pride (Eysenck, 1993; Wade & Tavris, 1993).

Cue-dependent forgetting, thought to be the most common type of forgetting, is the inability to retrieve information stored in memory because of insufficient internally or externally generated cues. Cue-dependent forgetting "means that the information is still stored in long-term memory, but there is no suitable retrieval cue to trigger off the memory" (Eysenck, 1993, p. 90). Retrieval cues are items of information that can help us find the specific information we are looking for. A person’s mental or physical state may act as a retrieval cue, evoking a state-dependent memory (Wade & Tavris, 1993). Yet another reason for forgetting may be due to the inability to find the appropriate memory trace rather than disappearance of the memory system itself. According to Eysenck (1993) trace-dependent forgetting "occurs because the memory trace has deteriorated or decayed, and has consequently been lost from the memory system" (p. 89). Forgetting does also occur in STM where it is mainly due to decay of memory, and strong memory is more likely to be retrieved than a weak memory over time. Forgetting in STM can also be due to interference which works in the same way as in LTM (Leahey & Harris, 1993).

Traditional measures of memory such as recall and recognition involve the use of direct instructions to retrieve information about specific experiences and are therefore measures of explicit memory (Eysenck, 1993). Recognition involves identifying information that was previously encountered while recall is the ability to retrieve and reproduce from memory previously encountered information (Wade & Tavris, 1993). Recognition also involves selecting from a number of alternatives the one answer that an individual thinks is correct, e.g., multiple choice questions. In recognition tests, the aim is to assess if people can choose, or recognise, previously learned items of information when they are presented along the incorrect items. Recall is one of the most used methods for the measurement of retention, and it consists of a person having to reproduce something he/she has been asked to learn. There are two types of recall, namely, verbatim recall and free recall. Verbatim recall refers to the reproduction of information in the form in which it was received while free recall is the recall of material in the form in which the person him/herself organised it during the learning process (Jordan & Jordan, 1989). For information to be retrieved from memory it must be activated. We can recognise many things that we cannot recall as recognition normally involves situations where more sources of activating memory are provided. Thus, people may recognise more words from a previously learned list/text than recall the same words (Jordan & Jordan, 1989; Anderson, 1990). The following, figure 2.1, gives an illustrated summary of the above-discussed approach (see also Appendix A (2)).

Figure 2.1: Summary of the information-processing approach



The Atkinson-Shiffrin, information-processing model has been developed and widely accepted for conceptualizing memory. Its major assumptions are that information is made available by the environment, then processed by a series of processing systems (e.g. attention, perception, STM). These processing systems transform or alter the information in various systematic ways (e.g. three connected lines are presented to our eyes, but we see a triangle). The next best-known approach to explaining memory is the levels-of-processing approach (Leahey & Harris,1993). The following section will be a brief discussion of this approach in order to aid us in conceptualizing memory.

In this theory, instead of discreet memory stores, Craik & Lockhart (1972, in Leahey & Harris, 1993) proposed that memory involves different levels of processing, with trace persistence being a function of how deeply the analysis has proceeded. For instance, processing speech only to a point of understanding what language the speaker is using would be a very shallow level of processing, while understanding the content thoroughly, including all the implications and nuances, would be a very deep level. Thus, deeper levels of processing involve processing meaning and are associated with more elaborate, longer lasting and stronger traces of memory (Eysenck, 1993; Leahey & Harris, 1993).

Other aspects of processing which play a part in determining LTM are elaboration and distinctiveness. Elaboration refers to the amount of knowledge that is processed at a particular level and its explanation overlaps with that of elaborative rehearsal in the information-processing approach, which is also known to improve memory. Retention in STM is the same as maintenance at a superficial level of encoding, while storage in LTM requires semantic encoding according to both theories. Memory traces which are distinctive or unique in some way are better remembered than those which are not distinctive (Gunenberg & Morris, 1978; Eysenck, 1993).

Familiar memory phenomena may be reinterpreted using a levels-of-processing framework. For example, forgetting due to what might be described as failure to transfer from working to long-term memory occurs because the analysis during comprehension has not proceeded to a sufficiently deep level. Rehearsal is reconceptualized as recirculation of the material, which may occur at any level by continued attention to the analysis of that particular level (Leahey & Harris, 1993).

However, this framework has been criticised due to the lack of an independent measure of depth of processing which is sometimes defined by what is remembered better and there does not seem to be any real consensus on what constitutes deep vs shallow processing. There is also evidence that under some circumstances we remember information from so-called shallow processing very well, such as jokes, lyrics and offhand comments in a lecture or conversation. Despite its definitional and precision problems, the metaphor of levels-of-processing continues to be very influential in offering alternative way to think about memory from the traditional multi store model (Leahey & Harris, 1993).

2.2.2 Thinking

This section will consider processes that are involved in dealing with information that has been, or is being attended to and that which is stored in memory. After information has been perceived, stored in memory, and recovered/retrieved, "it must be put to good use - for example, to make decisions or solve problems" (Reed, 1988, p. 6). These processes are executed basically through thinking. "During most of our waking hours, and even when we are asleep and dreaming, we are thinking; it is hard not to think" (Morgan, et al., 1981, p. 178).Thinking can be said to be a sort of information-processing which goes on during the period between a stimulus and the response to it, i.e. thinking is a set of cognitive processes which mediate between stimuli and responses. It is a mechanism that is involved in manipulating information, either collected through the senses or stored in memory in the form of concepts, images or propositions, from previous experience so as to be able to respond to the immediate situation. In other words, thinking consists of a cognitive rearrangement or manipulation of information from the environment and symbols stored in memory. It primarily utilises mental manoeuvring of internal representations of objects, activities and situations. When a person is thinking, he/she does not operate on all the information that is potentially available. Internal symbolic representations simplify and summarise material from the environment thus making thinking uncomplicated (Morgan, et al., 1981; Wade & Tavris, 1993).

Thinking is also defined as a type of knowing which involves formation and manipulation of symbolic representations. Symbolic representations essentially involve seeing something in the mind's eye. Such symbolic representations can be made in the presence of the relevant physical objects (e.g. chess pieces on the board), i.e. in respect of concrete things, and also in the absence of such physical objects, i.e. in terms of abstract ideas. Symbols represent something else, some events or items in the world, and by their very nature demand that they shall not be the things themselves (i.e. the things of which they are symbols). They are created freely and may not necessarily be accurate representations of reality. Symbols are also culturally transmitted and thus the meaning and application of symbols must be learnt. There are three types of symbolic representations/systems, viz, concepts, images and language. They are also known as people's symbolic "thinking apparatus" (Jordan & Jordan, 1989).

Concepts, one type of symbolic representation or unit of thought, are formed through direct contact with objects and situations. A concept is "a category used to class together objects, relations, activities, abstractions, or qualities that share common properties" (Wade & Tavris, 1993, p. 277). Concepts are ways of classifying the diverse elements in the world around us, they are convenient tools to use in thinking about the world and solving problems. They involve symbolic constructions that represent some common and general feature or features of objects or events. A concept is also defined as "a set of abstracted features which together form a category" (Jordaan & Jordaan, 1989, p. 413). Abstraction, in this situation, would involve the formation of a conceptual category by selecting certain features of an object, situation or idea and simultaneously disregarding other features, e.g. categorising a pear, apple and banana as fruit despite their different colours, shapes, etc. (Jordan & Jordaan, 1989).

In order to describe the way in which abstracted features are combined or placed in relationship to one another so as to form a category or concept, conceptual rules are used. These rules are applied spontaneously. The affirmation rule states that a category or concept is formed when one characteristic is present, i.e., the presence of one character "A" confirms the concept. This can also be applied in reverse where the absence of a certain character "A" confirms the presence or absence of another category. The conjunction rule is applied when a category is formed through the presence of two or more features/characteristics of objects or events together. The type and number of characteristics brought together to form a concept is subjective as they differ from one person to another, following our different direct or indirect experience. A concept can also be formed in accordance with either inclusive disjunction rules where for instance, both character "A" and "B" must be present or exclusive disjunction rules where either "A" or "B" must be present and not both (Morgan, et al., 1981) The conditional rule is applied "if character "A" is present then "B" must also be present in order to serve as an example of the concept" while the relationship rule is applied when "a concept is formed through the relationship existing between various characteristics, and not through grouping characteristics together" (Jordaan & Jordaan, 1989, p. 419).

Images refer to "people's ability to form symbolic representations of a thing and its sensory properties without actually having the thing with them" (Jordaan & Jordaan, 1989, p. 411). They also involve representations of abstract ideas which have no sensory properties. People vary in how much they use images in their thinking. Images are usually visualised as complete pictures in the head. Eidetic imagery, which is a rare form of imagery, involves the ability to recall a virtually photographic image of a previously formed percept. It is particularly common in young children and may not necessarily be an accurate representation (Jordan & Jordan, 1989).

For most people much of the time, thinking is a verbal matter. Language is "a system of symbols which we employ for making sense of our world, in a way which also makes sense for others" (Jordan & Jordan, 1989, p. 422). Verbal thinking uses symbols and rules of grammar to join words and phrases into sentences. The words, their meanings and the rules for merging them together are stored in semantic LTM. Communicating reveals the fact that we are thinking and what we are thinking about. Inner/implicit speech involves an internalisation of speech as an aid to ordering and clarifying our thoughts and feelings about something. It manifests itself in the thinking process and it also organises and directs thought. It is different from explicit use of language. Inner speech possibly plays a mediating role in our thought processes and it promotes effective thinking. It is however, not necessarily a prerequisite for effective thinking. It consists solely of key words, phrases and simple grammatical constructions. Language/linguistic competence can also promote effective thinking in three ways, viz, it helps in classifying and stabilising a person's perceptions which will facilitate meaning attributions in future perceptual situations; it makes it easier to apply and manipulate concepts; and to understand relationships between concepts. Thinking can take place without language. It may also involve "visual thinking" and/or spatial organization (Morgan, et al., 1981; Jordan & Jordan, 1989).

Not all mental processing is conscious. Thinking also involves mental processes that lie outside of our awareness. There are subconscious processes which consist of mental mechanisms occurring outside of conscious awareness but are accessible when necessary. These include all the automatic routines that we perform "without thinking" like typing or driving a car. There are also unconscious processes which remain outside of awareness but which nonetheless affect behaviour. These include for example, "intuition" and experiences where people have solutions "pop into their mind". Conscious thought is really only needed when we must make a deliberate choice or when events happen that cannot be handled automatically. Mindful conscious thinking involves reasoning, making rational decisions and solving problems creatively (Reed, 1988; Wade & Tavris, 1993; Malim, 1994).

There are two broad types of thinking viz, directed and undirected thinking. Undirected thinking is "the unsystematic and disorderly manipulation of symbols without a clearly defined goal" (Jordan & Jordan, 1989, p. 435). It involves an experience of a spontaneous flow of disconnected thoughts which are not directed towards any specific task or problem. It sometimes occurs in daydreaming and fantasising and is not always based on reality. It is often an essential component of directed thinking which is "the orderly and systematic manipulation of symbols in respect of a relatively clearly defined goal" (Jordan & Jordan, 1989, p. 435). Directed thinking is divided into reproductive and productive directed thinking. Reproductive thinking is a process whereby a mental task is executed by means of the reproduction of already acquired information. Productive thinking, on the other hand, involves the relatively orderly and systematic manipulation of symbols in a way which incorporates creation of information by discovering new relationships and by reorganising existing information in an original way. It includes processes such as problem-solving, reasoning, creativity and learning. Our ability to think effectively, reason and to solve problems increases as we accumulate experience (Jordan & Jordan, 1989).

STM combines information from both the environment and LTM whenever an individual tries to learn new information, make decisions, or solve problems. For instance, solving a problem involves the environmental stimulus, which is the question/problem at hand, and information from LTM, i.e., knowledge, rules or experience of solving the problem. Thus, thinking processes involve utilization of both incoming information and stored knowledge (Reed, 1986).

This section of cognitive processes will focus on problem-solving, creativity, reasoning and decision making, as well as learning. These thinking processes often have to work together so intimately that at times it becomes difficult to see them as separate processes. Most of the mental/cognitive processes are executed in order to solve existing or envisaged problems (Anderson, 1991).

(1) Problem-solving

Anderson (cited in Eysenck, 1993) defines thinking as "what happens in experience when an organism, human or animal, meets, recognises and solves a problem" (p. 131). Every-day-to-day activity involves solving problems and it would seem that all cognitive abilities are fundamentally problem solving in nature. "Problems bring all our cognitive abilities into play: internal representation, memory and reasoning" (Wade & Tavris, 1993, p. 290).A problem is defined as "any conflict or difference between one situation and another we wish to produce - our goal" (Morgan, et al., 1981, p. 182). Human thinking is always directed towards achieving goals and is motivated by the need to remove/reduce obstacles to those goals (Malim, 1994).

According to Polya (cited in Reed, 1988) solving a problem means "finding a way out of a difficulty, a way around an obstacle, attaining an aim that was not immediately understandable. Solving problems is the specific achievement of intelligence, and intelligence is the specific gift of mankind" (p. 249).

Thus, activities that are involved in problem-solving include, goal-directedness in that the individual is attempting to reach a desired end state/solution and this requires a sequence of mental processes which are cognitive in nature rather than automatic. Solving a problem requires reorganising the various features of the problem situation in an appropriate way. This may involve subgoal decomposition, i.e., a breakdown of the original goal into subgoals or subtasks and may entail transforming the original problem into another problem state (Eysenck, 1993).

An understanding of the problem is essential before it can be solved efficiently. This understanding involves coherence, i.e., all elements of the problem should fit together; correspondence between the way we represent the problem internally and the way it is really supposed to be; and the problem must be related to the background knowledge that we have. After understanding and representing a problem, a solution is arrived at through utilization of some strategies. Thus, problem-solving includes the original situation/problem, goal situation, and rules/strategies followed during working out of the problem. These strategies give direction to our thinking as they permit us to entertain only certain kinds of thoughts. Two major types of such strategies are algorithms and heuristics. The use of algorithms is characterised by an attempt to try out all possible solutions in a systematic way through an identification of a series of subgoals that, if correctly followed, will guarantee a solution to the problem. Some algorithms consist of a set of rules, e.g., arithmetic problems, while others require an exhaustive search through all possible solutions (Morgan, et al., 1981; Malim, 1994).

However, at times the solution does not follow an obvious sequence of steps but depends on certain rules of thumb known as heuristics. These are habitual strategies, usually based on past experience with problems. They guide problem-solving and suggest a course of action but do not necessarily guarantee an optimal solution. They are often used as shortcuts in solving complex problems. One heuristic strategy is "characterised by the fact that, on the basis of the available evidence, a person tries the most likely solution first" (Jordan & Jordan, 1989, p.

443), while another strategy involves looking at a large portion of the problem space at first, applying relevant information gained about the problem and then narrowing the search area until it becomes more manageable. This may include breaking down the problem into smaller subproblems, each of which is a little closer to the end goal. This process is also known as a means-end-analysis. Heuristics may also utilise a planning strategy that disregards some aspects of a problem to make it simpler. Planning strategies include analogies and isomorphs. With analogies an earlier problem/experience is used to compare with what needs to be solved currently; and problem isomorphs are sets of problems with the same structures and solutions, but with different details and contexts. There is also a backward search which involves starting at the goal and working backwards (Anderson, 1990; Wade & Tavris, 1993; Malim, 1994).

Problems/pitfalls in problem-solving may be due to the problem-solver's assumption of a fixed pattern of operations, or rigidity and reluctance to try out different approaches, and not shifting to an alternative pattern (i.e. operational/mental set). A set refers to "a state of perceptual readiness to assess a problem situation in a particular way, to adhere to that assessment and to perform, in accordance with that assessment, actions which do not lead to a solution, or which lead to cumbrous solutions (Jordan & Jordan, 1989, p.443). The person who has developed a mental set has a tendency to solve new problems using the same procedures that worked before. This may be problematic if the problem needs fresh insights and methods. One type of mental set, functional fixedness, is where the solver has a fixed notion of what each element in a problem is; or assuming that a problem has to be solved within the constraints of certain rules, although no such rules have been imposed (Wade & Tavris, 1993; Malim, 1994).

(2) Creative Thinking

Creativity, a process where people recognise that problems are often solvable in more ways than one, involves the ability to go beyond present knowledge, resist the persistence of search and produce something new. Bolton (cited in Jordan & Jordan, 1989) described creativity as follows:

> to say that a person has shown creative thought is to judge that which he has produced as original with respect to previous products and significance with regard to any future ones. This is true whether the product is a style of artistic expression, a theory in science, or an original way of solving a problem whose solution is already known. In all these cases the successful thinker breaks away from traditional modes of thought, in some instances to the extent of making necessary a revision of our most fundamental ideas (p. 489).

The creative process is in phases. The first phase, known as the orientation phase, is where the problem must be identified and defined properly. Next is the preparation phase which involves looking at and collecting all possible facts and material necessary for the problem. Then the incubation phase where a person may find him/herself unable to solve the problem and known methods not helping to provide a solution. The problem is put aside, either deliberately or involuntarily, but it is still at the person's unconscious mind. During this phase, some ideas which were interfering with the solution tend to fade and the creative thinker may have ideas or experiences that may provide clues to the solution. This phase can last for a few minutes to a period of years. The fourth phase, illumination, involves finding a sudden solution to the problem, i.e. an idea for the solution suddenly wells up into consciousness. The experience is often referred to as the "aha| experience" or insight experience. Next is the evaluation phase which involves checking/testing whether the solution is the correct one for the problem. The final stage, revision, involves having to go back to reassess the problem should the evaluation indicate the necessity. However, the creative process does not always occur according to the steps outlined and is not necessarily always based on problem-solving (Jordan & Jordan, 1989; Eysenck, 1993).

Creativity employs divergent and convergent thinking. Wade and Tavris (1993) defined divergent thinking as a "mental exploration of unusual or unconventional alternatives during problem-solving", and convergent thinking as "aimed at finding a single correct answer to a problem by applying knowledge and reasoning" (p. 294). Convergent thinking is concerned with a particular end result, i.e. usually the solution is the one that has been discovered by someone else. Convergent thinking, therefore, does not promote creativity. Divergent thinking occurs where there are several possible solutions but no obvious solution. It is regarded as an essential ingredient of creativity. It may also use convergent thinking to gather information and thoughts as building materials for ultimate creative achievement. Divergent thinking consists of three components, namely, idea fluency, flexibility and originality. Idea fluency means the number of ideas or thoughts one might have with regards to a certain problem. Flexibility would entail the ability to develop ideas over a wide range of possibilities and originality would be determined by how novel and unusual one's suggestions are (Morgan, et al., 1981; Jordan & Jordan, 1989). Several problems arise with creativity as "the challenge of measuring creativity is the paradox of trying to build a standard way (the test) of capturing a non-standard behavioural product (the created product)" (Petrosko 1978, cited in Jordan & Jordan, 1989, p. 493).

Although people might tend to assume that creativity depends on intelligence, the correlation between the two is rather low, especially for the higher intelligence level. Thus, it is the kind of thinking that a person does that makes for creativity. Daily use of intelligence indicates that the quality of a person's actions are being judged. It is used with regard to the speed with which a person performs a particular task requiring a particular mental ability and the degree of difficulty of the tasks a person can perform (Morgan, et al., 1981; Jordan & Jordan, 1989).

(3) Reasoning and Decision making

Reasoning is the mechanism by which people process information in order to reach conclusions, to evaluate and generate logical arguments. It requires drawing inferences from observations, facts or assumptions. Wade and Tavris (1993) stated that "in reasoning, we use concepts, propositions and images stored in memory to review the past, make judgements and solve problems" (p. 281). According to Jordan and Jordan (1989), "to reason is to make some kind of claim, assertion or statement with some kind of evidence (p. 447). Reasoning involves a proposition which consists of at least two statements. The one statement, known as the premise, is used to provide proof or supporting evidence for the other statement which is a conclusion. There are two types of reasoning, i.e., formal and informal reasoning. "In formal reasoning, we apply rules of logic to solve well-specified problems. In informal, or everyday, reasoning, we make plans, evaluate arguments, and choose options in order to solve problems that are less clearly defined" (Wade & Tavris, 1993, p. 283).

Three most basic types of formal reasoning, viz, deductive, inductive and abductive/analogical reasoning, involve drawing conclusions from a series of observations or premises. Deductive reasoning is concerned with the conclusions which follow necessarily if certain statements or premises are assumed to be true. It entails conditional reasoning, which is important in mathematics and science, and reasoning about quantifiers. "Typical tests that are used to measure reasoning include mathematical problems, ..." (Anderson 1991, p.440). Inductive reasoning, on the other hand, involves making a generalised conclusion from premises that refer to particular instances. It operates through the generation of hypotheses. Inductive reasoning is "reasoning in which the premises provide support for a certain conclusion, but it is still possible for the conclusion to be false" (Wade & Tavris, 1993, p. 281). Science depends a lot on inductive reasoning as it involves making careful observations and then drawing some conclusions which researchers think are probably true. The accuracy of inductive reasoning is dependent on engaging in rational and logical thinking. Analogical reasoning involves discovering a pattern, focuses on recurring patterns in the relationships between things, events or phenomena. It is highly suitable for the discovery of patterns in the way things are coherently related in a particular context. No attempt is make to make logical deductions or to point out causes (Reed, 1988; Jordan & Jordan, 1989).

However, thinking logically, i.e., either inductively, deductively or abductively does not solve all problems that one encounters in one's daily life. One also needs some real world knowledge and the ability to think dialectically. Dialectical reasoning involves critical thinking, looking at opposing facts or ideas and weighing or comparing them, with a view toward determining the truth or resolving differences. It includes looking at contradicting or competing facts, opinions or views in order to make a decision or choice. Making a decision often requires judgement of probability. Comparison is also involved as it considers the values of possible outcomes of the different choices, and the probabilities of those outcomes occurring Eysenck, 1993; Wade & Tavris, 1993).

Decision making involves how people make choices described in either a normative (prescriptive) or descriptive sense, i.e. how people make decisions or how they actually do make decisions. An assumption is usually made that our decisions, and perhaps all our thoughts are rational. A rational decision is one that is made from a set of alternatives that one has identified and been able to make some choice among, and is intended to maximise utility for the person. Utility is related to value, and is of particular consequence to each individual. A rational decision is the one that has been made from relevant information available to the person (Leahey & Harris, 1993).

Most decisions are risky as one can never be sure of the outcome of one's choice. There are different approaches that are usually used in the decision making process. The multi-attribute utility approach can be used when one out of a number of objects has to be chosen. It involves identification of different dimensions relevant to a situation, weighting them and making a final decision depending on the total utility (usefulness) of each. This approach places great demands on the processing system. The elimination-by-aspects theory is when the decision maker eliminates options by considering one relevant attribute after another, until there is only one option remaining, and it is often found in empirical decision making. Most often decision making utilises a combination of strategies and depends on the nature of the decision/problem, the personality of the decision-maker, as well as other characteristics of both the task and the person making the decision (Eysenck, 1993; Wade & Tavris, 1993).

(4) Learning and Comprehension

Learning involves the assimilation of new information into the existing store of information in LTM. To learn new information and enter it into LTM usually requires considerable effort and the use of deliberate learning strategies. These include rehearsal of material that we need to learn; coding which attempts to "place the information to be remembered in the context of additional, easily retrievable information such as mnemonic phrase or sentence"; or elaboration which involves formation of images/pictures of items that are to be learned, i.e. "creating visual images to remember verbal information". Serial learning is another type of learning which involves memorizing items in the sequence in which they occur. Verbal rehearsal is usually considered as a form of "rote learning" as it involves simply repeating information over and over again until we think we have learned it (Reed, 1988).

In most situations, to learn means that the person must be in some formal setting, e.g., a school in which he/she is expected to acquire a certain amount of knowledge/information and to master certain skills. However, learning does not only involve the inculcation of formal knowledge, but also the inculcation of information apropos of social and moral behaviour. Learning thus comprises behaviour changes initiated by formal learning situations and by life experiences. There are five types of learning, viz, classical and operant conditioning - both classed as association learning, social learning, moral learning and cognitive learning. It should be noted that these types of learning are not mutually exclusive, i.e. particular characteristics of one type of learning can be common to other types of learning. Learning can also be classified in terms of the degree of understanding the learner must have of what is being learnt, and the level of awareness on which learning takes place (Jordaan & Jordaan, 1989).

Cognitive learning is learning with understanding and insight. Cognitive learning involves attention which is focused on the application of symbolic thinking. Learning has taken place when a person has acquired knowledge of something that was previously unknown to him, or when he can do something he previously could not do. The learning situations and learning material are perceptually organised, concepts and rules are formulated and information that is obtained is reorganised into new significant patterns (Jordaan & Jordaan, 1989).

There are three basic things which are learnt during cognitive learning. They are mutually related and are, namely, verbal skills, intellectual skill and perceptual-motor skills. Verbal skills refer to "the ability to understand verbal messages, and to formulate one's own understandable verbal messages either implicitly (inner speech) or explicitly (speaking and writing)" (Jordaan & Jordaan, 1989, p. 528). Verbal information is acquired in the form of facts, definitions, descriptions, principles and generalizations. Learning verbal skills initially depends on the ability to associate things, then to discriminate between the different sounds and then associate the different sounds with the objects they refer to. The learner will then be able to form, through associations, symbolic representations of objects and actions. Development of verbal skill requires learning the rules by which the words of a language are combined in order to communicate comprehensibly, i.e. learning the grammar of the language (Jordaan & Jordaan, 1989).

As the learner's verbal information develops, it is applied with increasing skill. The ability to apply information gained is essentially an intellectual skill, which refers to a person's knowing how. Intellectual skills are in a form of a hierarchy according to the complexity of thought required. Discrimination, the simplest intellectual skill, is the ability to see the differences between objects, situations and symbols. It enables people to learn concepts. Not only concepts are learned, but also the rules which express, in the form of a statement, the relationship between two or more concepts. Then complex rules can be formed by combining simpler rules. A higher-order rule is a statement which expresses the relationship between different rules (Jordaan & Jordaan, 1989).

Sensory-motor/perceptual motor skill refer to "a skill in which muscle movement (motor) plays a prominent part but always under perceptual control, i.e. the muscle movement is dependent on what and how effectively the person perceives " (Jordaan & Jordaan, 1989, p. 538). Learning the process for most perceptual motor skills consists of three arbitrary phases. The cognitive phase, often referred to as the development of a verbal plan, is the phase where a person sets out to understand the learning task by analysing it and by verbalizing what is expected of him. The verbal plan becomes an automatic "muscle plan" with time and with increasing skill. The movements that are learned during the cognitive phase are executed as discrete or relatively independent units. During the associative phase, there is increasing compatibility of what a person perceives with what he/she does. The execution of the actions gains increasing smoothness and co-ordination. Through repeated practice, the movements become so automatic that there are fewer and fewer mistakes. The autonomous phase, which is the final phase, is characterised by precision and efficiency in the performance of a task. The movements or different components of a task have been synchronised into a continuos and flowing pattern of action. The person is hardly aware of the action and is less susceptible to distracting factors (Jordaan & Jordaan, 1989).

Perception of speech and processing of that information depends on, and is markedly affected by the context. Meaning is extracted from speech, by relating the stimulus that is presented to information already stored in long-term memory. Comprehending speech and reading involves taking into account and processing the grammatical structure and the meaning of what is presented (Eysenck, 1993). Comprehension involves the use of prior knowledge to understand new ideas, particularly abstract ideas. Prior knowledge has a great impact on the comprehension and retrieval/recall of information. Comprehension is determined by what a person already knows as well as by the organization of perceived new ideas in text. Although background knowledge usually makes comprehension and recall easier, it can also be the source of errors and confusion. Comprehension is easiest when the ideas can be related to ideas that are still available in memory. If no relations are found, the new information will be stored separately (Reed, 1988).

2.2.3 Attention

Attention appears to be central to all forms of information processing and analysis. It is important in limiting the amount and kind of information that can be recognised at one time, and in selecting the amount and type of material that can be utilized or entered into memory. Attention is the core process during perception of information, encoding, storage and retrieval. Attention and pattern recognition/perception occur to help identify and select information for further processing. Theses processes draw from information that is currently being presented and that which is further along the line of information-processing, i.e. in LTM. In addition, learning new material, remembering and forgetting, i.e., memory, and how effectively we think and deal with our everyday problems, are strongly influenced by our perception and how well we attend to information that is either from the environment or from memory (Reed, 1988; Jordan & Jordan, 1989; Malim, 1994).

As human beings are constantly bombarded by stimuli from the environment, attention, concentration and vigilance play an important role especially in the selection of information that has to be processed for transfer and storage in memory. "Attention is the term given to the process that select certain inputs for inclusion in the focus of experience" (Morgan et al., 1981, p.313). It determines what we are experiencing or perceiving at a given time. First evidence of attention is seen at the level of sensory perception and sensory memory. While sensory memory is capable of registering vast amounts of information from the environment, only those events that are at the focus of attention are registered with more clarity. More information is available to sensory memory than can be analysed and processed and as we cannot process all the information in our sensory channels, we filter out irrelevant information. For information to be retained it must be attended to and transformed into some permanent form. Attention plays a vital role in perception and selection of sensory information for further processing. It is also important in concept formation, problem solving and decision making. Sometimes attention is used synonymously with concentration, and it refers to our ability to select a piece of incoming stimulation for further analysis (Reed, 1988; Anderson, 1990; Eysenck, 1993).

Baddeley (1995) defined attention as "the control of information within the organism, and may be divided into components including the capacity to select a stimulus or response, to divide attention, to switch attention and to sustain attention over time" (p. 14). It was also defined by James (in Eysenck, 1993) as

> ... taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalisation and concentration of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others (p.42).

Our attention is directed by either internal factors such as motives, needs and/or interest, or external factors that include the intensity and size of the information/material that is perceived, the contrast and novelty, repetition and/or movement. Attention can either be focused/selective or divided. Focused attention involves processing and responding to only one out of two or more stimuli presented at the same time. Broadbent's filter theory suggested that information from all the sensory channels presented at any given time enters a sensory buffer, which was identified as a bottle-neck and located at the early stage of processing. It is at this buffer that one of the inputs is selected on the basis of its physical characteristics, which include their pitch, loudness and spatial position, for further processing by being allowed to pass through a filter. This filter is designed to prevent the information-processing system from being overloaded as we have only a limited capacity to process information. The inputs not initially selected remain in the sensory buffer for a short time, and if they are not processed they decay rapidly. The message/information that is not at the focus of attention is rejected by the filter. Broadbent's filter theory suggested that focused attention especially in the auditory modality, is an efficient process. When different stimuli are received, either from the internal or external environment, there will be attended information that is processed in greater detail than the unattended information (Eysenck, 1993). While the meaning of the unattended message may not be processed, it is not completely discarded as some of its characteristics are noticed (Anderson, 1990).

However, Treisman (1964, in Eysenck, 1993) proposed an attenuation theory, in which she stated that the unattended message is processed to a much greater extent than Broadbent allows for. Her theory assumes that selective attention is not as efficient in filtering as Broadbent asserts. Treisman further stated that it will usually be the physical characteristics of the unattended inputs which are remembered rather than their meaning. A more radical departure from Broadbent's theory was proposed by Deutsch and Deutsch (1963, in Eysenck, 1993) who claimed that all inputs are fully analysed before any selection occurs. The filter in this case is placed later in the information-processing system, immediately before a response is made. A reasonable compromise position was adapted by Johnston and Heinz (1978, in Eysenck, 1993) who stated that selection can occur at several different stages in processing depending on the demands on the processing capacity by the current task.

Divided attention involves attending to and processing all the two or more stimuli presented at the same time. Due to the limited resources that are available for processing, attending to two or more stimuli at the same time can lower performance. Performance is also dependent on the type of stimuli or tasks at hand. Task difficulty, i.e., " ... the demands placed by the task on the resources of central capacity" (Eysenck, 1993, p.55), may have an effect on attention as complex tasks impose heavy demands on the central resources. The more frequently and extensively a task is practised, the less attention it requires and it will be undertaken more efficiently. This highly practised task will now become an automatic process, i.e., it will occur without intention, without conscious awareness and can eventually be performed without interfering with other cognitive activities (Reed, 1988; Anderson, 1990; Eysenck, 1993). It appears that it is difficult to carry out similar tasks at the same time. Similarity of a task may mean similarity of the stimuli in the presented tasks, similarity of the internal operations involved or similarity of responses. The more similar the stimuli are, the more interference and confusion will occur, which may affect the simplicity or difficulty of a task (Eysenck, 1993).

Attentional failures are involved in absent-mindedness and action slips - i.e. performance of unintended actions. Vigilance, which is also known as sustained attention, is in terms of people's ability to pay continuous attention to tasks which are monotonous, long-lasting and involve the detection of signals. Research by Nachreiner (cited in Eysenck, 1993) has shown that performance on vigilance tasks is higher with higher levels of motivation and arousal with the more aroused and alert individual being more attentive. There is usually a progressive deterioration of performance over time, known as the performance/vigilance decrement which occurs particularly with attending to tasks that are not interesting, monotonous, and/or have to be attended to for long periods of time. Performance on such a task may also be dependent on factors such as the individual's physiological state and personality, the time of the day and other external factors (Eysenck, 1993; Malim, 1994).

Besides attending to a stimulus, we must start to analyse and identify it in order to begin processing it. Pattern recognition, which is a basic function in human information processing, concerns the question of how we recognise environmental stimuli as exemplars of concepts already in memory. It is a process of attaching meaning to information that we process. Pattern recognition is a general phenomenon that cuts across all sensory modalities, including everything from how we recognise a certain letter we read as a T, or understand someone's speech as containing the sound 'p', recognise Rover as a dog or recognise a certain social interchange (Leahey & Harris, 1993).

Although these cognitive skills are discussed separately, they are interdependent and work together. Thinking processes depend on information from the environment and that stored in memory. There are interactions among perception, attention, memory and thinking skills. Processes like problem solving or learning for instance, involve processing and manipulating information that is either perceived from the environment or is stored in memory (Reed, 1988).

2.3 IRON DEFICIENCY

This section will discuss the different iron levels and their cut-off points. Iron levels, in this study will be, viz. iron replete/sufficient, mild iron deficiency, moderate iron deficiency and severe iron deficiency. Iron status/level is usually discussed in relation to the specific iron compartments, i.e. storage, transport and red cell iron. "A deficiency in storage iron occurs first, followed by deficits in the iron transport and erythroid compartment" (Cook et al., 1992, p. 192). These specific iron compartments are discussed below with an indication of the cut-off points..

2.3.1 Iron levels/status

(1) Iron storage

Iron is first detected in the storage compartment. Serum ferritin is what can be detected and provides a precise quantitative measure of the total iron in the storage compartment. Ferritin is the storage protein for iron and is found in large quantities in iron storage tissues such as bone marrow, the liver and the spleen, but only minute quantities in human serum, normally between 12 and 300 micrograms/litre. Thus, any amount less than 12 micrograms/litre indicates a depletion of iron stores (Prasad & Prasad, 1991; Cook et al., 1992).

Serum ferritin measures iron reserves and is therefore a better index of iron sufficiency than iron deficiency. Once iron stores are depleted as indicated by a fall in serum ferritin below 12 micrograms/litre, the measurement gives no indication of the severity of iron deficiency. It is therefore a " ... less reliable indicator of iron status in populations with a high prevalence of iron deficiency anaemia" (Cook et al. 1992, p. 194). It is most helpful when coupled with measurements which reflect advanced degrees of iron deficiency. Another drawback with serum ferritin is that certain disorders such as chronic inflammation, malignancy or liver disease are associated with a disproportionate rise in values relative to iron stores. Although these conditions are relatively uncommon they cannot be totally ignored. In areas where infections are common, the use of ferritin is problematic (Cook et al., 1992).

(2) Iron transport

Functional iron is transported from the storage compartment bound to proteins such as ferritin, transferrin or hemoseridin. Once iron stores are depleted, any further decline in body iron is accompanied by a reduction in the concentration of plasma iron. The most informative expression of plasma transport is the serum iron or plasma iron expressed as a percentage of the total iron binding capacity (TIBC), referred to as transferrin saturation (SAT). A reduction in transferrin saturation below to 15% and below, for children who are 5-10 years of age, is a reliable index of an undersupply of iron. Transferrin saturation values are actually more useful in screening for iron overload than for iron deficiency. The ease of determination of transferrin saturation levels with automated chemistry systems and the long experience with its interpretation ensure its continued use in population studies to identify both iron deficiency and iron excess (Cook et al., 1992; WHO report, 1994). The main limitation of transferrin saturation is its relation with wide diurnal variations in plasma iron concentration. Concentrations in healthy subjects may vary by as much as 100% during a 24-hour interval and can also be affected by infection or inflammatory processes (Cook et al., 1992; WHO report, 1994).

(3) Red cell parameters

Included amongst the red cell indices are the mean corpuscular volume (MCV) red cell distribution width (RDW), haemoglobin (Hb) or haematocrit (Hct) and free erythrocyte protoporphyrin (EP), which are considered to be the most sensitive indices of iron deficiency. The commonest red cell index used is haemoglobin (Hb) due to its ease of measurement (WHO report, 1994). The largest proportion, approximately two-thirds, of body iron is contained in blood and exists as haemoglobin (70%). Laboratory measurements to detect evidence of reduced haemoglobin formation in circulating red cells are important in the detection of overt iron deficiency. The reduction of circulating red cells due to impaired haemoglobin formation is known as anaemia and can be caused by various factors which include iron deficiency, hereditary blood disorders, protein calorie malnutrition and chronic infection or inflammation (Martin, 1980).This indicates the problem of diagnosing whether anaemia is due to iron deficiency or other difficulties. However, "... in nutritional surveys one can usually assume that iron deficiency is the cause of impaired haemoglobin formation", and consequently, the cause of anaemia (Cook et al., 1992, p. 196). This is what is adopted and is the assumption on which this study is based.

Haemoglobin or haematocrit determinants have been used longer and more widely as indicators of iron status than any other iron parameter (Cook et al., 1992; WHO report, 1994). The haemoglobin concentration defines a more advanced stage of iron deficiency and provides an indication of severity of iron deficiency once anaemia has developed. Thus any assessment of iron status must include haemoglobin concentration as it is the simplest and least expensive assay available for detecting iron deficiency. A major limitation of haemoglobin determinants is the lack of both sensitivity and specificity as anaemia is not a specific finding for iron deficiency. Therefore, haemoglobin cannot be solely relied on as an indicator of iron status, it has to be combined with other measures such as serum ferritin and/or transferrin saturation (Cook et al., 1992; WHO report, 1994).

Thus, following a brief discussion of the different iron compartments, a definition of the specific iron levels will now be given. The terms "*iron replete*" or "*iron sufficient*" have been used to denote a normal total body iron content. "*Iron deplete*" or "*mild iron deficiency*" designates a decrease in body storage iron without any effect on haemoglobin iron or iron in other functional iron compounds. This is usually reflected by a decrease in serum ferritin (i.e. a serum ferritin value that is 18-24 micrograms/litre) without changes in other measures of iron status. "*Iron deficiency without anaemia*" or "*moderate iron deficiency*" is designated by a low serum ferritin in addition to a reduction in the transferrin saturation (indicated by serum ferritin values of 12-18 micrograms/litre and transferrin saturation values of 15% or less). *"Severe iron deficiency/iron deficiency anaemia"* results from a further diminution in total body iron where the haemoglobin is below reference limits, serum ferritin and transferrin saturation are decreased, free erythrocyte protoporphyrin is elevated and mean corpuscular volume is decreased (indicated by serum ferritin of 12 micrograms/litre or less, saturation transferrin of 15% or less, and haemoglobin values of 110 g/L or less) (Lozoff & Brittenham, 1987; Lozoff, 1989; Cook et al., 1992; WHO report, 1994). For classification of Iron levels the following table 2.1 is given.

Table 2.1: Summary of Classification Levels for Iron (according to WHO/UNICEF/UNU report, 1994, June, p. 47):

	Iron stores (serum ferritin ug/L)	Transport iron (SAT, EP and TR)	Functional iron (Hb g/L) and MCV
Iron overload /excess	elevated	elevated	normal
Normal (iron replete)	normal	normal	normal
Mild iron deficiency (depleted stores	low (18-24)	normal	normal
Moderate iron deficiency (iron deficiency without anaemia)	low (12-18)	low: SAT< 16 % EP < 80 ug/dL RBC TR < 8.5 mg/L	normal
Severe iron deficiency/anaemia - mild - moderate - severe	very low (<12)	low: SAT < 16 % EP < 80ug/dL RBC TR < 8.5 ug/L	low to very low 110-120 80-110 <80

KEY: SAT = transferrin saturation
Hb = haemoglobin

PLEASE NOTE: only serum ferritin, SAT and Hb are used and discussed in this study

2.3.2 Assessment of iron deficiency

Due to economic constraints/lack of facilities or in cases of large scale measurements, some screening programmes may have to rely on only one or perhaps two laboratory measurements to identify iron deficiency. In cases where only a single measure is used, the choice depends on the prevalence of iron deficiency in the targeted population. If the prevalence is low, an early index of iron lack such as the serum ferritin is needed, whereas if anaemia is highly prevalent, the haemoglobin concentration is most informative. If both measurements are normal, iron deficiency may be confidently excluded, whereas if both values are abnormal, iron deficiency is identified unequivocally. A low ferritin and normal haemoglobin concentration indicate storage depletion whereas a low haemoglobin and normal serum ferritin warrant further haematologic evaluation (Cook et al., 1992).

A more effective method would be to use various combinations of measurements to enhance the specificity of prevalence estimates or to define varying stages of iron lack. "The measurement of haemoglobin, serum ferritin, serum iron and transferrin enables the detailed individual characterization of iron status to be made" (WHO report, p. 30). "In general, there is not one single perfect test to diagnose iron deficiency, nor is the use of multiple tests a practical way to overcome the limitation of single tests" (ibid., p. 45). Multiple indicators increase the sensitivity of the diagnosis and reduce the risk of sample heterogeneity in studies of functional effects. Defining iron status by no less than two indicators seems to be generally used (Pollitt, 1993).

Although it is ideal to define iron deficiency with as many parameters as possible, it should be noted that for population based applications using Hb and either one of MCV/ serum ferritin/SAT/EP/transferrin receptors to assess iron status is adequate (Cook et al., 1992). For this study, only haemoglobin and transferrin saturation were analysed. Serum ferritin was left out "because serum ferritin is easily elevated in response to any infectious or inflammatory process, a serum ferritin in the normal range cannot always be taken to indicate iron sufficiency without some certainty that the individual is free from any infectious or inflammatory condition. For this reason, in areas where infections are common, the use of serum ferritin is problematic" (WHO/UNICEF/UNU report, 1994, p. 45). Furthermore, "the serum ferritin concentration is a less useful guide to iron deficiency in children than in adults partly because of the low concentration found in children over 6 months of age" (Chapman & Hall, 1995, p.32). As a result, the following, Table 2.2, shows the classification system decided upon for this study. See also Appendix B for a summary review of different studies which also guided this classification.

Table 2.2: The Classification System for Iron Levels Used in the Current Study

Iron Level	**Transferrin saturation** (SAT %)	**Haemoglobin** (Hb g/l)
Iron sufficiency	> 16%	> 120 g/l
Iron deficiency without anaemia (moderate iron deficiency)	<16 %	100<Hb<120 g/l
Iron deficiency with anaemia (severe iron deficiency)	< 16 %	< 100 g/l

The prevalence of iron deficiency without anaemia is estimated to be about 2.5 times that of iron deficiency with anaemia. Iron deficiency without anaemia is common in developing countries, where it is known to have adverse functional consequences, and "impairment in psychomotor development and cognitive function are among the most important deficits associated with iron deficiency" (Cook et al., 1992, p. 190). Iron deficiency anaemia reflects the severe end of the spectrum of iron deficiency (Cook et al., 1992). Iron deficiency anaemia is probably the most common and widespread nutritional disorder in the world. It is estimated that about half (46-51%) of the children and women, and a quarter of the men in developing countries are iron deficient. Anaemia severe enough to produce symptoms such as weakness, shortness of breath and dizziness is uncommon even in developing countries (Lozoff & Brittenham, 1987; Simeon & Grantham-McGregor, 1990; Prasad & Prasad, 1991; Levinger, 1992; WHO report, 1994).

Although an epidemiological picture of the prevalence of iron deficiency in women is available, no such information is available on other groups. In Southern Africa, about 35% of pregnant women have been found to be iron deficient. It was stated that where prevalence rates are not available for other age groups, the criteria is usually similar or even higher among preschool-age children compared to that of pregnant women. School-age children do not need as much iron as preschool children and their prevalence can be estimated by comparing that to that of non-pregnant women, which is about 30% in Southern Africa. "In general, adequate epidemiologic studies in countries are rather seldom available" (WHO report, 1994, p. 24). Onwukeme and Olomu (1991) stated that although haematological values in adult Africans and neonates have been studied extensively, little information is available on children of ages of 6 months to 12 years who constitute a large proportion of the population. There is "therefore a great deal to be done ... to complete the epidemiological picture" (WHO report, 1994, p. 20).

2.4 IRON DEFICIENCY: SOME RISK FACTORS AND ITS EFFECTS ON COGNITIVE FUNCTIONS

Literature on risk factors for psychological development indicates that growing up in poverty is the single most powerful influence on psychological, educational and physical development. Dawes and Donald (1994) stated that the majority of South African children can be considered to be grossly disadvantaged and at risk for less than optimal psychological development. This is mainly due to the struggle to obtain the essentials of life, -such as food and shelter, and the structurally generated conditions of disadvantaged communities which include overcrowding, lack of basic services such as proper sanitation and electricity, lack of clean water and inadequate health and educational facilities (Simeon & Grantham-McGregor, 1990; Dawes & Donald, 1994; Levinger, 1994). It is estimated that in South Africa about "50% of all households lack the means of providing sufficient food to secure healthy families. The large majority of food insecure households are African and Coloured, and they are most likely to be living in rural areas, poor urban communities and informal settlements" (UNICEF: SA, p. 6). These conditions result in problems that include malnutrition and micronutrient deficiencies.

Such disadvantaged environments, like lack of clean water and proper sanitation, result in many different problems including parasite infections which further complicate the problem of micronutrient deficiencies, particularly iron deficiency. Stephenson and Holland (1987) further stated that "... the poorest members of society, who most need their physical and mental health to ensure their survival and ability to cope with scarce resources, are the most likely to be debilitated from both malnutrition and helminthiases". Iron deficiency is known to result in lethargy, apathy, poor concentration, poor learning, and increased susceptibility to infection (Nokes et al. 1992; Boivin, Giordani, Ndanga, Maky, Manzeki, Ngunu & Muamba, 1993). Helminth infections, chronic malnutrition and micronutrient deficiencies with their resultant malaise and lethargy, other opportunistic illnesses, and socioeconomic environmental impoverishment, can act together to seriously impair a child's intellectual development (Boivin et al. 1993).

Further complicating the problems encountered is the fact that "vast numbers of school-aged children in developing countries face major health and nutrition problems that adversely affect their ability to take advantage of the limited educational opportunities available to them" (Levinger, 1994, p. 20). Such health problems include, amongst others, micronutrient deficiency disorders which impede a child's propensity and ability to interact with and take optimal advantage of learning resources and opportunities (Levinger, 1994-Jan). Thus, there appears to be a multitude of risk factors that may have an effect on the physical, psychological and social development of children in developing countries. As a result it becomes extremely difficult to unravel the role of individual insults, the effects of which may vary in different circumstances (Grantham-McGregor, 1994).

Although the exact mechanism through iron deficiency affects cognitive skills is not known, there are several postulations. One of the ways of understanding the mechanisms through which iron affects cognitive skills is through the Horowitz' structural-behavioural model which incorporates the developmental theories of both the organismic and the behaviouristic point of view. The model explains development as influenced by genetic-biological factors, the environment and its impact on individuals and learning from the social and cultural milieu. It was originally proposed by Gowen, then redefined by Horowitz by "taking the most robust features of developmental theories" (Horowitz, 1989, p. 590). It postulates that "the adequacy of development of an individual in any particular behaviour domain is the result of individual organismic factors acting in relation to the aspects of the environment that prove to be facilitative or nonfacilitative of development" (Horowitz, 1989, p. 591).

Horowitz (1989) acknowledges the complexity of development and thus highlights the fact that it is only by means of an interdisciplinary approach that the process of development can be fully understood. People have individual differences that can either be genetic or constitutional, i.e. they have their origins in the cumulative effects of both biological and environmental variables.

Underlying the structural-behavioural model is a premise of risk factors. Risk factors may be thought of as social and/or biological. Social risk factors are more likely to affect learning and information processing than the basic structural parameters of the behavioural domain while the biological risk factors have the capability of affecting structural characteristics as well as the process of learning and information processing. Horowitz (1989), stated that

> When biological risk factors are present for sufficient duration or are in their few occurrences sufficiently potent to inflict critical physical damage on the organism, inadequate information-processing and learning behaviours can, over time, cumulate to become inadequate information processing and learning abilities (p.594).

This perspective thus permits us to ask questions about the effect of some exposure to biological risk factors like micronutrient deficiencies and whether the effects are transient or permanent.

Both Horowitz (1989) and Baddeley (1995) stated that attentional behaviour is of particular importance to information processing in the early years and is more susceptible to the effects of variations in iron levels. Some children are more vulnerable to the effects of iron deficiency, for instance, due to compensatory environmental and/or organismic variables. Thus, in some children, the iron deficiency will be a functionally lesser risk factor than for other children.

Baddeley (1995) further claimed that the effect of iron deficiency is also perceptual or motor impairment, which can be illustrated by measures of visual discrimination and motor skill. Memory is also adversely affected. Memory can be divided into three stages, viz. encoding, storage and retrieval and "the sensitivity of a given test may depend on the extent to which it makes demands on each of these stages" (Baddeley, 1995, p. 14). The effect on memory includes working memory and episodic memory which encompasses the capacity to store and retrieve specific experiences.

The next section will focus on the effects of iron deficiency on cognitive functioning as indicated by research studies.

2.5 EFFECTS OF IRON DEFICIENCY ON COGNITIVE FUNCTION

Lozoff (1989) stated that "until recently it was often presumed that iron deficiency anaemia had few deleterious effects unless severe enough to compromise cardiovascular function. However, evidence that iron has important behavioral effects has steadily accumulated during the past decade". This is important as iron deficiency anaemia is amongst the most common nutritional deficiencies in developing countries (Lozoff, 1989; Levinger, 1994). "Approximately 1.3 billion people are estimated to suffer from iron deficiency of whom 210 million are school-aged children ... The highest levels of anaemia among school children are estimated to be in South Asia and Africa, where the prevalence rate extends to about half the cohort" (Israel & Hornsby, cited in Levinger, 1994). However, as the prevalence rates vary considerably within countries and regions as well as by gender, it becomes important to follow the basic guidelines and do more research in each region (Levinger, 1994). Research on the effects of malnutrition and micronutrient deficiencies is important because their prevalence among children of school age and their effects on school learning variables have been documented (Pollitt, 1990).

Studies of infants and preschoolers with iron deficiency, reported lower scores for iron-deficient subjects on tests of mental and motor development. Increased irritability, fearfulness, inattentiveness, a low level of engagement in their immediate environment and decreased social responsiveness was also exhibited. Motivation, arousal, ability to attend to stimuli and concentrate and vigilance, which were found to be affected, collectively impinge upon an individual's learning receptiveness. Learning receptiveness, in turn affects aptitude; -i.e. the time it takes to learn or master a particular task; which is frequently associated with IQ.

Higher cognitive skills such as conceptual learning were also found to be impaired (Pollitt, 1990; Levinger, 1994).

According to Wharton (1995), research studies from countries, such as USA, Java, Indonesia, Costa Rica, Birmingham and Egypt, demonstrated that iron deficient anaemic infants, aged 6 to 24 months, performed significantly lower on the Mental Developmental Index (MDI) of the Bayley Scales than controls without the iron deficiency. Assessments of cognitive function and scholastic performance have indicated that iron deficiency is a problem in older children too. Some studies have shown a positive response to iron supplementation over short periods of time, within 14 days in one study, which was well before any correction in haemoglobin (Wharton, 1995). "It is presumed that this response is due to at least partial replenishment of iron involved in metabolic processes in the brain leading to changes in behaviour and attentiveness" (ibid., 1995, p. 19). This could also be due to the fact that haemoglobin is not necessarily as a result of iron deficiency or the adverse effects may have been due to other milder forms of iron deficiency. However, a study on Chilean toddlers did not show any adverse effects of iron deficiency without anaemia on development. This Chilean study, conducted by Walter et al., (cited in Lozoff, 1989) indicated that iron deficiency anaemic children had significantly lower mental and motor scores than either iron-deficient nonanaemic infants or the iron-replete controls. Their prospective study indicated that infants with more chronic and severe iron deficiency achieved less well than those with acute anaemia. It was thus concluded "that iron deficiency severe enough to cause anaemia is associated with impaired performance on developmental tests in infancy" (Lozoff, 1989, p. 1056). Thus, it would appear that the severity, chronicity as well as the duration of the iron deficiency is important in determining the effect it has on physical and mental development (Wharton, 1995).

The same results were indicated by Lozoff et al. (cited in Lozoff, 1989) on infants in Costa Rica after conducting a study to indicate at what level iron deficiency affected development. Their results suggested that infants with iron depletion/deficiency with normal Hb levels did not receive lower mental or developmental test scores (as measured by the Bayley Scales of

Infant Development). Infants with moderate iron deficiency had lower mental and motor test scores than their control, and infants with mild anaemia received lower motor test scores but not mental scores.

Lozoff (1989) stated that significant cognitive or motor deficits have not yet been found among nonanaemic infants. Some investigators assumed that disturbances in affect, arousal or attentiveness were important determinants of infants' poorer developmental test performance. Alterations that were also observed included " ... solemnity, fearfulness, irritability, lack of persistence, short attention span, tiredness, tension, hesitation ..." (Lozoff, 1989, p. 1057), all of which seemed to be closely related to poor development and lower performance. Studies conducted on preschool-aged children in the USA, Guatemala and Java have detected changes in attentional processes and in oddity and discrimination learning. Research in India has noted substantial improvements of iron-treated children on a battery designed to measure cognitive function and it included "visual recall, (a test of memorizing capacity), digit span (a test of attention, short-term auditory memory and auditory sequencing), mazes (a test of discrimination and perception) and a clerical task (a test of discrimination and perception)" (Lozoff, 1989, p. 1062). However, there are still important issues that need to be resolved, such as what are the specific cognitive functions that may be impaired by iron deficiency, and what are the functional significance of behavioral alterations due to iron lack (Lozoff, 1989).

Studies on 5 and 5.5 year old children who had been anaemic as infants indicated that despite the fact that the anaemia had been corrected when they were infants they still scored lower on IQ tests (WPPSI - markedly in PIQ), quantitative concepts and visual matching (Woodcock-Johnson Preschool Scale), and gross motor skills (Bruininks-Oseretsky motor test). These results suggest possible lasting ill-effects of iron deficiency anaemia (Lozoff, 1989).

According to Lozoff and Brittenham (1987) although a lot of research has been conducted on infants, on the effects of iron deficiency, very little was done on age groups after infancy. A 1982 study by Seshadri and co-workers in India, on 5-6 year old boys with low Hb levels, showed a significant improvement of total IQ scores after 60 days of oral iron-folic acid supplementation. However, as there was no nonanaemic group for comparison, the anaemia may have been due to a variety of factors and inclusion of folic acid in the treatment may have been a confounder.

Pollitt and associates (cited in Lozoff & Brittenham, 1987), conducted two research studies on 3-6 year old children in the USA and Guatemala. Following an information-processing model, they devised a cognitive battery assessing attention, learning and memory processes. Their results indicated that improved iron status was associated with improved attentional processes, without effect on memory, or rate of learning. However, despite following a theoretical model of cognition, the functional significance of the observed cognitive changes remained unknown.

Webb and Oski (cited in Soemantri, Pollitt & Kim, 1985), conducted a study on 12-14 year old junior high school students from an economically deprived, Black community in Philadelphia which indicated that anaemic ($10.0 < \text{Hb} < 11.5$ g/dL) students obtained lower achievement scores (as measured by the Iowa Test of Basic Skills) than the nonanaemic group. The performance of the anaemic group also suggested that IDA is associated with disturbances in speed of processing information and response to stimuli, attention and perception. These processes, in turn, result in poor academic achievement (Soemantri et al., 1985). An Egyptian study (cited in Soemantri et al., 1985), showed a positive association between iron status among school-aged (average 9.5 years) children and efficiency in problem-solving. This study also showed that nonanaemic children tended to respond faster and more accurately than the anaemic group. Soemantri et al. (cited in Lozoff & Brittenham, 1987), in Indonesia also indicated that iron deficiency anaemia had an effect on school performance.

Soemantri et al. (1985) conducted their study on children from an economically deprived rural area in central Java, Indonesia. Children with IDA (Hb <11.0 g/dL and SAT $< 15\%$) were compared with the iron replete children (Hb >12.0 g/dL and SAT $>20\%$) on measures of IQ (as measured by the CPM), educational achievement tests and concentration (Bourden-Wisconsin test). The results indicated no significant differences in the IQ scores of the anaemic and nonanaemic group. After three months of supplementation with iron, there was a significantly greater improvement in the performance in the school achievement and concentration tests of children who were anaemic before treatment, than in nonanaemic children. Although their results led to the conclusion that attention was affected, it could not be determined which attentional processes, i.e. whether it was selective attention, attention span, or vigilance which was specifically involved. Pollitt (1990) stated that attention span is low in iron deficient subjects and that it may be related to motivational factors such as perseverance. Further evidence suggests that although iron-deficient children are apparently less attentive to environmental clues that facilitate problem-solving, they can process information as well as iron-replete children once they learn a task. However, they tend to take longer to learn a task and exhibit less motivation to persist in intellectually challenging tasks (Levinger, 1994).

Soewendo, Husaini and Pollitt (1989) conducted a double-blind, clinical nutritional trial assessing the functional consequences of iron supplementation in Indonesian preschool children from three tea plantation areas. These children were in three categories: iron replete, iron-deplete and iron-deficient anaemic (as indicated by measures of serum ferritin, transferrin saturation, free erythrocyte protoporphyrin and haemoglobin). This research study was guided by a hypothesis suggesting that iron deficiency has adverse effects on selective cognitive processes, rather than on a global mental ability such as intelligence. The test battery they devised measured attentional acquisition and extinction, problem-solving, three oddity learning tasks which tap conceptual ability; and the Peabody Picture Vocabulary Test (PPVT). They excluded measures of short-term memory as they concluded, from their previous research study that iron deficiency did not affect memory.

After eight weeks of supplementation with iron, none of the psychological tests discriminated between the iron-replete and the iron-deplete groups. They thus dropped the iron-depleted group in their final analysis of results. Results indicated no difference between the IQs of iron-replete children and anaemic children. The treated group improved significantly as compared to the placebo group on two tests of oddity learning and one of discrimination learning. They found that overall, there was an increased performance in cognitive processes related to visual attention and concept acquisition and the nature of the alteration observed suggested that the locus of effects is not restricted to the conception of environmental information but also involves higher-order cognitive processes. They also observed that the alterations improved within 8 weeks before the iron deficiency was fully reversed. However, the reason for this improvement was not explained in the study.

The decision by Soewendo et al. to exclude memory tests may have been premature as some studies (e.g. Groner et al., cited by Lozoff 1989, Seshadri & Gopaldas, 1989), suggest that memory might be affected by iron deficiency indicating conflicting findings and thus the need for further research in the area. Following this study, it was hypothesized that the effect of iron deficiency may become more marked with increasing information loads rather than affecting performance via decreasing subjects' attention. This followed the observation that the role of iron status appeared to be less important in tasks in which the information load was small or tasks that examined passive knowledge. The fact that some of the measures employed in the study did not indicate effects of iron status may have been an indication of tests that were not sensitive enough. Thus, this is a reflection of the lack of efficient tests in this field and consequently highlights a great need for more research of more appropriate, sensitive tests and evaluation methods (Yehuda, in Soewendo et al., 1989). It was also recommended that any research study that needs to show a full picture of the effects of iron treatment on brain function and behaviour should include both the iron-replete group and the iron deficient group in the design (Soewendo et al., 1989).

Soemantri's (1989) study showed results that were similar to those indicated by Soewendo et al. (1989). His study was conducted on rural Indonesian children of ages 8.1-11.6 year. The children were classified as anaemic (defined by Hb value <11.0 g/dL and SAT $<12\%$) or nonanaemic (Hb >12.0 g/dL and SAT $<20\%$). There were no significant differences between the IQS of anaemic and nonanaemic children as measured by the Coloured Progressive Matrices, and on achievement tests, as measured by a battery they designed for this purpose. A three month supplementation with iron did not show any significant differences in IQ scores although the performance of anaemic children on achievement tests improved significantly. It was thus thought that the improvement would have been higher if the iron treatment was followed by an improvement of other variables such as socioeconomic level, nutritional status and environmental sanitation. A study by Agarwal, Upadhyay, Agarwal, Singh and Tripathi

(1989), on anaemic and nonanaemic children of 6-8 years of age, also found no association between anaemia and IQ scores. Another study conducted by Sandstead et al. (1971), on preschool children from economically, socially and environmentally disadvantaged homes, found a correlation between iron level and iron status using the Standford-Binet test.

In contrast to the above studies, a study by Pollitt, Hathirat, Kotchabhakdi, Missel and Valyasevi (1989), found a correlation between IQ and the status of iron. Their study, conducted in Thailand on 9-11 year old children, who were classified as iron replete, iron-depleted and iron deficiency anaemic (as defined by Hb, SAT, serum ferritin, EP) showed statistically significant different scores amongst these children. These children were tested on the Coloured Progressive Matrices (IQ), an arithmetic test and a Thai language test to assess school achievement. Both the iron depleted and the iron deficient children performed significantly lower than the iron-replete children on the measures that were used. However, this could not be corrected even after 14 weeks of treatment with iron. It was thought that the failure of treatment could have been due to factors that include the values used to define iron deficiency, the iron dosage or the duration of treatment, the nutritional status of the children or socioeconomic status.

The adverse effect of iron deficiency on IQ was also shown by Seshadri and Gopaldas (1989) on Indian children. They detailed results of four research studies they conducted from 1982-1987 on Indian children from a low socioeconomic background. None of the children in the study was severely malnourished as indicated by the weight and height measures taken at the beginning of each study. The first study, done on children of ages 5-8 years, compared those children who had anaemia (Hb < 11.0 g/dL) with nonanaemic children. It was shown that the IQ of these children as measured through the use of the Indian adaptation of the Wechsler's Intelligence Scales for Children (WISC), improved significantly after intervention with iron-folic acid for 60 days. The improvement of older children, i.e., the 7-8 year olds was more than that of the younger children. It was thus postulated that chronic IDA had greater adverse effects than the more acute anaemia as it was probable that the older children had chronic anaemia. Their second study was conducted on 5-6 year old boys, comparing the anaemic (Hb < 105 g/l) to nonanaemic children. The WISC was also used and the IQ scores of the children who were initially anaemic improved significantly after a 60 days intervention with iron supplements.

The third study was conducted on boys of ages 8-15 years. Tests that measured visual-recall, digit-span, maze cognitive function test and clerical task were administered before and after the intervention. After 60 days supplementation with iron there was a significant improvement in the post-intervention scores of treated anaemic children which led them to conclude that iron "... had better impact on cognitive function, namely, recent memory, attention, auditory memory, auditory sequencing, visual-motor coordination and visual perception" (Seshadri & Gopaldas, 1989, p. 679). Nonanaemic subjects did not show any significant improvements of overall cognitive-function scores from pre- to post-treatment evaluation. Their fourth study involved underprivileged girls aged 8-15 years who also received an iron supplementation for a period of 60 days. They used the same psychometric measures as those in the third study. After supplementation, a significant improvement in measures for attention, discrimination, memory, perception and visual-motor coordination was observed. The benefits following iron supplementation "could be expected to improve the scholastic performance of similar children" (Seshadri & Gopaldas, 1989, p. 684). In all their four studies, Seshadri and Gopaldas (1989) did not indicate the effects of iron deficiency without anaemia (i.e., the milder forms of iron deficiency) (Walter in Seshadri & Gopaldas, 1989).

Pollitt (1990) stated that research studies on the effects of iron deficiency have revealed its deleterious effects on cognitive function. There is a difference in the aspects/domains of cognitive function that are indicated by each study. He noted that "among the most susceptible cognitive domains are visual-perceptual organization, visual-motor coordination and speed of information processing" (Pollitt, 1990, p. 180). Holland and Stephenson (1987), believed that iron deficiency anaemia is associated with poor school performance and reduced intellectual, psychological and social development in children. School children who were exposed to a dose-appropriate iron intervention showed a significant improvement in their performance on tests of particular cognitive processes like attention, visual-perceptual organization and short-term recall, that was not observed among iron deficiency anaemic children of the same age groups who received a placebo (Pollitt, 1993). From his review of studies, Pollitt (1993) concluded that iron deficiency anaemia causes an alteration in cognitive functions among preschool and school age children as results from clinical trials showed a distinct pattern.

It was indicated by Lockheed and Verspoor (cited in Levinger, 1994-Jan) that school-aged children deficient in iron stores also exhibit reduced levels of alertness and concentration which have an influence on learning. They display less aptitude for making appropriate selections from information presented in the classroom setting. "These traits inhibit the development of a child's active learning capacity (ALC) and impinge upon school achievement" (Levinger, 1994-Jan, p. 14). Thus Pollitt (1990, cited in Levinger, 1994-Jan) concluded that "... where iron deficiency anaemia is prevalent, the condition acts directly to impede educational efficiency" (p. 14).

2.6 **SUMMARY**

Several studies have demonstrated an association between iron-deficiency anaemia and less than optimal physical and mental development in children. There is evidence showing that iron therapy results in improvements in certain behavioural and mental tests. This was demonstrated by performance scores on tests of development, learning and school achievement. However, the mechanisms and functional significance of the changes are not completely understood, "...further studies are essential to clarify effects of IDA itself, to assess the reversibility of these effects, and to determine the importance of lesser degrees of iron deficiency in children" (Haas & Fairchild, 1989, p. 703).

Iron deficiency, together with other micronutrient deficiencies have been found to have a negative effects on cognitive function, by lowering the child's attention span, particularly among previously or currently malnourished children (Leslie & Jamison, 1990). Mwamwenda (1989) stated that these deficiencies can also result in problems of short attention span, distractibility and a tendency to repeat errors even when shown the correct way. There can also be problems in processes that include perceptual-motor impairments and memory disorders.

Although research information on school aged children with iron deficiency is sparse and diverse, available data has consistently revealed a negative effect on cognitive ability more especially through it causing lack of concentration or interest, apathy and/or sleepiness, visual motor-coordination, visual perceptual organisation, low IQ scores, attention deficits, poor performance on tests of information-processing, conceptual learning and concept acquisition (Soewendo et al., 1989; Leslie & Jamison, 1990; Pollitt, 1990; Levinger, 1994-Jan). However, a major problem with the interpretation of studies on iron deficiency anaemia is due to the fact that it indicated the more severe lack of iron, which is associated with other adverse environmental and nutritional conditions, which may independently affect behaviour. Furthermore, the level at which iron deficiency has deleterious effects is not clearly established as yet.

Data reveals contradictory results where iron deficiency without anaemia is involved. There is also insufficient information about the specific nature of the psychological effect and the specific cognitive constructs/domains as the psychometric batteries used in different studies point to a wide variability (e.g. Bayley scales, WISC, Raven's Progressive Matrices, oddity learning). It is also argued that the diversity of results in some cases may have been due to psychometric tests that were not sensitive enough or those that were not appropriate due to the fact that they were standardized on different populations (Pollitt, 1993).

Findings from various research studies have been consistent in some cases e.g., attentional processes and contradictory in others e.g., memory and IQ. Some data show a clearer picture that there are noncognitive functions e.g., affect and motivation that interfere with attentiveness. Studies among school children have reported alterations in attention, reception of environmental information, reduction of motor activity which all have an effect on performance observed in the measuring of cognitive tasks. Thus, it would seem that there may be a direct effect on cognition and an indirect effect through affective states and motivation (Pollitt, 1993).

Therefore, issues provoking debate and thus highlighting the need for more research include, the adequacy of criteria used to define the severity of iron deficiency, the sensitivity and specificity of tests used to measure cognition. It is also not clear which functions are affected by iron deficiency and the lack of appropriate tests of cognitive functions may be responsible for the negative findings in some cases (Simeon & Grantham-McGregor, 1990). Specific constructs/domains of cognitive function that are affected and the effects of milder forms of iron deficiency (i.e. iron deficiency without anaemia) also require further research (Lozoff, 1989; Pollitt, 1993; Sheard, 1994). "Among preschool and school age children the relationship between psychological test performance and severity of anaemia has not been explored sufficiently well to warrant an inference" (Pollitt, 1993, p. 528)

2.7 OBJECTIVES AND HYPOTHESES OF THE STUDY

The objectives and hypotheses of the study will be presented in this section owing to the need to first explain the cognitive skills that are indicated to be affected by levels of iron in the body, and the need to explain the variations in iron status and measurements of iron.

2.7.1 Objectives of the study

The study aims:

(I) to explore whether the effects of iron deficiencies on measures of cognitive skills, i.e., short-term memory, concentration and attention span, problem-solving skills, visuo-spatial perception and learning, as measured by the chosen instruments [Coloured Progressive Matrices (CPM) (Appendix C), Rey's Auditory Verbal Learning Test (RAVLT) (Appendix D), Symbol Digit Modalities Test (SDMT) (Appendix E) and Young's Group Mathematics Test (GMT) (Appendix F)] will differ according to iron status, i.e., iron replete, iron deficiency without anaemia and iron deficiency with anaemia.

(ii) to determine the prevalence of iron deficiency in the sample selected which will give a crude indication of the rate of iron deficiency amongst school-aged children in the Vulamehlo area. This will also serve as a basis for advocacy of programmes for prevention of iron deficiency in children of school-going age and also intervention measures where warranted. According to Levinger (1994) "data on the prevalence of micronutrient deficiency disorders ... is still incomplete. It is difficult if not impossible to target communities on the basis of what is currently known" (p. 59).

(iii) To assess whether the performance of children in this study, on the chosen psychometric tests (i.e. Raven's Coloured Progressive Matrices (CPM), Rey Auditory Verbal Learning Test (RAVLT), the Symbol Digit Modalities Test (SDMT) and Young's Group Mathematics Test (GMT), is comparable to the normative data given in the manuals of these tests. This is particularly important as the tests are administered in Zulu and in groups.

2.7.2 The study hypotheses

(I) Are there any significant differences in performance between children according to the levels of iron status, namely iron replete, iron deficient without anaemia, and iron deficient with anaemia, on measures of cognitive function, viz.

a) short-term memory as measured by the RAVLT and the SDMT
b) concentration and attention as measured by the RAVLT;
c) learning and assimilation of new information as measured by the RAVLT;
d) visuo-motor perception and speed as measured by the SDMT;
e) arithmetic comprehension and reasoning as measured by the GMT; and
f) IQ as measured by the CPM.

(ii) Are there any significant gender differences on the cognitive functions mentioned above.

CHAPTER 3

METHODOLOGY

This chapter will concentrate on a description of the methods, subjects and procedure applied in conducting the study. Two pilot studies were undertaken, and they are both discussed. The first one was in Ndwedwe and the second in Umlazi. The second pilot study was conducted in order to test some observations and modifications following the first pilot study. The main study is then discussed.

3.1 PILOT STUDIES

3.1.1 Aims of the pilot studies

These included testing how people's performance in group administration would differ from the standard individual administration particularly on the Rey's Auditory and Verbal Learning test (RAVLT) which is designed for individual administration. There was also the need to observe how the children would perform on the test measures and the flow of the administration process with the test instructions translated to Zulu.

Other aims included examining the feasibility of the selected psychometric tests (Ravens Coloured Progressive Matrices, Rey's Auditory Verbal Learning Test, the Symbol Digit Modalities Test and Young's Group Mathematics Test), i.e., determining whether it was practically possible to conduct all the measures in one sitting without children exhibiting signs of exhaustion. It was also important to determine the amount of time it would take to administer all the tests and observe how the testers would work, specifically with the proposed maximum number of children in a group. Finally, the aims included using the field experience to provide any necessary training of the testers and to modify the instructions.

3.1.2 Study Design

(1) Subjects

The first pilot study was undertaken in a primary school in the rural Ndwedwe area approximately 80 kilometres north of Durban. The school was conveniently selected on the basis of it being small, under-resourced and not easily accessible due to the unfavourable road conditions especially during rainy weather. The second pilot was conducted as a follow-up on the recommendations from the first study. It was also undertaken with more emphasis on giving testers an opportunity to pilot test a group of children and trying to determine how bias amongst testers can be reduced. This pilot study was executed at the Sandakahle primary school in Umlazi which is an urban area about 15 kilometres south of Durban. Consent to undertake the pilot studies was obtained from the principals and standard one teachers.

For both pilot studies the subjects selected were children of ages eight, nine and ten, who were doing standard one at the time. From the Ndwedwe school, twenty children were tested of whom four (20%) were eight years old, seven (35%) were nine years old and nine (45%) were ten years old. Six (30%) were girls and fourteen (70%) were boys. From the Umlazi school, 90 children of whom 29.6% were eight years old, 51.6% were nine years old and 18.8% were 10 years old were tested. Of these, 53.1% were girls and 46.9% of them were boys.

(2) Measurement instruments

The literature indicates that iron deficiency may have an impact on the short-term memory of children; visuo-spatial memory; perceptual processing and encoding of information; concentration and attention; time taken to make decisions; learning and mental alertness; motivation and interest; visual attention and assimilation of new information; arithmetic skills; all of which have a direct link with how children perform at school (Boivin et al,. 1993; Levinger, 1994a).

The psychometric tests that were chosen for purposes of this study included the Raven's Coloured Progressive Matrices (CPM) (Appendix C) which is a measure of intellectual ability. For an indication of immediate memory span, new learning, susceptibility to interference and recognition memory (Spreen & Straus, 1991), Rey's Auditory-Verbal-Learning Test (RAVLT) was included. This test was modified for group administration and translated into Zulu (Appendix D). The Symbol Digit Modalities Test (SDMT) (Appendix E) was selected for an indication of visuo-spatial processing, encoding of information and motor speed (Smith, 1982). Lastly, Young's Group Mathematical Test (GMT) (Appendix F) was included for arithmetical comprehension and reasoning. All the test instructions were translated into Zulu.

(3) Procedure

For the Ndwedwe pilot study, testing was conducted on all the testees as a single group by a psychologist together with three trained assistants while for the Umlazi study, three testers were involved, each tester with two assistants. To prevent copying from one another, testees did not share desks.

3.1.3 Findings and Recommendations from the Pilot Studies

The psychometric tests appeared to be adequate in that they allowed for a wide range of performance. They also allowed for a sufficient assessment of individual differences with adequate allowance for improvement in performance. The time taken to administer all the tests was approximately three hours including a 15 minute break. The testees showed a high level of interest in the tests and did not complain of any tiredness or exhibit signs thereof. Thus, it was concluded that it was feasible to conduct all the four tests in one session.

Following the pilot studies the following modifications had to be made: answer booklets were compiled as it was observed, in the first pilot study that distributing and collecting answer sheets for each section, more especially the different trials of the RAVLT, and the writing down of the name on each answer sheet, took time and disrupted the testing process. These answer booklets were utilised for the second pilot and were found to be effective in reducing the chaos and the delay (see Appendix G: the answer booklet attached). The instructions of the mathematics test needed to be modified to use the simpler language more commonly used and understood by children of the age range in the study and all the testers were to attend a briefing session to discuss standard ways of administering the tests for the main study.

It was recommended that one more assistant be assigned to each tester,- i.e., three assistants for a group of testees, - which would mean more attention given to children as each assistant would attend to not more than ten children per session. Teachers were to be excused during the testing session as their presence appeared to distract the children.

3.2 MAIN STUDY

The measurements for this study included psychometric tests and blood samples to determine the iron levels. It was undertaken in June of 1995.

3.2.1 Study Design

This is a post-test-only control group design (cross-sectional analytic study) where the independent variable is the level of iron as indicated by the haemoglobin, and transferrin saturation levels at the time of testing. These levels of iron were: iron replete/sufficiency, iron deficiency without anaemia (moderate iron deficiency) and iron deficiency anaemia (severe iron deficiency) (see Table 2.2). The dependent variables were IQ, short-term memory, attention, learning and assimilation of new information, visuo-motor speed and arithmetic comprehension, as measured by the chosen instruments, viz., the CPM, the RAVLT, Young's GMT and the SDMT.

(1) Subjects

The target population was rural primary school children in the Vulamehlo area. Vulamehlo is a rural magisterial district about 150 kilometres south of Durban. This area was chosen because it has a non-governmental community centre (Siyabona) through which most of the key contact people in the area could be accessed. Children of ages eight, nine and ten years, were selected from the primary schools in this district. It was thought that these children would be old enough to understand instructions and in the case of girls, not too old to lose additional iron through menstrual periods.

A list of all the primary schools in the area was obtained from the circuit inspector's office. Schools that were easily accessible by road even during rainy seasons were considered first. Those schools that were regarded as small (i.e., less than fifty children in standard one) were excluded from the sample and all the schools that were already feeding on fortified biscuits were also excluded from the sample. All the children of specified ages in standard one were included in the sample, but those children whose parents declined consent were excluded. Finally, 11 schools from the area were included in the sample. From these schools, 810 children in standard one and of ages eight, nine and ten constituted the final sample. Table 3.1 below shows the distribution of the children in the sample.

Table 3.1: Age and Gender Distributions (In Percentages) of the Whole Sample (N = 810)

AGE	**MALE** N = 354 (43.70%)		**FEMALE** N = 456 (56.30%)		**TOTAL** N = 810	
	N	Percentage	N	Percentage	N	Percentage
8 years	90	(11.11%)	166	(20.49%)	256	(31.60%)
9 years	140	(17.28%)	167	(20.61%)	307	(37.90%)
10 years	124	(15.31%)	123	(15.91%)	247	(30.49%)

(2) Measurement Instruments

These were divided into the medical and psychometric tests.

(a) Medical Tests

Blood samples were collected over a period of six days by two teams of medical doctors and assistants from the Department of Community Health, University of Natal. Venous blood samples were collected from each child into a tube which was labelled with the child's study number, kept in cooler boxes to be transported to the haematology laboratory (King Edward VIII hospital) for analysis. Blood was analysed for Hb concentration and transferrin saturation levels (refer to Section 2.3.2 and Table 2.3 for a discussion and classification used for this study).

(b) Psychometric Testing

Testing was conducted over a period of eleven days during weekdays from approximately 09h00 to 12h00. The five testers involved were, a qualified counselling psychologist, three clinical psychology interns and a social science graduate with a psychology major. Testers were briefed by the qualified psychologist prior to testing to ascertain that they would give the same instructions and follow the same procedures in the field. Testers were also involved in pilot-testing the measuring instruments used. Each tester was assigned three assistants who were briefed as to their tasks, by the psychologist. The rationale was for them to know what is expected from the testees to help in identifying those testees experiencing problems during the testing session.

It should be noted that measuring behaviour and mental/cognitive development and functioning is often problematic because the validity of available tests is often questionable in countries where there are no standardised indigenous norms for the tests. Global tests such as developmental assessments and IQ tests have been used most frequently, but may not be sensitive to the subtle changes expected from nutritional deficits. It is also not yet clear which functions are affected by iron deficiency and lack of appropriate tests of cognitive functions may be responsible for the negative findings in some cases. As a result it is usually difficult to find tests that are appropriate and sensitive to cognitive changes (Simeon & Grantham-McGregor, 1990). Often "investigators working with infants prefer to use the Bayley Scales of Mental and Motor Development (BSMMD), while those working with pre-schoolers and school-age children have chosen IQ tests [e.g., Wechsler Intelligence Scale for Children (WISC), Raven's Progressive Matrices]" (Pollitt, 1993, p. 523). The tests that were selected for this study were: Raven's Coloured Progressive Matrices (CPM); Rey's Auditory Verbal Learning Test (RAVLT); Symbol Digit Modalities Test (SDMT) and Young's Group Mathematics Test (GMT). These tests are discussed in greater detail below.

(I) Raven's Coloured Progressive Matrices (CPM)

The CPM was first developed by Raven in 1947 as a downward extension of the Standard Progressive Matrices (SPM) for use with young children and individuals with intellectual deficiencies or very advanced age. It is a non-verbal measure of the level of intellectual development based on perceptual abilities and visuospatial reasoning. It is also described as a test of observation and clear thinking (see Appendix G: sample of CPM problems). It can be used satisfactorily with people of any language and thus instructions can be given in the testee's home/preferred language. It is designed for use with both young children (age of 5.5+ years) and adults, and is considered a culture-fair test which can be administered to groups of people. Measso et al. (1993) found that gender, age and level of education significantly influence performance on the CPM. "The test covers cognitive processes of which children under the age of 11 years are usually capable" (Spreen & Straus, 1991, p. 46). However, care should be exercised as defects of vision, inattentiveness and inability to understand instructions, are factors that render self-administered or group test procedures harzadous (Raven, Court & Raven, 1990).

This test indicates whether a person is capable of forming comparisons and reasoning by analogy. The CPM can also measure to what extent an individual is capable of apprehending and perceiving discrete figures as spatially related wholes and analysing and organising them into their components. It also measures the degree to which a person's capacity for abstract thinking has developed and may reasonably be expected to mature (Raven, 1960; Raven, Court & Raven, 1990).

The CPM consists of 36 problems divided into three subscales (A, Ab, B) of 12 items each. In each case subjects are presented with an incomplete design and six alternatives among which they must choose the one that best completes the design. Costa (cited in Measso et al., 1993) stated that the items are not homogenous, "that items in set A involve mainly visuospatial abilities, items in set AB involve gestalt processing, and items in set B measure analogical and abstract thinking" (p. 70). The items are arranged in order of difficulty both within and between the scales. "Each item consists of a coloured abstract design with a missing piece to be completed by selecting the best alternative choice, based on characteristics ranging from discreet form to more complex logical relationships" (Esquivel, 1984, p. 206). It is an untimed test and thus assesses power of thinking rather than speed.

Although by itself, it is not regarded as an adequate measure of "general intelligence" it is nonetheless believed to be one of the best single measures of Spearman's "g" or general ability (Raven, Court & Raven, 1993, cited in Richter et al., 1994; Spreen & Straus, 1991). Concurrent validity studies show a moderate correlation (about 0.7) between the CPM and conventional tests of intelligence such as the Wechsler and Stanford-Binet scales (Burke in Spreen & Straus, 1991; Esquivel, 1984). There is a higher correlation with performance than verbal subscales. It makes it possible to assess a person's present intellectual activity irrespective of his acquired knowledge.

The split-half reliability for the test ranges between .80 and .90. The re-test reliability of the test tends to be lower for children under the age of 7 years (0.65) and from the age of 8 years, it has been reported to increase to 0.80. Over the whole range for which the test is constructed, it has shown a re-test reliability in the neighbourhood of 0.90. This may be a reflection of "the fluctuating nature of cognitive development during earlier years rather than psychometric flaws in the scale in this respect" (Esquivel, 1984, p. 211). Burke (in Spreen & Straus, 1991) has reported internal consistency coefficients of above 0.70. Freyberg (cited in Carlson & Jensen,

1981) stated that the test is internally consistent and homogenous, even for young children. Cross-cultural reliability and validity studies (Carlson & Jensen, 1981; Esquivel, 1984), have shown that the CPM is a valid measure of nonverbal intelligence amongst children from culturally, economically and linguistically diverse backgrounds. In Carlson and Jensen's study (1981), there was information that indicated that the CPM is equally reliable for Hispanic, Anglo and Black people in the USA.

Although the CPM's correlation with tests of academic achievement seems to be relatively lower, it appears to have a relationship with some areas of learning such as reading, comprehension, and problem-solving tasks (convergent-cognitive figural). Stallings (cited in Esquivel, 1984) found a correlation between increased CPM scores, and children's involvement in exploratory and independent activities in flexible classroom environments. According to Esquivel's (1984) study, although a direct relationship was not found between higher academic scores and the CPM, there was a suggestion that there may be some association between analogical and creative kinds of learning. The CPM was found to be a meaningful evaluator and indicator of learning potential (Esquivel, 1984).

A child from age eight onwards can usually complete the CPM satisfactorily by himself/herself, provided there is adequate supervision, and when allowed to work quietly at his/her own speed without interruption, the CPM usually gives a consistent and reliable indication of his/her mental functioning (Raven, Court and Raven, 1990). There is no time limit for this test and thus children are allowed to work at their own pace.

(ii) The Symbol Digit Modalities Test (SDMT)

This test involves written language symbols and is a relatively culture-fair test which can be used with examinees speaking languages other than English and on any people regardless of age. It involves the timed coding of numbers with abstract symbols (see Appendix E (b) for a sample of the test). The SDMT is a measure of visual and perceptual attention, psychomotor performance, speeded visuomotor/visuospatial tracking, learning, short-term memory (Polubinski & Melamed, 1986; Bowler et al., 1992; Uchiyama et al., 1994). The SDMT can also be used to predict reading and mathematics achievement (Zolten et al., 1994). Performance on the test involves encoding a symbol from test form, holding it in working memory while scanning the array of symbols in the key for a match, looking for the associated digit below the appropriate symbol in the key and writing down the answer. Scoring is based on the number of correct substitutions made in 90 seconds (Polubinski & Melamed, 1986; Bowler et al., 1992).

The written version is administered either individually or in groups and is used, amongst others, to demonstrate any educational difficulties, dyslexia, aphasia or cerebral dysfunction. The SDMT offers an economical method for early screening of apparently normal children for possible covert manual motor defects, visual acuity, oculomotor co-ordination and visuo-spatial orientation difficulties (Smith, 1982). A study of the test by an educational psychologist (Hutton, cited in Smith, 1982) demonstrates its value in assessing reading readiness and predicting reading disabilities in children beginning formal education. Smith (1982) further suggested that more research in educational and experimental applications is needed to contribute to further definition of its value and limitations.

The test-retest reliability of the test on a non-clinical sample was found to be 0.80. The SDMT has shown sex differences at all ages with females performing better than males (Polubinski & Melamed, 1986; Snow & Weinstock, 1990; Wong & Cliplin, 1991). This is attributed to "greater speed and accuracy in writing by females or to the higher incidence of sinistrality in males" (Smith, 1982). However, Yeudall et al. (in Bowler et al., 1992) did not report any gender differences. Some studies have suggested that age and IQ may have an impact on performance (Uchiyama et al., 1994; Waldmann et al., 1992). Macpherson (1991) found no age differences for children who were between eight and ten years old.

(iii) Rey's Auditory Verbal Learning Test (RAVLT)

The RAVLT is a test of auditory memory and allows for evaluation of immediate memory span, new learning through repetition, susceptibility to retroactive or proactive interference, short-term and longer-term retention and recognition memory (Ryan, Geisser, Randall & Georgemiller, 1986; Lezak, 1995). It was originally developed by the psychologist Andre Rey and normed on French-speaking subjects but has since been altered and adapted for English-speaking subjects by Taylor and then Lezak (Wiens, McMinn & Crossen, 1988). The test and its instructions have been modified from the original French version. Peaker and Stewart (1989) reported test-retest reliability coefficients ranging from .53 to .73. They also stated the "split-half reliability is not a concern of the RAVLT, due to the nature of the test" (Peaker & Stewart, 1989, p. 222).

Franzen (1989), stated that more information was still needed specifically on normative data, reliability, and that validity studies using subjects without problems still need to be conducted. In addition, the test has been widely used mostly with clinical, adult samples and as a result, very few norms are available on healthy children (Peaker & Stewart, 1989; Geffen, Moar, O'Hanlon, Clark & Geffen, 1990).

The test consists of a list of 15 words which are read out loud to the testee for five consecutive trials, each trial followed by a free-recall, which is a measure of immediate memory span for words (Peaker & Stewart, 1989). Upon completion of the five trials, an interference/distraction list B is presented, followed by a free-recall of that list. Then delayed recall of the list A is tested, i.e., the testee is requested to recall list A without the presentation of the words again. Finally, recognition is tested by presenting either a story or list of 50 words to see if the testee can recognise the 15 words that were in the original list A. Recognition measures the efficiency of retrieval and examines the capacity to differentiate between information that was learned (Spreen & Strauss, 1991; Lezak, 1995). For purposes of this study, a list of 50 words was presented and the testees were requested to underline those words they recognised from list A. This task requires rapid visual scanning which also involves fluent reading and comprehension (Rourke, 1981).

The test also examines learning ability. Scores on trial I through to V form a learning curve, and the slope of this curve provides a measure of verbal learning, i.e,. ideally the scores are supposed to increase with each trial. Recall on the trial that follows the interpolated/interference list, gives a measure of delayed recall, and when compared with performance on trial V may reveal difficulties in the retention of newly learned information or susceptibility to proactive interference. Higher recall on trial I than list B may be a result of proactive inhibition, whereas higher recall on list B than trial I might suggest initial performance difficulties and/or anxiety (Peaker & Stewart, 1989; Spreen & Straus, 1991).

Findings on the effect of sex on performance have been contradictory with some studies (Evison, 1986, cited in Peaker & Stewart, 1989; Geffen et al., 1990) stating that females have superior performance while other studies (Wiens et al., 1988), found superior male performance. Another study conducted on Zulu speaking children, by Macpherson (1991) found no significant sex differences. Spreen & Strauss (1991) stated that age and intellectual level may contribute to performance on the RAVLT. This test, when administered to adults, showed a decline in performance with increasing age. In young children however, performance is expected to increase with age. It was also suggested that performance can be affected by different education levels (Wiens et al., 1988). Ryan et al. (1986) demonstrated that the RAVLT is sensitive to verbal mnemonic dysfunction and it yields information that differs from that provided by tasks of attention-concentration and verbal intelligence.

A World Health Organisation research conducted in Zaire suggested that there may be some cultural bias in the words used for the test, "e.g. there are no turkeys and very few curtains in Zaire" (Lezak, 1995). In this study the Zulu version, which was first translated and used by MacPherson (1991) on school children, was administered (Appendix B). For the translation into Zulu, a few words were altered in order that their meaning could be "more culturally applicable". The word "turkey" was replaced with "chicken" and "ranger" with "herdboy" (MacPherson, 1991, p. 9). The effect of these changes has not been empirically investigated but "laboratory experiments have shown that word imagery, concreteness, and meaningfulness influence verbal memory" (Paivio in Wiens et al., 1988, p. 69). Moreover, effects of the cultural and educational differences still need to be defined (Wiens et al., 1988).

The test is normally administered orally on an individual basis. However, for the purposes of this study, due to the number of subjects in the sample only group administration could be conducted. The children had to write their answers and were given two minutes for each trial. Performance on this test may thus be affected by factors such as motor speed and perhaps decay from memory due to the delay that will result from writing the words. This therefore highlights the fact that normative and validity studies need to be conducted particularly on the Zulu, group-administered version.

Problems with the administration of the above tests arise due to the fact that the majority of research appears to focus on adult populations and clinical or disabled subjects. As a result, there are still questions with regard to standardization and normative data.

(iv) Young's Group Mathematics Test (GMT)

The test is suitable for use with groups of children over a wide range of ability. It also provides norms for below-average children (Young, 1980). This test is made up of two sections, viz: the oral and computation sections. Each section is then subdivided into two parts. Thus overall, the test is made up of: oral one, oral two, computation one and computation two.

Each computation subtest also has two practice examples and then testees were allowed eight minutes to work on their own. The test was administered in Zulu (see Appendix E (2). The Zulu translation was done by an external person not involved in the study, then all the five testers discussed, modified some words and agreed on a final version. Some words had to be changed to make them more "culturally appropriate" e.g., the word "tarts" was changed to "cakes", "engine" to "truck", "marbles" to "balls"; and the names "Dick and Jim" were changed to "Sipho and Thembi".

(3) Procedure

Throughout the whole study, ethics were considered in the following way: Ethical approval was obtained from the Ethics Committee of the University of Natal (Medical Faculty). Parents and/or caretakers gave informed consent (see Appendix H). Those children whose parents declined consent, were excluded from the study. Permission to do the study was also obtained from the tribal authorities/chiefs (amakhosi) in the Vulamehlo district, the two circuit inspectors (one for the former Department of Education and Training (DET) and the other for the former KwaZulu department of education) (refer Appendix I: 1-3), principals and the school committees (verbal permission during meetings held with the committee members prior to conducting the study). Furthermore, during the undertaking of the study, each child had a study number assigned to him/her and thus names were not available to the field workers except to the research team, for confidentiality reasons.

During the process of administering the tests, testers and assistants arrived at each school at least 30 minutes before starting time each morning to arrange classrooms and desks according to the number of children that were to be tested for the day. After the children were seated, they were first requested to write down their names, and then any two psychometric tests were administered before a 15 minute break. Due to the shortage of CPM testing booklets, these had to be alternated between testing sessions and as a result the order in which the tests were administered varied. The four assistants helped with distributing the test booklets, answer booklets and pencils, supervising the children throughout the testing and collecting completed booklets at the end of testing.

The administered tests were then scored in the following manner: with the CPM and the GMT, the correct answers for each section were counted and a total score computed, and for the SDMT scoring was according to the total number of correctly completed blocks. For the RAVLT, performances on each of the learning (List A, Trial 1 to 5), distraction (List B, Trial 6), postdistraction recall (Trial 7) and recognition trials were computed separately. The sum of the number of recalled words over Trial 1 to Trial 5 was also computed.

CHAPTER 4

RESULTS

This section presents the results of the study. The data was summarised using means and standard deviations. Comparisons between groups were made using the t-test statistic where variances were equal. An approximate t was used where variances were unequal(#). Satterwaite's 1946 approximate was used to compute the degrees of freedom associated with the approximated t. Multivariate Analysis of Variance (MANOVA) was used to test the effect of independent factors across all tests. The analysis was done on the group as a whole and again on a subsample with equal groups in the haemoglobin categories. The Wilks' Lamda statistic was used to test for significant effects of the independent factors. The trial data consisted of tests repeated five times on each child. A repeated measures analysis of variance was performed to take account of the correlation among the repeated measurements. Cronbach's Coefficient Alpha was used to measure the consistency between the CPMA, CPMAb and CPMB tests on the same individual as well as among the four Maths subtests. All analyses were done using SAS statistical software. Results showed some gender effects for all the psychometric tests except for the Maths test. There was also no significant effect of iron deficiency on most of the measured cognitive skills.

4.1 PARTIAL CORRELATION COEFFICIENTS AND INTERNAL CONSISTENCY OF THE PSYCHOMETRIC MEASURES USED

The correlations among some of the psychometric tests that were utilised were weak. There was a negative, weak correlation between SDMT and both the CPMB and CPMAb. The opposite would have been expected, i.e., an increase in the CPM, which is a measure of intellectual capacity, would have been expected to go together with an increase in performance on any other psychometric test. However, because these are partial correlations, they at least partial out the effects of other factors on performance. Table 4.1 below gives an indication of the correlation coefficients.

Table 4.1: Correlation Coefficients of the Psychometric Tests

	CPMB	CPMAb	SDMT	MATH1	MATH2	MATH3	MATH4
CPMA	0.29	0.25	0.11	0.12	0.17	0.14	0.13
CPMB		0.46	-0.03	0.14	0.15	0.12	0.13
CPMAb			-0.02	0.14	0.17	0.19	0.19
SDMT				0.16	0.14	0.12	0.10
MATH1					0.46	0.36	0.36
MATH2						0.40	0.40
MATH3							0.47

Please note that from the above table the following pertains:

- CPMA, Ab and B = the three subsections of the Coloured Progressive Matrices;
- SDMT = derived from the correct number of responses on the Symbol Digit Modalities Test; and
- MATH 1-4 = the four subsections of the Maths Test.

Internal consistency between the CPMA, CPMAb and CPMB was moderate (Cronbach's coefficient alpha = 0.62) while Maths1, Maths2, Maths3 and Maths4 showed a strong internal consistency (Cronbach's coefficient alpha = 0.71).

4.2 PERFORMANCE ON THE PSYCHOMETRIC TESTS

The psychometric tests were analysed first to see the children's overall performance on the tests before looking at the effect of iron levels may have on performance.

The tested children were within the same age range (eight to ten years) and as such, an age effect on performance was not necessarily expected. The results on performance on all the psychometric measures are presented according to gender (Table 4.2).

Gender differences in performance would have been expected for children who are in their puberty years especially due to the expected lower iron levels in girls following loss of blood through menstruation. However, due to the fact that children in this study were prepubescent, gender was not initially expected to have an effect on performance. Nevertheless, preliminary analysis of data showed gender differences which could not be ignored. Thus, gender was considered for further analysis and discussion of results.

Table 4.2: Performance on all the Administered Tests according to Gender

TEST	**MALE**			**FEMALE**			**t**	**df**	**p values**
	N	MEAN	(SD)	N	MEAN	(SD)			
CPM	289	14.56	(4.28)	366	13.44	(3.08)	3.74	505.3 #	0.0002*
SDMT	290	15.34	(6.37)	365	14.27	(6.29)	21.4	653.0	0.03*
MATHS	288	28.71	(7.25)	365	29.71	(7.19)	1.76	651.0	0.08
RAVLT (1-5)	271	25.15	(6.60)	344	27.13	(6.85)	3.60	613.0	0.0003*

- # = estimated degrees of freedom where variances were unequal
- * = results significant at indicated level

Male students had significantly higher mean total scores on the CPM test, mean 14.56 (SD=4.28) than female students, mean 13.44 (SD=3.08), p=.0002; as well as on the SDMT, mean 15,34 (SD = 6.37) compared to females, mean 14,27 (SD=6.29), p=.03. On the other tests, i.e., the RAVLT and the total Maths test, female students outperformed male students, although the difference was not significant for the total Maths test. The difference was only significant for the RAVLT where the mean for males was 27.13 (SD=6.85) and for females the mean was 25.15 (SD=6.60), p=.0003.

4.2.1 Performance on the Coloured Progressive Matrices

As indicated by Table 4.3 below, all the three subsections of the CPM showed statistically significant gender differences with male children scoring consistently higher than female children.

Table 4.3: Performance on the subsections of the CPM according to gender

CPM	**MALE**			**FEMALE**			**t**	**df**	**p**
	N	MEAN	(SD)	N	MEAN	(SD)			**Values**
CPMA	289	7.04	(1.53)	366	6.82	(1.39)	1.94	653.0	0.05*
CPMAb	289	3.36	(1.84)	366	2.92	(1.49)	3.25	548.9#	0.001*
CPMB	289	4.16	(2.04)	366	3.70	(1.47)	3.25	504.0#	0.001*
TOTAL	289	14.56	(4.28)	366	13.44	(3.08)	3.74	503.3#	0.0002*

- # = estimated degrees of freedom where variances were unequal
- * = results significant at indicated level

4.2.2 Performance on Young's Group Mathematics Test

Table 4.4 indicates that female students scored higher on three of the four maths test and on the maths total score. However, the difference was statistically different only on Maths 3 where the mean for female students was 7.67 (SD = 2.57) compared to 7.07 (SD = 2.65) for male students (p=.003). Male students scored higher only on the first subsection.

Table 4.4: Performance on the Maths subtests (GMT) according to gender

MATHS	MALE			FEMALE			t	df	p Values
	N	MEAN	(SD)	N	MEAN	(SD)			
MATH1	290	7.54	(1.91)	366	7.48	(1.83)	0.37	654	0.71
MATH2	290	5.88	(1.98)	366	5.95	(1.89)	0.47	654	0.64
MATH3	289	7.07	(2.65)	366	7.67	(2.57)	2.94	653	0.003*
MATH4	289	8.20	(3.09)	365	8.58	(3.28)	1.51	652	0.13
TOTAL	288	28.71	(7.25)	365	29.71	(7.19)	1.76	651	0.08

- * = results significant at indicated level

4.2.3 Performance on Rey's Auditory Verbal Learning Test

Table 4.5: Performance on the RAVLT subsections according to gender

RAVLT	MALE			FEMALE			t	df	p Values
	N	MEAN	(SD)	N	MEAN	(SD)			
TRIAL 1	374	3.25	(1.26)	345	3.26	(1.21)	0.08	617.0	0.94
TRIAL 2	280	4.73	(1.48)	358	4.97	(1.55)	2.00	636.0	0.05*
TRIAL 3	280	5.35	(1.63)	358	5.74	(1.83)	2.89	624.9#	0.004*
TRIAL 4	281	5.73	(1.83)	361	6.26	(2.03)	3.39	640.0	0.001*
TRIAL 5	279	6.01	(1.91)	361	6.63	(2.10)	3.88	638.0	0.0001*
TOTAL (1-5)	279	25.15	(6.60)	344	27.13	(6.85)	3.60	613.0	0.0003*
TRIAL 7	266	4.80	(1.90)	332	5.26	(2.05)	2.81	596.0	0.005*

- # = estimated degrees of freedom where variances were unequal
- * = results significant at indicated level

On the RAVLT, female scores were generally higher than male scores for all five subtests including their total. These differences between male and female scores increased from trial 1 to trial 5 and were statistically significant for all subsections except for trial 1. Table 4.5 above gives an indication of performance on the RAVLT subsections.

4.2.4 Performance on the SDMT

Male children scored significantly higher on the SDMT, mean 15,34 (SD = 6.37) compared to female children who had mean = 14.27 (SD= 14,27), p = 0.03. This is shown in Table 4.6 below.

Table 4.6: Performance on the SDMT

TEST	**MALE**			**FEMALE**			**t**	**df**	**p Value**
	N	MEAN	(SD)	N	MEAN	(SD)			
SDMT	290	15.34	(6.37)	365	14.27	(6.29)	2.14	653	0.03*

- * = results significant at indicated level

4.3 EFFECT OF IRON LEVELS ON PERFORMANCE AS MEASURED BY THE ADMINISTERED PSYCHOMETRIC TESTS

Before an analysis of the effect of iron levels on performance was conducted, data was checked for the number of subjects in each of the iron groups (see table 2.3 for the classification of the groups). This was done firstly through the use of Haemoglobin (Hb) levels. The number of subjects were found to be as follows:

Table 4.7: Number of subjects in the three groups according to Hb levels

Group	**Hb level (g/L)**	**Total No of subjects**
1	Hb >= 120	405
2	100 < Hb < 120	72
3	Hb < 120	9

Due to the small numbers, especially in the third group it was decided that for further analysis the second and the third group should be combined. These groups were group one, determined by an Hb >= 120 g/L and group two, indicated by Hb < 120 g/L. Further analysis was then conducted to determine whether Hb levels had any significant effects on the children's performance on the administered psychometric tests. Results are given for each test and subtest in the subsections below.

4.3.1 Effect of Hb levels on the Coloured Progressive Matrices

A multivariate analysis of variance (MANOVA) was conducted, with gender and Hb levels as the independent factors and CPMA, CPMAb, CPMB as the dependent variables. This showed that there was an overall gender effect (Wilks' Lamda, $p = 0.009$; DF = 3 and 477; $F = 3.90$) as well as an haemoglobin effect (Wilks' Lamda, $p = 0.05$; DF = 3 and 477; $F = 2.65$). The gender effect is not surprising considering that table 4.4 above has already shown that males scored significantly higher than females on all subsections of the CPM, including the total score.

In view of the significance of both the gender and haemoglobin effects, the results were further analysed separately for each gender, to further determine the effects of haemoglobin levels on the CPM scores. Results are shown in Tables 4.8a and 4.8b.

Table 4.8a: Effect of Hb levels on the CPM for male children

TEST	Hb < 12			Hb >= 12			t	df	p Values
	N	MEAN	(SD)	N	MEAN	(SD)			
CPMA	37	6.81	(1.43)	173	7.07	(1.59)	0.93	208.0	0.35
CPMAb	37	2.86	(1.23)	173	3.42	(1.87)	2.26	76.5#	0.03*
CPMB	37	3.62	(1.80)	173	4.32	(2.16)	1.84	208.0	0.07
TOTAL	37	13.30	(2.67)	173	14.82	(4.54)	2.73	87.5#	0.008*

- # = estimated degrees of freedom where variances were unequal
- * = results significant at indicated level

Male children with an Hb>= 12 scored better on all the subtests including the total than those with an Hb < 12 (Table 4.8a above). However, only CPMAb and the total CPM showed a statistically significant association with Hb levels.

For female children (Table 4.8b), those with an Hb >= 12 scored higher on the CPMB and on the total CPM. Only the CPMB showed a statistically significant association with Hb levels, Hb >= 12, mean = 3.81 (SD = 1.45) compared to mean of 3.29 (SD = 1.07) in the group with Hb < 12 (p = .008). However, they showed similar scores on the CPMA and the CPMAb.

Table 4.8b: Effect of Hb levels on the CPM for females

TEST	Hb < 12			Hb >= 12			t	df	p
	N	MEAN	(SD)	N	MEAN	(SD)			Values
CPMA	44	6.80	(1.27)	228	6.82	(1.49)	0.09	270.0	0.92
CPMAb	44	2.93	(1.13)	228	2.92	(1.58)	0.08	79.0#	0.94
CPMB	44	3.29	(1.07)	228	3.81	(1.45)	2.73	77.1#	0.008*
TOTAL	44	13.02	(2.05)	228	13.54	(3.18)	1.38	88.5#	0.17

- # = estimated degrees of freedom where variances were unequal
- * = results significant at indicated level

The significance of haemoglobin effect is questionable for both the male and female children. This is because the very disproportionate sample sizes in both cases (for males Hb < 12, n = 37 and Hb> 12, n = 173; for females Hb < 12, n = 44 and for Hb > 12, n = 228) may skew the results in favour of the groups with larger sample sizes. Following this, it was decided to take a random sample of 81 cases from the group with Hb levels greater than 12, and compare it with a haemoglobin level less than 12, whose number was also equal to 81. A multivariate analysis of variance indicated no significant haemoglobin effect with groups of equal sample size (Wilks' Lamda, p = .39; DF = 3 and 156; F = 1.01).

4.3.2 Effect of Hb levels on the SDMT

Table 4.9a: Effect of Hb levels on the SDMT for males

	Hb < 12			Hb >= 12			t	df	p
	N	MEAN	(SD)	N	MEAN	(SD)			value
SDMT	37	15.05	(6.77)	174	15.40	(6.40)	0.29	209	0.77

Table 4.9b: Effect of Hb levels on the SDMT for females

	Hb < 12	Hb >= 12	t	df	p
	N MEAN (SD)	N MEAN (SD)			Value
SDMT	44 13.47 (5.63)	227 14.12 (6.42)	0.91	269	0.36

Male children with an Hb >= 12 achieved higher scores on the SDMT than those with an Hb < 12 although the difference was not statistically significant (p = .77). Female children showed the same pattern where the difference was also not statistically significant (p = .36) (Tables 9a and 4.9b).

4.3.3 Effect of Hb Levels on the Maths test

A multivariate analysis of variance (MANOVA) with gender and Hb levels as the independent factors and GMT (Maths) subtests as well as the total of the subtests as the dependent variables showed that there was no gender factor affecting the Maths scores (Wilks' Lamda, p = .10; DF = 4 and 476; F statistic = 1.96). In addition, hypothesis of no overall haemoglobin effect could not be rejected (Wilks' Lamda, p = .12; DF = 4 and 476; F statistic = 1.82). However, when separate t-tests were conducted independently for each subtest at each level of gender, male children with Hb >= 12 achieved higher scores on all the GMT subtests including the total score. However, this association only reached statistical significance for the Maths 1 test where the mean for the group with Hb >= 12 was 7.54 (SD = 1.91) compared to the mean for the group with Hb < 12 of 6.84 (SD = 1.89), (p = .04) (Table 4.10a below). (Note that multiple t-tests do not account for the inflation of the level of significance due to family-wise error).

Table 4.10a: Male performance on the Maths test according to the two Hb groups

TEST	Hb < 12			Hb >= 12			t	df	p Values
	N	MEAN	(SD)	N	MEAN	(SD)			
Maths 1	37	6.84	(1.89)	174	7.54	(1.91)	2.04	209	0.04*
Maths 2	37	5.57	(1.82)	174	5.92	(1.98)	0.99	209	0.32
Maths 3	37	6.68	(2.51)	174	7.11	(2.58)	0.94	209	0.35
Maths 4	37	7.51	(3.59)	174	8.18	(2.92)	1.21	209	0.23
Total	37	26.59	(7.52)	174	28.76	(7.12)	1.66	209	0.10

- * = results significant at indicated level

Table 4.10b below indicates that for female children, on three of the four Maths subtests, as well as the total Maths score, the mean was higher in the group with Hb >= 12. However, for Maths 4 the pattern was reversed. Only for Maths 2 was the association with Hb groups statistically significant where the mean for the group with Hb >= 12 was 6.07 (SD = 1.98) compared to 5.41 (SD = 1.62) for the group with Hb < 12 (p = .04).

Table 4.10b: Female performance on the Maths test according to Hb categories

TEST	Hb < 12			Hb > = 12			t	df	p Values
	N	MEAN	(SD)	N	MEAN	(SD)			
Maths 1	44	7.45	(1.47)	228	7.54	(1.92)	0.35	74.5#	0.73
Maths 2	44	5.41	(1.62)	228	5.07	(1.98)	2.07	270.0	0.04*
Maths 3	44	7.16	(2.14)	228	7.71	(2.72)	1.28	270.0	0.20
Maths 4	44	9.04	(2.16)	228	8.61	(3.29)	1.11	87.1#	0.27
Total	44	29.07	(5.17)	227	29.96	(7.42)	0.97	81.6#	0.33

- # = estimated degrees of freedom where variances were unequal
- * = results significant at indicated level

However, the above Maths results should be interpreted cautiously. As has been mentioned above, a MANOVA, which takes account of repeated comparisons or family-wise error, indicated no gender or haemoglobin effect for the Maths subtests. The differences therefore, could be due to the multiple comparisons of the t-tests, computed separately for Hb levels as they do not necessarily take account of multiple comparisons.

4.3.4 The Effect of Hb Levels on the RAVLT

(1) Effect of Hb on the RAVLT Trials according to Gender

For both male and female children, Hb categories showed no statistical effect on RAVLT performance (Tables 4.11a and 4.11b).

Table 4.11a: Male performance on the RAVLT according to the two Hb categories

TEST	Hb < 12			Hb >= 12			t	df	p
	N	MEAN	(SD)	N	MEAN	(SD)			values
Trial 1	34	3.44	(1.16)	167	3.20	(1.32)	0.98	199	0.33
Trial 2	36	4.78	(1.57)	170	4.73	(1.53)	0.17	204	0.86
Trial 3	35	5.46	(1.34)	171	5.28	(1.64)	0.60	204	0.55
Trial 4	35	6.09	(1.88)	171	5.68	(1.83)	1.18	204	0.24
Trial 5	35	6.06	(2.09)	170	6.09	(1.96	0.10	203	0.92
Trial 1-5	34	25.97	(6.96)	165	25.05	(6.77)	0.72	197	0.47
Trial 7	34	4.73	(2.39)	162	4.94	(1.82)	0.42	41.4#	0.64

- # = estimated degrees of freedom where variances were unequal

Table 4.11b: Female performance on the RAVLT according to the two Hb categories

TEST	Hb < 12			Hb >= 12			t	df	p
	N	MEAN	(SD)	N	MEAN	(SD)			Values
Trial 1	42	3.45	(1.19)	220	3.29	(1.24)	0.75	260	0.45
Trial 2	43	5.16	(1.38)	225	5.09	(1.60)	0.28	266	0.78
Trial 3	43	5.63	(1.65)	225	5.89	(1.87)	0.87	266	0.39
Trial 4	43	6.16	(1.90)	226	6.40	(2.05)	0.71	267	0.48
Trial 5	43	6.49	(1.79	227	6.73	(2.15)	0.69	267	0.49
Total 1-5	42	27.02	(6.57)	220	27.59	(7.05)	0.48	260	0.63
Trial 7	42	5.09	(1.69)	203	5.35	(2.15)	0.72	243	0.47

(2) Changes in the RAVLT Scores across Trials 1-5

As the data consisted of a series of tests repeated five times on each child, a repeated measures of analysis of variance was performed using the complete data set to take account of the correlation among the repeated measurements of the RAVLT. The hypothesis of no time effect was rejected (Wilks' Lamda, p = .0001; DF = 4 and 455; F statistic = 174.1) with the conclusion that scores change over time. The next hypothesis tested was that of no interaction between time and sex, which was also rejected (Wilks' Lamda, p = .01; DF = 4 and 455; F statistic = 3.22). Thus the effect of sex on performance changes over time. Again, as seen in the univariate analysis, females show more improvement. The third hypothesis tested is that of no interaction between time and haemoglobin levels. This hypothesis could not be rejected and the conclusion is that haemoglobin levels do not affect the change in the scores over time.

4.4 OVERALL ANALYSIS BASED ON TOTAL SCORES BY GENDER AND Hb LEVELS

An analysis based on the CPM, Maths test and RAVLT total scores, showed that male students in the group with Hb > = 12 had a higher total score for the CPM, the Maths test and the SDMT (Tables 4.12a and 4.12b). The difference was significant only for the CPM where the group with Hb > = 12 had a mean score of 14,82 (SD = 4,54) compared with the group with Hb > 12 which had a score of 13.30 (SD = 2,66), (p = .008). However, an analysis based on an equal number of subjects for each Hb level, for the entire data set, showed no Hb effects (Wilks' Lamda, p = .15; DF = 4 and 421; F statistic = 1.68). There were no statistically significant effects of Hb on any of the tests. Again the sex variable had a strong effect (Wilks' Lamda, p = .0001).

Table 4.12a: Male performance on all the psychometric tests according to the Hb groups

TEST	**Hb < 12**			**Hb > = 12**			**t**	**df**	**p Values**
	N	MEAN	(SD)	N	MEAN	(SD)			
CPM	37	13.30	(2.66)	173	14.82	(4.54)	2.73	87.5#	0.008*
RAVLT	34	25.97	(6.96)	165	25.05	(6.77)	0.72	197.0	0.47
TRIAL7	34	4.73	(3.39)	162	4.84	(1.82)	0.47	41.4#	0.64
MATHS	37	26.59	(7.52)	174	28.76	(7.12)	1.66	209.0	0.10

- # = estimated degrees of freedom where variances were unequal
- * = results significant at indicated level

Table 4.12b: Female performance on all the tests according to Hb categories

TEST	Hb < 12			Hb >= 12			t	df	p Values
	N	MEAN	(SD)	N	MEAN	(SD)			
CPM	44	13.02	(2.05)	228	13.54	(3.18)	1.38	88.5#	0.17
RAVLT	43	27.02	(6.57)	220	27.59	(7.05)	0.48	260.0	0.63
MATHS	44	29.07	(5.17)	227	29.96	(7.42)	0.97	81.6#	0.33
TRIAL7	42	5.09	(1.69)	203	5.35	(2.15)	0.72	243.0	0.47

- # = estimated degrees of freedom where variances were unequal
- * = results significant at indicated level

4.5 SUMMARY

The results on overall performance on the used psychometric tests showed no age differences. There were significant gender differences. Males performed significantly better on both the CPM and the SDMT. The pattern of better performance by males on the CPM was consistent over all of its subsections. Female children performed significantly better on the RAVLT. The pattern was also consistent for all the subsections of this test. There were no significant gender differences on the Maths test. Hb/iron levels did not have any significant impact on performance on all the tests that were used.

CHAPTER 5

DISCUSSION AND CONCLUSION

5.1 DISCUSSION

This section discusses the current results comparing them to past research results. The discussion will first be according to the overall performance of the children on the administered psychometric tests, and then the effect(s) of iron levels on these tests and the skills they purport to measure. There are some inconsistencies that are found from previous research studies. Some of the results from this study may help to shed some light on questions that already exist in this area of research. The study therefore highlights the need for properly standardized psychometric instruments for black, Zulu-speaking rural children, as well as for other African children who can be considered as disadvantaged. As a result, a lot of questions remain unanswered.

5.1.1 Performance on the Psychometric Tests

Overall performance of the children in the current study was lower than norms given for previous research studies. These low scores can be attributed to a variety of reasons which include the fact that the tests had to be administered to a group of children versus individual administration. The instructions were also given in Zulu and words had to be translated as well. For the RAVLT, children were required to write down their responses as opposed to giving verbal responses. This put them at a disadvantage and their results may be more a reflection of speed of writing rather than their memory or processing of information.

It would appear that performance on all the administered tests is lower than most of the norms given for the tests. This may be due to a variety of reasons some of which have already been mentioned. These basically include the format of administration, the group used and the language of administration. This overall low performance questions the applicability of the norms of the administered tests on Zulu speaking children. All these highlight the need for more research and design of psychometric instruments for black, disadvantaged children whose first language is not English.

(1) Performance on the RAVLT

On the RAVLT performance of the children in the current study was much lower than the performance of the eight to ten year old children in other studies (MacPherson's, 1991; Spreen & Straus, 1991; Murdoch et al., 1994). The results indicated no proactive interference, which would be indicated by a recall of fewer words on Trial 6 than on Trial 1. Thus, learning and repeating List A did not in any way interfere with learning new information (List B). There was better performance, on list B (Trial 6) than on Trial 1 of List A. It would appear that the children were perhaps more alert and attentive which may have enhanced their learning of new information. No retroactive interference was observed either as the decrease in the number of words recalled on Trial 7 was not by more than one point compared to recall on Trial 5 (i.e. just before the distraction). According to Spreen and Straus (1991), a recall of one to two fewer words on the recall trial (i.e .Trial 7) as compared to Trial 5 is to be expected for a normal population.

The learning curve reflected in the number of words recalled as the number of trials progresses was not adequate for the children in this study as compared to what Spreen and Strauss (1991) suggested, i.e remembering two more items on each successive trial. The children seemed to have remembered an average of one point on each successive trial. Again, this could be a reflection of writing speed rather than memory itself.

The current outcomes on the effect of sex on performance, i.e. females performing better than males on the RAVLT were the same as what other researchers found (Peaker & Stewart, 1989; Geffen et al., 1990; Lezak, 1995). Better female performance was believed to be due to their superior verbal abilities (Peaker & Stewart, 1989; Lezak, 1995). However, this could not have been the case in this study as the RAVLT was administered in a written format. Better female performance could be due to females' better writing and/or finger dexterity resulting in better writing speed. The gender differences were also contradictory to the fact that Lezak (1995) reported that general ability contribute significantly to performance on this test. Although males performed significantly better on the CPM, a test of intellectual ability, they still had lower scores on the RAVLT. Wiens et al. (1988), on the other hand, found no sex differences on the RAVLT. It should be noted however, that only 13% of the subjects in their study were female. Murdoch et al. (1994) reported that females tend to lag behind in performance, although they did not report a significant lower performance by females. Thus, there is an indication of probable gender differences but it is still not clear which gender outperforms the other.

(2) Performance on Raven's CPM

According to norms given in Raven, Court and Raven (1990), the overall performance of the children on the CPM, was at the tenth percentile which is graded as below average in intellectual capacity or as an equivalent of an IQ of 80. The exact same results are found if they are compared with normative data found in Spreen and Strauss (1991). The low performance of a large group of children, who at least seem to be coping well at school may be a reflection of either the way the test was administered or that the current test norms are not applicable to this group of children.

Results and consequent statements on gender differences have been contradictory and inconclusive. Spearman (1923, in Court, 1983) "claimed that there is no evidence for a superior level of the innate "g" factor in either sexes, yet on tasks of general ability males are superior to females and on tasks involving eduction of spatial relations and correlates ..." (p. 55). Spreen and Strauss (1991) did not report any superior performance by either males or females. Esquivel (1984) claimed that children of both sexes perform equally well on the CPM under any circumstances. Raven (1948, cited in Court, 1983) placed little importance on the question of gender differences and stated that data was not sufficient to investigate such differences However, there have since been research studies that allude to sex differences and more investigation into the issue may be imperative. Court (1983) reviewed several studies, of which eight of them reported significant better performance by males, two reported significant better achievement by females while two of them found no significant gender effects. In the current study, males performed significantly better than females which seems to be somehow consistent with results reported by Measso et al. (1993).

(3) Performance on the SDMT

The overall performance of children on the SDMT in the sample was much lower than the norms given by Smith (1982) for the eight to nine year old children. Their scores were also lower than the scores of the children in MacPherson's (1991) study. It should be noted that although the SDMT can be administered to a group, this is not considered as the best option as in involves visuo-motor speed and integration which the verbal administration format does not demand of a respondent (Smith, 1982). This could have had an impact on the performance and the results on this test or perhaps the question of the applicability of this test to this sample of children is a question which needs to be examined.

Some research studies have reported superior female performance on this test (Smith, 1982; Polubinski & Melamed, 1986; Mann et al., 1990; Wong & Gilpin, 1991; Williams et al., 1993). Superior female performance has been attributed to greater speed and accuracy in writing by females (Smith, 1982). Polubinski and Melamed (1986) attributed superior female performance to differences in cerebral organisation. It is however, still not known whether the difference in performance between the sexes reflect differences in the speed of oculomotor processes, simple mental processes, or complex and cerebral processes (Smith, 1982). Contradictory to those research reports, males in this study performed significantly better than females. For this study, this is not surprising considering that on the CPM males performed better than females. Waldmann et al. (1992) and Uchiyama et al. (1994) reported that intellectual ability and performance on the SDMT are related. There are other studies which found no significant gender differences on performance on the SDMT (Bowler et al., 1992; Waldmann et al., 1992).

(4) Performance on Young's GMT

According to the norms given in Young (1982) the overall performance of the children in this study was at a mathematics quotient of 89 which according to Young can be seen as an equivalent of an IQ of 89. He stated that (1982), "there is some evidence that general agreement between mathematic quotient and intelligence is to be expected" (p. 19). However, concluding that the children in the current study are at a low average level of intellectual functioning may not be justified. Currently there are no norms that can be considered to be representative of Zulu-speaking children. Furthermore, the test, which is in English, had to be translated into Zulu. As a result, the low performance of children on this test may be not be a valid indication of their potential. Performance on this test needs to be compared with other measures of mathematical ability (e.g. school grades for mathematics). There was a consistent trend for females to perform better than males in this study. Snow and Weinstock (1990) stated that males tend to outperform females on arithmetic problems. Furthermore, Zolten et al. (1994) claimed that the SDMT is supposed to predict reading and mathematics achievement. On the contrary, although male children performed better on the SDMT, they tended to lag behind in the Maths test.

5.1.2 Effect of Iron Levels on Cognitive Skills

These will be discussed according to the cognitive functions that, according to literature review, are expected to be affected by levels of iron in the body. Results from this study and other studies indicated that iron deficiency has a deleterious effect on some cognitive skills. The reason why low iron levels did not have much of an effect on cognitive skills could have been due to the fact that there were very few children with low iron levels. Furthermore, children falling within the lower end of iron deficiency were even fewer. This highlights the fact that more information is still needed on the effect of very low levels of iron on cognitive skills. In addition, because different results suggest an effect on different skills the question of exactly which cognitive skills are affected, through what mechanism is still not answered and needs further exploration.

Another reason why there were no significant effect of low iron levels on performance on the measures that were used could be due to the tests themselves. This tests had to be administered in groups although the ideal and best preferred method of administration is individual administration. In addition, the instructions as well as the actual method of administration had to be altered for the convenience of the current sample of children. The other problem could be that the tests were just not sensitive enough to tap into the cognitive skills that are affected by low iron levels. As a result the importance of designing psychometric tools that are more applicable to this area of research as well as populations such as those used in this study cannot be emphasised enough.

(1) Effect of Iron Levels on IQ

In the current study, lower levels of iron had some effect on children's IQ as those children with higher levels of iron performed significantly better than those with lower levels. However, the difference was only significant for male children when the disproportionate sample size was not controlled for. Some research results reported a definite impact of iron deficiency on IQ (Lozoff, 1989; Pollitt et al., 1989; Sigman et al., 1989; Levinger, 1994a; Brown & Pollitt, 1996). However, others found that there were no significant differences between the IQ scores of children with iron deficiency anaemia and those without iron deficiency anaemia (Soemantri et al., 1985; Argarwal et al., 1989; Soemantri, 1989; Soewendo et al., 1989). Thus, there are still some inconsistencies and with regard to the effects of iron deficiency on IQ the results are still inconclusive. Even some researchers found conflicting results. Seshadri and Gopaldas (1989) for instance, found an effect with the children who were seven to eight years old but found no significant effects with younger children of five to six years of age.

(2) Effect of Iron Levels on Acquisition and Assimilation of New Information

Learning and incorporation of new knowledge and information did not seem to be affected by levels of iron. These suggest the capacity to acquire new material and concepts and as a result learn new information remains intact. Haas and Fairchild (1989) obtained dissimilar results in their study where they stated that tests of learning were influenced negatively by iron deficiency. Soewendo et al. (1989) found that there were lower scores on concept acquisition and also asserted that they found the effect of iron to be more crucial in learning situations or repetition tasks. Thus, the results in this study differed from what other researchers have found.

(3) Effect of Iron Levels on Mathematical Achievement

Some research studies reported that children with iron deficiency had lower scores on mathematics skills (Pollitt et al., 1989; Goldman, 1995; Wharton, 1995). In this study, there was a tendency for children with higher iron levels to perform better on maths comprehension although the difference in performance was not significant. To some degree reasoning and verbal comprehension of given instructions were also affected. Seshadri and Gopaldas (1989) discovered that iron deficiency had a negative effect on verbal learning which could also be measured by an understanding of the instructions given during administration. According to Wharton (1995) the severity of iron deficiency and its duration are important in having an impact on performance. The lack of significant effects in this case, may have been due to the fact that there were fewer numbers of children with iron deficiency and the duration of the deficiency was not known.

(4) Effect of Iron Levels on Motor Skills and Speed

Information from research results indicates that iron deficiency has a deleterious effect on motor efficiency and speed (Soemantri et al., 1985; Lozoff, 1989). Seshadri and Gopaldas (1989) found that visual perception and visual discrimination are also affected. In this study, there was a tendency for iron deficient children to perform better on tests of visual perception, discrimination and motor speed as compared to those children with iron sufficiency, although the difference was insignificant.

(5) Effect of Iron Levels on Short-term Memory

Iron deficiency did not have a significant effect on short-term memory and/or immediate recall. There was no effect on either auditory or visual memory. These results were in agreement with Soewendo et al. (1989), who also found no significant effects of iron deficiency on short-term memory. Different outcomes were reported by Groner et al. (in Soewendo et al., 1989) and by Seshadri and Gopaldas (1989) where effects on short-term memory were reported. Other researchers also found significant lower scores on visual recall of children with iron deficiency and also that children without iron deficiency were faster in response and more accurate (Soemantri et al., 1985).

(6) Effect on Attention and Concentration

Research studies have reported the impact of iron deficiency on attention and concentration. Levinger (1994b) claimed that alertness, attention and concentration, which influence learning are significantly affected by iron deficiency. Significant attentional deficits as a result of iron deficiency were also reported in other studies (Soemantri et al., 1985; Lozoff et al., 1989). However, in this study, iron deficiency did not seem to have a significant impact on these skills.

Attention can also be used, in part, to explain the performance on other cognitive tasks as it involves the children's reception of information, interest and motivation which have an impact on how people will generally perform on tother tasks. This can also help to explain why there was no significant negative effects on other cognitive tasks. There are several problems with attention though. It is still not known which of the attentional processes, i.e., whether it is selective attention, attention span or vigilance, which are precisely involved. Furthermore, factors such as motivation and/or interest and physiological arousal can have an effect on attention.

It was noted that for most of the cognitive tasks there was some effect of iron deficiency but the effect was not significant. This can partly be due to the fact that there were much smaller numbers of children with iron deficiency which may have resulted in the insignificant effect.

5.2 SUMMARY OF RESULTS

From research results, there is some evidence that some of the cognitive skills of children with iron deficiency are affected negatively. Nevertheless, from the present study, it can be concluded that IQ, concentration, attention and short-term memory are not affected by low iron levels. Available information from literature and research is not consistent on this issue, and the mechanisms through which IQ and other skills reported by other researchers are affected are still not known. It is also not yet clear which cognitive functions are affected due to the disagreements in the findings from different studies. The unavailability of appropriate tests, which seems to be a major contributory factor, may be responsible for negative results, i.e., the tests used may not be sensitive and/or exhaustive enough to tap all or at least most of the consequences of iron deficiency. Another problem is the fact that data on the prevalence of micronutrient deficiencies, including iron deficiency, is still incomplete. As a result it is still difficult to target communities and develop public health programmes on the basis of what is available.

Nonetheless, achieving optimal cognitive development for better academic achievement should be a major priority for all people concerned with the education of children. Cognitive development is essential for the acquisition of skills and abilities that are necessary to progress satisfactorily at school. Promoting cognitive development for school-children is important for fostering formal education as education seems to lie at the heart of all efforts to assist the world's most disadvantaged people and appears to be the key to social and economic development. Thus, strategies are required to help children benefit from the education they receive, and it is imperative that studies be undertaken that will take into account the weaknesses of previous research designs.

5.3 CONCLUSION

In this, the final chapter, a critical look at the study is presented including information on what future research studies on factors similar to those in the current study can perhaps consider. From the results, it can be concluded that there are significant gender differences on performance on the RAVLT and on the SDMT but not on the CPM and the Maths test. Iron deficiency had no significant effect IQ, memory, learning and assimilation of new information, attention, concentration and arithmetic skills. The questions of, exactly which cognitive mechanisms are affected, the mechanisms through which these are affected, at which level of iron deficiency any negative impact is found, are still not answered with the implication that research in this field of work is still imperative.

5.3.1 Shortcomings and Strengths of the Study

An integrated discussion of both the limitations and the advantages that this study hold will now be discussed. This is also an indication of the contribution this study has made.

A possible bias of the study is the exclusion of those schools which were not easily accessible by road especially on rainy days, the exclusion of those schools that were considered to be small and those schools. However, it is also important to note that not every school in the area could be included in the study and that the current sample is big enough.

This study has found relationships and/or correlations between iron deficiency and lowered performance on some of the cognitive skills, e.g. IQ. However, due to the design that was used, the study still does not answer the question of causality. Furthermore, due to the exclusion of the iron replete category following the fact that serum ferritin was not measured and small numbers falling into that category, it is still hard to differentiate between the effects of mild, moderate and severe forms of iron deficiency. It is suspected that the mild and moderate forms of iron deficiency may be more common than the severe end of the spectrum (Lozoff, 1989; WHO/UNICEF/UNU report, 1994). This was compounded further by abandoning the third group due to the small number of subjects in that group. As a result, it is difficult to determine the point, in the continuum of iron deficiency, at which cognitive skills become affected.

Although the children selected for the study were from the same environment, parental factors such as their socioeconomic status, intelligence and education of parents and/or caretakers were not taken into consideration. These factors have been found to have a positive effect on the cognitive development of children following the fact that better educated parents have been found to provide a conducive environment that enhances those abilities responsible for better performance on cognitive tasks. In addition, they also provide early and continuing stimulation and motivation to their children hence improving their cognitive development (Grantham-McGregor, 1995). Besides, it has been documented that such parents have the knowledge to buy the food that have the essential micronutrients (Burger et al., 1993). Thus, there is a possibility that the children with lower iron levels may have a concurrent lack of other micronutrients which have been found to have deleterious effects on cognitive development. Such micronutrients conditions would include, for instance, protein-energy malnutrition which was found by other researchers to be the most common, and iodine deficiency (Jamison & Leslie, 1989; Seshadri & Gopaldas, 1989; Lozoff, 1989; Levinger, 1994a). Not having had breakfast in the morning has also been reported to have a negative effect on performance, at least for that day (Simeon & Grantham-McGregor, 1989). As a result, it cannot be determined with absolute confidence that the mentioned negative effects on cognition were exclusively due to iron deficiency. Again, these effects may also have been due to disproportionate sample sizes.

An additional factor is the consideration of the school environment, such as the availability of school materials, which could enhance cognitive development. Therefore, it also seems reasonable at this stage to keep asking whether alterations in affect, motivation or fatigue might underlie cognitive score findings or the load/amount of information or the nature of the tasks the subjects are required to process at a time.

Despite all the limitations, there are some points about this study which cannot be completely disregarded. The children in this study came from a relatively homogenous population in terms of cultural and/or traditional characteristics and practices. According to Sandstead et al., (1971) it seems likely that environmental factors such as "cultural deprivation" and environmental deprivation may contribute to children's development and performance on tests. Thus those effects were controlled for. Furthermore, as this was a community based study, potential biases involved with patient populations were minimized.

The study is also worth considering, especially with regard to the information that will add to the already available normative data. Currently there is very few available normative data on the psychometric tests, especially on Black South African children from a 'normal population'. Although the data in this study may not be considered to be the solution it certainly gives the basis for other research and design of programmes to alleviate the problem of inappropriate psychometric tests. Besides, the limitations pointed out in this study can be avoided in future designs. The validity of the observations in the study was strengthened by the size of the sample used particularly with children of the same age range from the same area, infra structurally. Younger, prepubescent children, were selected, thus avoiding the possible interfering effects of sexual maturation on cognitive development as well as controlling for the loss of iron in girls through menstruation. Furthermore, as the children were not too young, they could handle the stress of venipuncture.

About 23% of the children in the study were found to be iron deficient according to the classification categories used. In areas where the prevalence of iron deficiency in children is known, it can be estimated by using that of pregnant women in the same area. The expected percentage according to information available, which is estimated for South African children, was at least 35% (Levinger, 1994; WHO/UNICEF/UNU report, 1994). At the time of this study there was no known information about the epidemiology of iron deficiency for children in the area. A comforting fact is the point that there were fewer children with iron deficiency as compared to what was expected.

Although only a few children in this study could be classified as iron deficient, the relevance of the study is due to the reality that school age children from disadvantaged communities, by and large suffer from micronutrient deficiencies such that there is an undisputed need to study the effects of these deficiencies to be able to design programmes based on information. Most of the attention on such effects has been mainly focused on infants and preschool children.

The recommended method for measuring iron deficiency is two or more of the following variables: serum ferritin, transferrin saturation, serum ferritin, erythrocyte protoporphyrin and haemoglobin. For this study, iron deficiency was determined by the measuring of a combination of transferrin saturation and haemoglobin. It cannot be ignored therefore that two measuring factors were used, which is considered to be adequate especially where large samples are used.

5.3.2 Implications of the study and Recommendations for future Research and Implementations

It is more important to undertake intervention studies that will perhaps help in determining causality instead of knowing only the relationships between iron deficiency and cognitive function. A therapeutic response in Hb to iron supplements is seen as the best criterion for establishing iron deficiency. Iron supplementation studies can also help in determining the reversibility of iron deficiency and/or of its effects. In addition, such intervention studies can be focused on determining both the effects and causes of iron deficiency. It has been found that not only food deficient in iron is the cause of iron deficiency, but also factors such as parasite infections have been found to affect iron deficiency (Walter in Seshadri & Gopaldas, 1989; Pollitt, 1990; Levinger, 1994a). Such considerations will have implications for development of programmes that will assist in eliminating or decreasing the prevalence of iron deficiency considering that it has been associated with adverse effects on cognitive development.

There is a considerable need for finer investigations of consequences of milder forms of iron deficiency and determining when, along the continuum of iron deficiency, cognitive development is affected. Further studies need to control for other factors such as helminth infections, other micronutrient deficiencies, parental circumstances and socioeconomic status. At this point we cannot rule out whether a rigorous control of the social and economic environment might give different results. Variables such as arousal or the physiological state of children including hunger are known to have an effect on cognitive functions (Lozoff, 1989). Perhaps there is need to control for those factors in future studies.

Findings from the current study and other studies from other countries have implications for both clinical and public health interventions. The presence of the relationship between iron deficiency and less than optimal performance on cognitive tests which also have a negative impact on academic performance, warrants public health programmes. Such programmes must focus on iron deficiency, its effects on education and social and economic implications. These can also be a way of fostering collaboration between health workers and educationists. Firstly there is a need to understand how such child characteristics as health and nutrition status can impede cognitive development and thus learning. Then armed with that information, we must put it to use both in the classroom and in the community at large. Finally we must create a milieu at policy, school and community levels that will support these actions. All these, should be carried out concurrently. Thus, research and reports should be designed in such a way that they make it clear that the problem of iron deficiency affects both the health and the education of a child. Although the results on the effect of iron deficiency on cognitive skills were not definitive in this study, there was a tendency for children with lower iron levels to obtain lower scores. This could be due to the utilised tests not sensitive enough to tap into the cognitive skills are actually affected by low levels of iron.

Community awareness and participation is also important especially because parents play a major role in feeding their children. These can be done through public health and nutrition education. It will need to be determined how much support, material and otherwise, the educators would need to run such programmes. Remediation teaching, at school and/or at home would be needed by children whose learning ability had been impaired by health and micronutrient problems. The problem would be in knowing who is available and capable of offering such remedial education.

There is also need to determine the mechanisms through which iron deficiency affects behaviour, development and/or cognitive function. Currently the bulk of research on such mechanisms seems to focus mostly on animal models.

Finally, there is still a great need to search for tests that are more sensitive and specific. There is a high possibility that some of the skills that are affected by iron deficiency are not detected. This is more a reflection of the state of the art in this field which is in dire need for more culture appropriate tests and evaluation methods. Studies show that researchers who are trying to look at the same thing use different instruments which make it difficult to generalize results with absolute confidence. The design for better tests would thus improve the uniformity and standardization of results.

REFERENCES

Agarwal, D. K., Upadhyay, S. K., Agarwal, K. N., Singh, R. D. & Tripathi, A. M. (1989). Anaemia and mental functions in rural primary school children. **Annals of Tropical Paediatrics**, **9**, 194-198.

Anderson, J. R. (1990). **Cognitive psychology and its implications**. W. H. Freeman & Company: New York.

Anderson, J. R. (1995). **Learning and Memory**. John Wiley & Sons Inc.: Singapore.

Baddeley, A. (1995, June). Measures of memory and attention in evaluating the effects of ill health on cognition. A paper read at a symposium on, **A healthy body and a healthy mind? The relationship between cognitive function and physical illness.** The Wellcome Trust, Worcestershire.

Bissety, N. (1995, March). **The Nutri Digest newsletter**. (Available from the KwaZulu-Natal Primary School Nutrition Programme, Department of Health).

Boivin, M. J., Giordani, B., Ndanga, K., Maky, M. M., Manzeki, K. M., Nguni, N., & Muamba, K. (1993). Effects of treatment for intestinal parasites and malaria on the cognitive abilities of schoolchildren in Zaire, Africa. **Health Psychology**, **12**(3), 220-226.

Bourne, L. F., Dominowski, R. L., Loftus, E. F., & Healy, A. F. (1986). **Cognitive processes.** Prentice Hall, Inc.: Englewood Cliffs, New Jersey.

Bowler, R., Sudia, S., Mergler, D., Harrison, R., & Cone, J. (1992). Comparison of Digit Symbol and Symbol Digit Modalities Tests for assessing neurotoxic exposure. **The Clinical Neuropsychologist**, **6(1)**, 103-104.

Brown, J. L., & Pollitt, E. (1996). Malnutrition, poverty and intellectual development. **Scientific American**, Feb, 38-43.

Bruer, J. T. (1995, June). Mind, body and public health. Paper read at a symposium on, **A healthy body and a healthy mind? The relationship between cognitive function and physical illness**. The Wellcome Trust, Worcestershire.

Bundy, D. A. P. & Nokes, K. (1995, June). The partnership for child development and the cognition panel - an international programme to improve the health and education of children through school based services and research. Paper read at a symposium on, **A healthy body and a healthy mind? The relationship between cognitive function and physical illness**. The Wellcome Trust, Worcestershire.

Carlson, J. S., & Jensen, C. (1981). Reliability of the Raven Coloured Progressive Matrices Test: Age and ethnic group comparisons. **Journal of Consulting and Clinical Psychology**, **49**, 320-322.

Clarke, N. M. A., Grantham-McGregor, S. M., & Powell C. (1991). Nutrition and health predictors of school failure in Jamaican children. **Ecology of Food and Nutrition**, **26**, 47-57.

Crawford, J. R., & Parker, D. M. (1989). **Developments in Clinical and Experimental Neuropsychology**. London: Plenum Press.

Connolly, K. J., & Grantham-Mcgregor, S. M. (1993). Key issues in generating a psychological testing protocol. **American Journal of Clinical Nutrition Supplement**, **57**, 317s-318s.

Cook, J. D., Baynes, R. D., & Skikne, B. S. (1992). Iron deficiency and the measurement of iron status. **Nutrition Research Reviews**, **5**, 189-202.

Court, J. H. (1983). Sex differences in performance on Raven's Progressive Matrices: A review. **The Alberta Journal of Educational Research**, **29**(1), 54-74.

Dawes, A., & Donald, D. (eds.). (1994). **Childhood and adversity: Psychological perspectives from Southern African research**. Cape Town, Johannesburg: David Phillip.

Esquivel, G. B. (1984). Coloured Progressive Matrices. In, Keyser D. J. & Sweetland R. C. (Eds.). **Test critiques: Vol 1**. USA: Test Corporation of America.

Ewbank, R. (1993). **An Evaluation of the child supplementary feeding programme.** UNICEF: Harare.

Eysenck, M. W. (1993). **Principles of cognitive psychology.** Lawrence Erlbaum Associates: Hillsdale.

Filskov, S. B., & Boll, T. J. (1981). **Handbook of Clinical Neuropsychology**. New York: Wiley & Sons.

Franzen, M. D. (1989). **Reliability and validity in neuropsychological assessment**. New York: Plenum Press.

Frets-Van Buuren, J. J., Letuma, E., & Daynes, G. (1990). Observations on early s school failure in Zulu children. **South African Medical Journal**, **77**, 144-146.

Geffen, G., Moar, K. J., O'Hanlon, A. P., Clark, C. R., & Geffen, L. B. (1990). Performance measures of 16 to 86-year-old males and females on the Auditory Verbal Learning Test. **The Clinical Neuropsychologist**, **4(1)**, 45-63.

Grunenberg, M. M., & Morris, P. (1978). **Aspects of Memory**. Methuen & Co Ltd: London.

Haas, J. D., & Fairchild, M. W. (1989). Summary and conclusions of the international conference on iron deficiency and behavioural development, October 10-12, 1988. **American Journal of Clinical Nutrition**, **50**, 703-705.

Goldman, S. R. (1995). Relationships among illness, treatment and measurable changes in cognitive strategies in problem solving. A paper read at a symposium on, **A healthy body and a healthy mind? The relationship between cognitive function and physical illness**. The Wellcome Trust, Worcestershire.

Grantham-McGregor, S. M. (1995) The role of achievement in the cognitive development of malnourished children. A paper read at a symposium on, **A healthy body and a healthy mind? The relationship between cognitive function and physical illness**. The Wellcome Trust, Worcestershire.

Horowitz, F. D. (1989). Using developmental theory to guide the search for the effects of biological risk factors on the development of children. **American Journal of Clinical Nutrition**, **50**, 589-597.

Jamison, D. T., & Leslie, J. (1990). Health and nutrition considerations in education planning. 2. The cost and effectiveness of school-based interventions. **Food and Nutrition Bulletin**, **12(3)**, 204-214.

Jordaan, W., and Jordaan, J. (1989). **Man in context**. Johannesburg: Lexicon Publishers.

Katzellenbogen, J., & Joubert, G. (1991). Section B: Protocol development. In Katzellenbogen J., Joubert G., & Yach D (Eds.), **Introductory manual for epidemiology in Southern Africa**. SA: Medical Research council.

Kvalsvig, J., & Connolly, K. (1994). Health and psychological development among children in poor communities. In Dawes A. & Donald S. (eds.) **Childhood and adversity: Psychological perspectives from South African Research**. Cape Town: David Philip, 92-106.

Leahey, T. H., & Harris, R. J. (1993). **Learning and Cognition** (3rd ed.) Prentice-Hall, Inc.: New Jersey.

Leslie, J. & Jamison, D. T. (1990). Health and nutrition considerations in education planning. 1. Educational consequences of health problems among school-age children. **Food and Nutrition Bulletin, 12(3)**, 191-203.

Levinger, B. (1994a). **Nutrition, health and learning: Current issues and trends.** Nutrition Paper of the Month. UNICEF: New York.

Levinger, B. (1994b) **Nutrition, Health and Education for All**. New York: Beryl Levinger.

Lezak, M. D. (1983). **Neuropsychological Assessment**. Oxford: Oxford University Press.

Lezak, M. D. (1995). **Neuropsychological assessment**. Oxford: Oxford University Press.

Lozoff, B., & Brittenham, G. M. (1987). Behavioural alterations in iron deficiency. **Paediatric Haematology**, **1(3)**, 449-464.

Lozoff, B. (1989). Iron and learning potential in childhood. **Bulletin of New York Academic Medicine**, **65(10)**, 1050-1066.

Lozoff, B. (1989). Methodologic issues in studying behavioural effects of infant iron-deficiency anaemia. **American Journal of Clinical Nutrition**, **50**, 641-654.

Levinger, B. (1994). **Nutrition, Health and education for all**. New York: Beryl Levinger.

MacPherson, A. (1991). **A Pilot Study for Norms on the Rey Auditory Verbal Learning Test, the Symbol Digit Modalities Test and the Trail Making Test for Black South African schoolchildren**. Psychology Department, Natal University: Pietermaritzburg (Unpublished Honours project).

Malim, T. (1994). **Cognitive processes: Attention, perception, memory, thinking and language.** Macmillan Press LTD, London.

Mann, V. A., Sasanuma, S., Sakuma, N., & Masaki, S. (1990). Sex differences in cognitive abilities: a cross-cultural perspective. **Neuropsychologia**, **28(10)**, 1063-1077.

Martin, E. A. (Ed.) (1980). **Concise Medical dictionary**. Oxford University Press: Oxford.

Measso, G., Zappala, G., Cavarzeran, F., Crook, T. H., Romani, L., Pirozzolo, F. J.,Grigoletto, F., Amaducci, L. A., Massari, D., & Lebowitz, B. D. (1993). Raven's colored progressive matrices: a normative study of a random sample of healthy adults. **Acta Neurologica Scandinavica**, **88**, 70-74.

Morgan, C. T., King, R. A., and Robinson, N. M. (1981). **Introduction to Psychology** (6th ed.). Aukland: McGraw-Hill International Book Company.

Murdoch, B. D., Fleming, J. H., Skuy, M., Painter, A., Schmidt, L., and Achutte, E. M. (1994). **Neuropsychological performance of a group of selected asymptomatic black South African children.** Pretoria: Human Sciences Research Council.

Mwamwenda, T. S. (1989). **Educational Psychology: An African perspective**. Durban: Butterworths.

Nokes, C., Grantham-McGregor, S. M., Sawyer, A. W., Cooper, E. S., and Bundy, D. A. P. (1992). Parasitic helminth infection and cognitive function in school children. **Proceedings of the Royal Society of London - Series B, 247**, 77-81.

Nutri Digest. (March, 1995). Newsletter published by the Department of Health: KwaZulu-Natal Primary School Nutrition Programme.

Onwukeme, K. E., & Olomu, I. N. (1991). Haematological indices in African Children. **Tropical and Geographical Medicine**, 171-173.

Peaker, A., & Stewart, L. E. (1989). In, Crawford J. R. & Parker D. M. (Eds.). **Experimental Neuropsychology**. New York: Plenum Press.

Planned UNICEF assistance to accelerate improvements in the situation of children and women in South Africa: 1994-1996. (1994). UNICEF: Johannesburg, SA.

Pollitt, E., Hathirat, P., Kotchabhakdi, N. J., Missell, L., & Valyasevi, A. (1989). Iron deficiency and educational achievement in Thailand. **American Journal of Clinical Nutrition**, **50**, 687-697.

Pollitt, E. (1990). Malnutrition and infection in the classroom. **Food and Nutrition Bulletin, 12(3)**, 178-190.

Pollitt, E. (1993). Iron deficiency and cognitive function. **Annual Review of Nutrition**, **13**, 521-537.

Pollitt, E. (1996) Timing and vulnerability in research on malnutrition and cognition. **Nutrition Reviews**, **54(2)**, s49-s55.

Polubinski, J. P., & Melamed, L. E. (1986). Examination of sex differences on a Symbol Digit Substitution test. **Perceptual and Motor skills**, **62**, 975-982.

Prasad, A. N., & Prasad, C. (1991). Iron deficiency: non-haematological manifestations. **Progress in Food and Nutrition Science**, **15**, 255-283.

Raven, J. C., Court, J., & Raven, J. (1990). **Manual for Coloured Progressive Matrices: Section 2**. Oxford: Oxford University Press.

Raven, J. C. (1960). **Guide to using the Coloured Progressive Matrices: Sets A, Ab, B.** London: H. K. Lewis & Co Ltd.

Reed, S. K. (1988). **Cognition: Theory and applications.** Brooks/Cole Publishing Company: Pacific Grove, California.

Richter, L. M., Rose, C., & Griesel, R. G. (1994). **Cognitive and behavioural effects of a school breakfast programme**. Research report for Kellogg Co of South Africa (Pty) Ltd: Pretoria.

Rourke, B. P. (1981). Neuropsychological assessment of children with learning disabilities. In, Filskov S. B. and Broll T. J. (Eds.). **Handbook of clinical Neuropsychology**. New York: John Wiley and Sons.

Royer, F. L., Gilmore, G. C., & Gruhn, J. J. (1981). Normative data for the Symbol Digit Substitution task. **Journal of Clinical Psychology**, **37(3)**, 608-614.

Ryan, J. J., Geisser, M. E., Randall, D. M., & Georgemiller, R. J. (1986). Alternate form of reliability and equivalency of the Rey Auditory Verbal Learning Test. **Journal of Consulting and Experimental Neuropsychology**, **8(5)**, 611-616.

Sandstead, H. H., Carter, J. P., House, F. R., McConnell, F., Horton, K. B., & Van der Zwaag, R. (1971). Nutritional deficiencies in disadvantaged pre-school children: Their relationship to mental development. **American Journal of Diseases of Children**, **121(6)**, 455-463.

Selnes, O. A., Jacobson, L., Machado, A. N., Becker, J. T.., Wesch, J., Miller, E. N., Vischer, B., & McArthur, J. C. (1991). Normative data for a brief neuropsychological screening battery. **Perceptual and Motor skills**, **73**, 539-550.

Seshadri, S., & Gopaldas, T. (1989). Impact of iron on cognitive functions in pre-school and school-aged children: the Indian experience. **American Journal of Clinical Nutrition**, **50**, 675-685.

Sheard, N. F. (1994). Brief critical reviews: Iron deficiency and infant development. **Nutrition Reviews**, **52(4)**, 137-146.

Shelnes, D. H. K., McFarland, K. A., & Bain, J. D. (1990). Construct validity of eight tests of attention: Comparison of normal and closed head injured samples. **The Clinical Neuropsychologist**, **4(2)**, 151- 162.

Shuttleworth-Jordan, A. B., & Bode, S. G. (1995). Use of the SAWAIS Digit Symbol Test of Incidental Recall. **South African Journal of Psychology**, **25(1)**, 53-57.

Shuttleworth-Jordan, A. B., & Bode, S. G. (1995). Taking account of age-related differences on Digit Symbol and Incidental Recall for diagnostic purposes. **Journal of Clinical and Experimental Neuropsychology**, **17(3)**, 439-448.

Sigman, M., Neumann, C., Jansen, A. A. J., & Bwibo, N. (1989). Cognitive abilities of Kenyan children in relation to nutirion, family characteristics and education. **Child Development**, **60**, 1463-1474.

Simeon, D. T., & Grantham-McGregor, S. M. (1989). Effects of missing breakfast on the cognitive functions of school children of differing nutritional status. **American Journal of Clinical Nutrition**, **49**, 646-653.

Simeon, D. T., & Grantham-McGregor, S. M. (1990). Nutritional deficiencies and children's behaviour and mental development. **Nutrition Research Reviews**, **3**, 1- 24.

Smith, A. (1982). **Symbol Digit Modalities Test manual**. University of Michigan: WPS.

Snow, W. G., & Weinstock, J. (1990). Sex differences among non-brain-damaged adults on the Wechsler adult intelligent scales: A review of literature. **Journal of Clinical and Experimental Neuropsychology**, **12(6)**, 873-886.

Soemantri, A. G., Pollitt, E., & Kim, I. (1985). Iron deficiency and educational achievement. **The American Journal of Clinical Nutrition**, **42**, 1221-1228.

Soemantri, A. G. (1989). Preliminary findings on iron supplementation and learning achievement of rural Indonesian children. **American Journal of Clinical Nutrition**, **50**, 698-702.

Soewendo, S., Husaini, M., & Pollitt, E. (1989). Effects of iron deficiency on attention and learning processes in pre-school children: Bandung, Indonesia. **American Journal of Clinical Nutrition**, **50**, 667-674.

Spreen, O., & Straus, E. (1991). **A Compendium of Neuropsychological test, Administration, norms and commentary**. New York, Oxford: Oxford University Press.

nutrition: Schistosomes and soil-transmitted helminths. London, New York: Taylor & Francis.

Uchiyama, C. L., D'Elia, L. F., Dellinger, A. M., Selnes, O. A., Becker, J. T., Wesch, J. E., Chen, B. B., Satz, P. , Van Gorp W., & Miller, E. N. (1994). Longitudinal comparison of alternate versions of the Symbol Digit Modalities Test: Issues of form comparability and moderating demographic variables. **The Clinical Neuropsychologist**, **8(2)**, 209-218.

UNESCO. (1989). **First technical report of the new UNESCO project to improve primary school performance through improved nutrition and health**. (Nutrition Education Series, Issue 18) Paris: UNESCO, Division of Science Technical and Environmental Education.

Van der Vynckt, S. (1992/3). Primary school health: Where are we and where are we going? **Hygie, Vol. XI**, 45-49.

Waldmann, B. W., Dickson, A. L., Monahan, M. C., & Kazelkis, R. (1992). The relationship between intellectual ability and adult performance on the Trail Making Test and the Symbol Digit Modalities Test. **Journal of Clinical Psychology**, **48(3)**, 360-362.

Wade, C., and Tavris, C. (1993). **Psychology** (3rd ed.). New York: Harper Collins College Publishers.

Wharton, B. (1995, June). Iron deficiency and the brain: Mathematics and mechanisms. In, Paper presented for a symposium on, **A healthy body and a healthy mind? The relationship between cognitive function and physical illness**. The Wellcome Trust, Worcestershire.

WHO/UNICEF/UNU consultation (1994). **A Report on Indicators and Strategies for Iron Deficiency and Anaemia Programmes**. Geneva, Switzerland: World Health Organisation.

Wiens, A. N., McMinn, M. R., & Crossen, J. R. (1988). Rey Auditory-Verbal Learning Test: Development of norms for healthy young adults. **The Clinical Neuropsychologist**, **2 (1)**, 67-87.

Williams, J., Zolten, A. J., Rickert, V. I., Spence, G. T., & Ashcraft, E. W. (1993). Use of nonverbal tests to screen for writing dysfluency in school-age children. **Perceptual and Motor Skills**, **76**, 803-809.

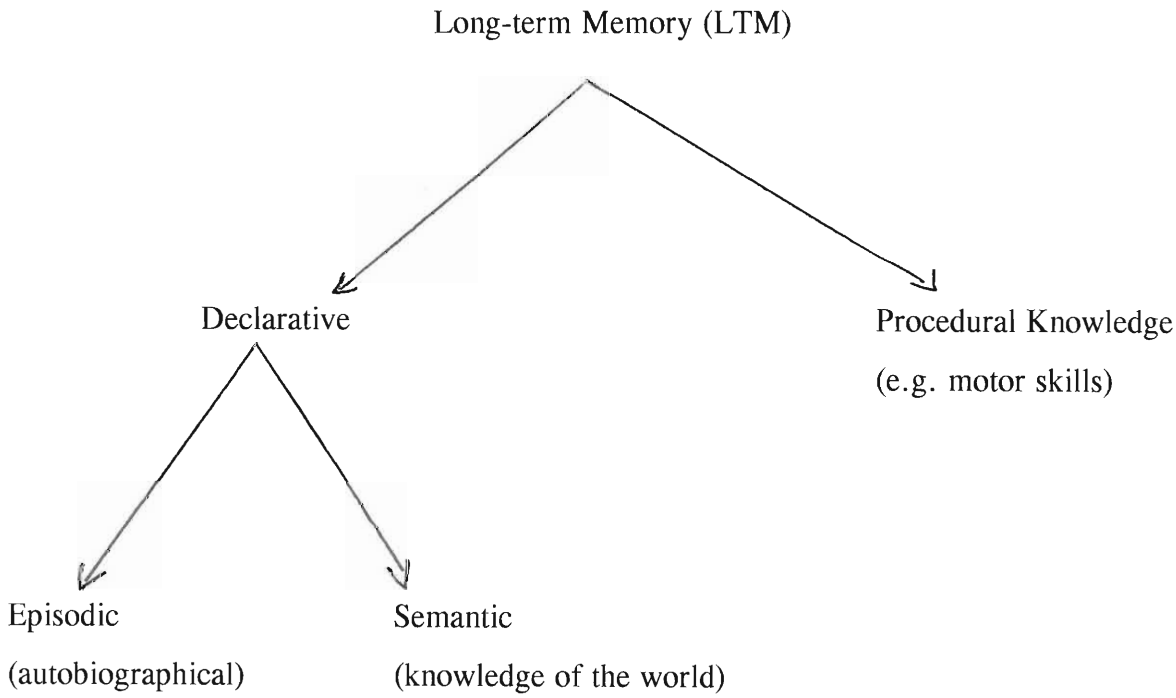
Wong, J. L., & Gilpin, A. R. (1991). Effects of speed vs accuracy instructions and field dependence on college students' Digit-Symbol matching performance. **Perceptual and Motor skills**, **73**, 314.

Zolten, A. J., Bush, L. K., Green, A., & Harrel E. H. (1994). Comparison of error rates and performance on Wechsler's coding and Digit Symbol subtests and the Symbol-Symbol test for children and adults. **Perceptual and Motor skills**, **79**, 1627-1631.

APPENDICES

APPENDIX A (1)

Summary illustration of Long Term Memory



APPENDIX A (2)

Summary of the Information -Processing Model

	Sensory Memory		Short-term memory		Long-term memory
Information/stimuli	1. Large capacity		1. Limited capacity		1. Unlimited capacity
from the environment	2. Has sensory	transferred	2. Brief storage of items	transferred	2. Storage thought to be
---------------------->	information	------------->	3. Conscious processing	--------------->	permanent
	3. Brief retention of		of information	retrieved	3. Information
	images			<--------------	organised and indexed
	forgotten		forgotten		

APPENDIX B

Summary Review of Research Studies on Effects of Iron Deficiency on Cognitive Function

Study	Classification Used
1. Soemantri et al. (1985) - Central Java Indonesia - Children mean age = 9.5 years	Classified them according to 1) iron replete/sufficient (Hb > 12.0 g/dL and % Tansferrin saturation (SAT > 20 %) 2) Iron deficiency anaemic (Hb < 11.0 g/dL and SAT < 15 %)
2. Lozoff (1989) - Costa Rico and Chile - conducted on infants	Classified according to anaemic vs nonanaemic (anaemia defined as Hb < 10.0 g/dL
3. Agarwal et al. (1989) - India on 6-8 year old children	Classified according to anaemic vs nonanaemic (anaemia also defined as Hb < 10.0 g/dL.
4. Pollitt et al. (1989) - Thailand on children of 9-11 years old	Classified according to (1) Iron replete (Hb > 12.0 g/dL, serum ferritin 10 ug/L) (2) Iron deplete (Hb > 12.0 g/dL and two of the following: SAT < 16%, FEP > 700 ug/L of RBC, serum ferritin < 10 ug/L and (3) Iron deficiency anaemic (defined by Hb < 12.0 ug/L and two of the parameters.
5. Soemantri (1989) - Indonesia - children with age = 10.4 years	Classified according to anaemic vs nonanaemic (anaemia defined as Hb 11.0 g/dL and SAT < 12 % and nonanaemic defined > 12.0 g/dL and SAT < 20 %)

6. Webb & Oski (in Soemantri, 1989) - Black American children - 12-13 years old	Classified according to anaemic vs nonaenamic (anaemia defined as 10.0 < Hb < 11.5 g/dL - and all the other children outside these values were excluded)
7. Soewendo et al. (1989) - Indonesia on preschool children	Classified children as iron replete, iron deplete (i.e. without anaemia and anaemia) but did not specify cut-off points.
8. Seshadri & Gopaldas (1989) - Several studies in India	
- children 5-8 years old	- Anaemia defined as Hb < 11.0 g/dL
- boys 5-6 years old	- anaemia defined as Hb < 10.5 g/dL
- girls 8-15 years	- anaemia vs nonanaemic (values not specified)
- boys 8-15 years	- anaemic vs nonanaemic (again values not specified)
9. Lozoff (1989) In Costa Rica on infants	Divided into anaemic (Hb <10,5 g/dL) and nonanaemic which was then subdivided into (1) Iron sufficient (serum ferritin > 12 ug/L, SAT > 10%, FEP < 1.77umol/L of RBC) (2)Iron depleted (serum ferritin < 12 ug/L) (3) Iron deficient (without anaemia) (low serum ferritin - not specified, and either a high FEP > 1.77 umol/L of RBC or a low SAT < 10 %)
10. Cook et al. (1992)	They classified according to iron replete, iron deplete, iron deficiency without anaemia and iron deficiency with anaemia. SAT - considered to be a reliable index of undersupply, Hb for boys < 13.o and for girls < 12.0 g/dL, and serum ferritin < 12 ug/L

11. Brief critical reviews (1994)	Classified into (1) iron deficiency anaemia (Hb < 10.5 g/dL, SAT < 10 %, serum ferritin < 12 ug/L) (2) Nonanaemic iron deficiency (Hb 12.0 g/dL, SAT < 10%,serum ferritin < 12 ug/L) (3) Iron sufficient (Hb> 12.0 g/dL, SAT > 19%, serum ferritin > 12 ug/L).

APPENDIX C

Zulu Instructions for Raven's Coloured Progressive Matrices

Vula ibhuku kumdwebo wokuqala (A 1) bese uthi:

Uma ubheka kulomdwebo (khomba umdwebo omkhulu), uzobona ukuthi kunengxenye engekho. Manje lapha ngenzansi sinezingxenye (khomba ingxenye ngayinye ngesikhathi). Iyinye isikwe ngokufanele ukuthi ingalingana lapha kulesisikhala (khomba futhi umdwebo omkhulu), kodwa yinye kuphela edwetshwe indlela efanayo nomdwebo ongenhla - ungasho ukuthi iyiphi?

Uma umvivinywa ekhomba unombolo 4 ithi "Yebo, iyona leyo efanelekile." bese uqhubeka nesivivinyo ngokuthi uthi: manje ngizokukhombisa eminye emidwebo. Ngamunye umdwebo kufanele uthole ingxenye kwezingenzansi ezofanelana nomdwebo ongenhla. Akesizame elandelayo.

Uma umvivinywa enza iphutha ku-A 1 ithi: cha, leyo akusiyona efanele, zama futhi. Uma umvivinywa ephumelela, muchazele ukuthi kungani impendulo yokuqala ingeyona. Uma umvivinywa eqhubeka nokunikeza izimpendulo ezingafanele kumzamo wesibili, muchazele ukuthi kungani lezi ezinye zingafanele ukuba izimpendulo.

APPENDIX D (1)

Rey Auditory Verbal Learning Test - Zulu Version

Name: Sex:

Age: DOB: School:

LIST A	T1	T2	T3	T4	T5	LIST B	A	B
isigubhu						itafula		
ikhethenisi						umelusi		
insimbi						inyoni		
ikhofi						isicathulo		
isikole						isitofu		
umzali						intaba		
inyanga						izibuko		
ingadi						ithawula		
isigqoko						ifu		
umlimi						isikebhe		
ikhala						imbuzi		
inkukhu						isibhamu		
umbala						ipensela		
indlu						isonto		
umfula						inhlanzi		
TOTALS						TOTALS		

RECALL LIST A: LIST B: LIST A:

Word List for Testing Ravlt Recognition:

UMYALELO: Ake manje ubheke lamagama angenzansi. Dwebela wonke lawomagama owabonayo kulawa angenzansi akade ekhona kuloluya luhla LOKUQALA (sisho phela lawomagama ebesikade silokhu siwaphinda-phinda).

insimbi	ikhaya	ithawula	isikebhe	izingilazi
iwindi	inhlanzi	ikhethenisi	ukushisa	amasokisi
isigqoko	inyanga	imbali	umzali	isicathulo
ingolobane	isihlahla	umbala	amanzi	uthisha
umelusi	ibhelunde	itafula	umlimi	istofu
ikhala	inyoni	isibhamu	ummbila	isidleke
izulu	intaba	ikhrayoni	ifu	inzingane

isikole	ikhofi	isonto	indlu	isibhubu
isandla	igundane	inkukhu	isihambi	uswidi
ipensela	umfula	isiphethu	ingadi	imbuzi

Word List for Testing Ravlt Recognition:

IMIYALELO: Ake ubheke lamagama angenzansi manje. Kresha noma shaya isiphambano (X) phezu kwawo lawomagagama owabonayo kuloluhla olungenzansi akade ekhona kuloluya luhla LOKUQALA. Ngisho phela lolu esize saluphinda-phinda kahlanu. Nanka-ke amagama ngenzansi. Khombula, kresha kuphela lawomagagama esiwaphinda-phinde kahlanu.

uzipho	ibhuku	uphahla	unyawo	amanzi
umoya	imoto	isibuko	itiye	ukhuni
ubuso	ingane	uthuli	ijezi	
inkomo	ibhala	umculo	isondo	ibhodwe
ugodo	usisi	indishi	umshini	isando
ubisi	intaba	ukudla	umunwe	ikati
isipuni	umuthi	ihlathi	umfana	isiginci
isifuba	igagasi	ibhola	ihhashi	udoli
insipho	ikhanda	iduku	ingubo	iphepha
inja	inyoka	ibhasi	isipikili	incwadi

APPENDIX D (2)

The Rey Auditory Verbal Learning Test - English Version

LIST A	T1	T2	T3	T4	T5	LIST B	B	A
drum						desk		
curtain						ranger		
bell						bird		
coffee						shoe		
school						stove		
parent						mountain		
moon						glasses		
garden						towel		
hat						cloud		
farmer						boat		
nose						lamb		
turkey						gun		
colour						pencil		
house						church		
river						fish		

TOTAL A1 to A5 = _____
TOTAL A6 - A5 = ______

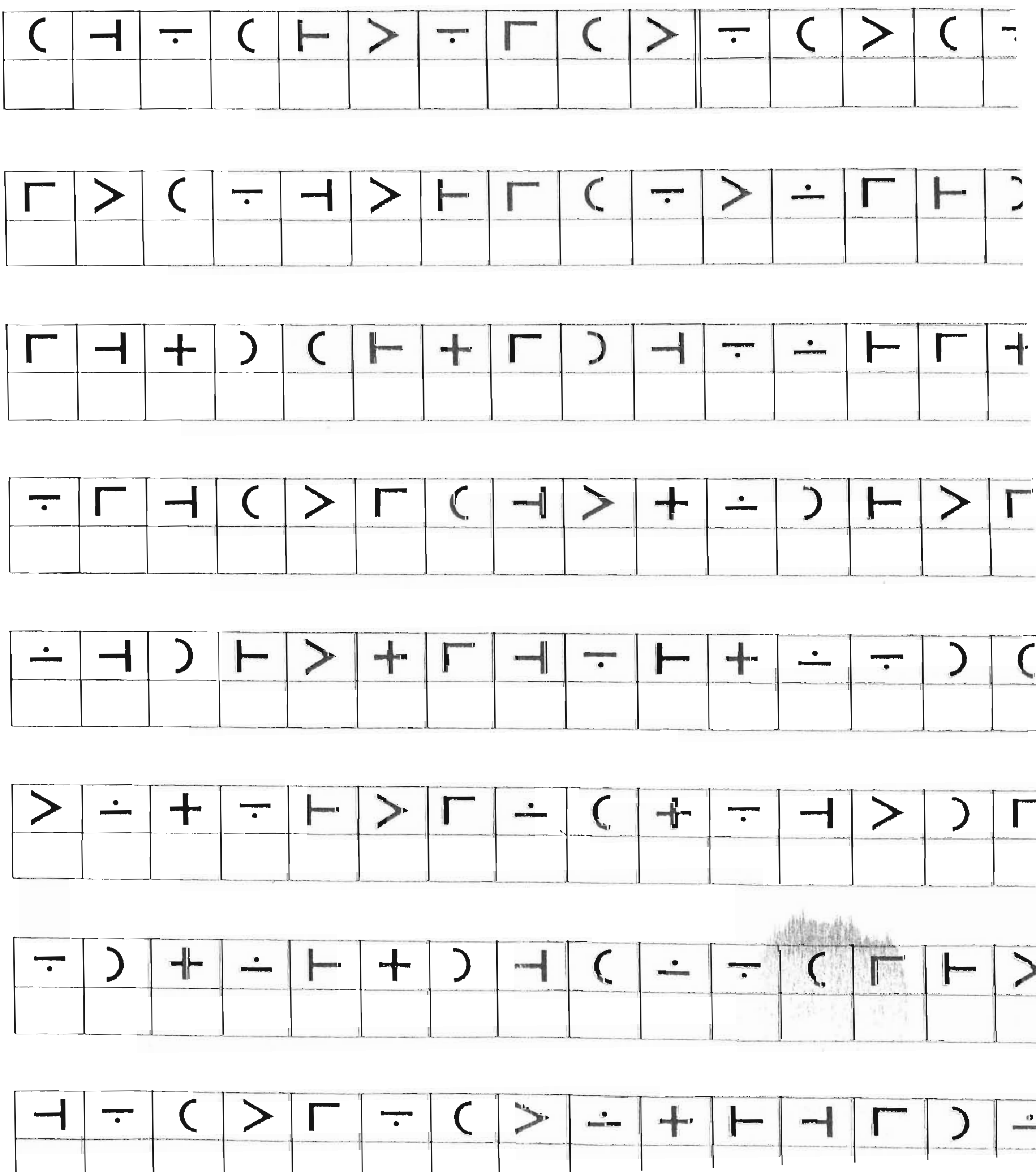
Word List for Testing RAVLT Recognition:

bell	home	towel	boat	glasses
window	fish	curtain	hot	stocking
hat	moon	flower	parent	shoe
barn	tree	colour	water	teacher
ranger	balloon	desk	farmer	stove
nose	bird	gun	rose	nest
weather	mountain	crayon	cloud	children
school	coffee	church	house	drum
hand	mouse	turkey	stranger	toffee
pencil	river	fountain	garden	lamb

APPENDIX E (1)

The Symbol Digit Modalities Test **KEY**

(	⨪	⊢	┌	⊣	>	+	)	∸
1	2	3	4	5	6	7	8	9



APPENDIX E (2)

Zulu Instructions for the Symbol Digit Modalities Test

Uma ubheka emabhokisini angenhla kulelikhasi, uzobona ukuthi ibhokisi lilinge emuqheni ongenhla (khombisa) linophawu oluhlukile kulona. Ngenzansi sinamanye amabhokisi amaningi, lilinye linenombolo ehlukile.

Manje, uma ubheka ngenzansi lapha (khomba umuqha wokuqala wamabhokisi ngaphansi kwesibonelo) uzoqaphela ukuthi amabhokisi angenhla anezimphawu, kodwa angenzansi awanalutho. Umsebenzi wakho ukuthi ugcwalise ngalinye lalawa mabhokisi ngenombolo ehambisana nalolophawu. Isibonelo (khomba uphawu lokuqala), uma ubheka uphawu lokuqala bese uya esibonelweni ngenhla uzobona ukuthi inombolo u-"1" ihambisana naloluphawu - gcwalisa-ke ngo-1. Iyiphi inombolo ongagcwalisa ngayo kwibhokisi lesibili? (Uma umvivinywa egcwalisa ngo 5, ithi "Yebo, iyona leyo efanele"). Manje, ukuze usilolonge, ngifuna ugcwalise wonke lawa asele uze ugcine kulomuqha bese uyama (qaphela indlela enzangayo bese ulungisa amaphutha uma ekhona - uphinde imithetho nqubo kufanele).

Manje, uma ngithi "qala" ngifuna ukuthi ugcwalise izinombolo kulawa mabhokisi asele ngangokusheshisa kwakho. Uma ufika ekugcineni komugqa (khomba ekugcineni komugqa wokuqala) qhubeka emugqeni olandelayo njalonjalo kuze kube ngiyakutshela ukuthi ima. Uma wenza iphutha, ungalokhu uzihlupha ngokulokhu uhlikiza, vele ubhale ngaphezulu. Okunye siza ungashiyi isikhala sebhokisi lingagcwalisiwe - yenza ngayinye ngesikhathi. Khumbula ukuthi usebenze ngokukhulu ukushesha. Ngabe usulungele ukuqala? Kulungile-ke, qala! (hambisa iwashi).

(Misa umvivinywa uma sekuphele imizuzwana engu-90 ncamashi eqalile).

APPENDIX F (1)

Youngs' Group Mathematics Test - English Version

In the oral sections, the question - with its immediate repeat - is read slowly and distinctly and 7 seconds is allowed before the next question. This is varied in two ways. The first two questions on the front page should be used to familiarise the children with the paper and with writing their answers on the dotted lines. The timing is of less importance than giving all possible help (short of correcting answers) and boosting confidence. But after the first two questions, the timing would be strict. The other exception to the 7 seconds limit is that for the clock question, 30 seconds is allowed.

INSTRUCTIONS TO THE CLASS (Guidance for the teacher alone is placed in brackets).

1. Front page, oral section

On your paper, you will see that there are some pictures. Each picture is in a sort of box. I'm going to ask you a question about each picture and you're going to write your answers on the dotted line in the box.

- APPLES: Point with your pencil to the apples on your paper. Now point to the largest apple. Below the apple there is a letter. Write the letter on the dotted line. (At each of these steps check that the children are following and repeat the instructions as often as necessary while giving help to any child who needs it).

- BOATS: Now point to the toy boats. Count the boats. Write. on the dotted line, the number of boats. (Check that the dotted lines are being used. Repeat question from 'Count ...' at least once).

- CUPS: Look at the cups. Two of the cups were broken. Write down how many were left. Two of the cups were broken. Write down how many were left.

- SERIES: Look at the numbers. One number has been covered up. Write down what you think that number is. Write it on the dotted line. One number has been covered up. Write down what you think that number is.

- SWEETS: The sweets. How many children can have two sweets each? Write down how many children can have two sweets each.

- LOAVES: The loaves. Write down how many you would have if you bought another loaf. Write down how many you would have if you bought another loaf.

- SHAPES: Look at the first shape. Find the shape that is exactly the same and write its letter. Write the letter of the shape that is exactly the same as the first one.

- TARTS: The tarts. How many tarts would be left if half of them were eaten? How many tarts would be left if half of them were eaten?

- RABBITS: Now find the rabbits at he top of the next column. Write down how many there would be if there were twice as many. Write down how many rabbits there would be if there were twice as many.

- TRIANGLES: I had a square of paper and I cut off part A. Write the letter of the part that was left. From a square of paper I cut off Part A. Write the letter of the part that was left.

- NUMBERS: Write down the number that has the most tens. Write the number that has the most tens.

- JARS: The jars. Each jar has a letter under it. Write the umber of the jar that is three-quarters full. Write the letter of the jar that is three-quarters full.

- SERIES: What is the number that has been covered up? Write it on the dotted line. What is the number that has been covered up? Write dit on the dotted line.

- BASINS: The basins. Each basin has a letter under it. Write sown the letter of the middle-sized basin. Write down the letter of the middle-sized basin.

- INTERSECTING CIRCLES: Write the letter that is in only two circles. Write the letter that is in only two circles.

2. Front page, computation section

This section, and the corresponding one on the reverse, are introduced by examples on the blackboard which the children read aloud. This ensures that no confusion arises from the teacher's use of language (add, plus, 'makes', subtract, minus, take away, etc.) which may be unfamiliar to the children. In some instances, where the children are from different schools or teachers, the teacher may need some alternative interpretations. Modify the introduction as necessary for older children.

Look at the blackboard. What does this say?
(Write 1 + 1 =) Yes. What is the answer? Good. (Write the answer). Now you have to do some more sums like this one. Write the answers on the dotted lines. Begin now. (Note the time and allow 8 minutes. Go round the class encouraging the children to make a start as necessary; correct them if they are re-writing the sums or using the wrong process. Stop after 8 minutes.

3. Back page, oral section

- FISH: Point to the bowls of fish. (Check).. Each one has a letter under it. (Pause). Write the letter of the bowl that has the most fish in it. Write the letter of the bowl that has the most fish in it.

- BIRDS: Look at the birds. One flew away. Write down how many were left. One bird flew away. Write down haw many were left.

- SQUARES AND CIRCLES: Write down how many squares have crosses. Write down how many squares have crosses.

- ENGINE: Look at the engine. There are some wheels on the other side which you cannot see. Write down how many wheels it has altogether. There are some wheels on the other side which you cannot see. Write down how many wheels it has altogether.

- CHOCOLATE: Look at the bars of chocolate. Write down the number of children who could have half a bar each. Write down how many children could have half a bar each.

- TREES: Now look at the trees. Each tree has a letter above it. Write down the letter of the fifth tree from the telegraph pole. Write down the letter of the fifth tree from the telegraph pole.

- KNIVES AND FORKS: How many people can have a knife and a fork each? Write down the number of people who can have a knife and a fork each.

- BAGS OF BRICKS: Now look at the bags of bricks. There are ten bricks in each bag. There are also some loose ones. Find them. Write down how many bricks there are altogether. There are ten bricks in each bag and some loose ones. Write down how many bricks there are altogether.

- CLOCK: Now find the clock at the top of the next column. What time does it say? Write it on the long dotted line. Write the time the clock says (Allow 30 seconds).

- SHAPES: Look at the first shape. Write the letter of the shape that is exactly the same. Write the letter of the shape that is exactly the same as the first one.

- CIRCLES: Write the letter of the circle that is bigger than the circle E and smaller than the circle B. Write down the letter of the circle that is bigger than the circle E and smaller than circle B.

- MARBLES: Your paper tells you how many marbles Dick had. Jim had twice as many. How many marbles had they altogether? Your paper tells you how many marbles Dick had. Jim had twice as many. How many marbles had they altogether?

- BRICKS: The bricks. How many bricks are there in the pile? How many bricks are there in the pile?

- BOXES: The paper tells you how many boxes of tomatoes the greengrocer had. Then he sold three and a half boxes. Write down how many boxes he had left. Write down how many boxes he had left after he had sold three and a half boxes.

- NUMBERS: Write the number that is different from the others. Write the number that is different form the others.

4. Back page, computation section.

(See remarks on the introduction of the front page of computation. Modify for older children).

Look at the blackboard. What does this say? (Write 2 - 1 =) Yes. What is the answer? Good. (Write the answer and similarly use the example 5-2=) Now you have to do some more sums just like these. You have plenty of time. Work carefully. Begin now. (Note the time and allow 8 minutes. Go round the class encouraging the children to make a start as necessary. If a child has added instead of subtracted, cross out his answers and help him to make a fresh start. This check is essential even for older children. Stop after 8 minutes.

APPENDIX F (2)

Young's Group Mathematics Test - Zulu Version

Kulesisigaba esikhulunywayo, imibuzo efundwa ngokuphindaphindwa, efundwa kancane nangesineke kanti futhi kulindwa imizuzwana eyisikhombisa ngaphambi kokuthi kufundwe umbuzo olandelayo. Lokhu kwenziwa ngendlela ehlukene kabili. Imibuzo emibili yokuqala, esekhasini elingaphambili, isetshenziselwa ukujwayeza umtwana iphepha lemibuzu kanye neigqa engamachashaza ekubhalelwa kuyo izimpendulo. Okwamanje, akubalilekile kakhulu ukugada isikhathi. Okubalulekile ukunikeza ingane lonke usizo olinganikezwa kanye nokukhulisa isibindi sengane. Kodwa-ke emveni kwalemibuzo emibili, ukugadwa kwesikhathi kubaluleke kabi. Okunye okwehlukile kulowomugomo wemizuzwana eyisikhombisa, ukuthi kulowombuzo ophathelene newashi, izingane sinikwa imizuzwana engamashumi amathathu ukuwuphendula.

<u>IMIYALEZO EBHEKISWE EKILASINI</u> (Ukubhekene nothisha kufakwe kubakaki)

1. <u>Ikhasa elingaphambili, eliyingxenye okukhulunywayo</u>.

Ephepheni lakho uzobona izithombe ezithile. Isithombe ngasinye sisebhokisini elithile. Ngizo kubuza umbuzo ngsithombe ngasinye, wenake uzobhala izimpendulo zakho emigqeni engamachashaza esebhokisini.

- AMA-APHULA: Ngephensela lakho khomba ama-aphula ase phepheni. Manje khomba elikhulo kunawo wonke. Ngaphansi kwalelo aphula kunohlamvu. Bhala lolohlamvu emigqeni engamachashaza. (Kuleso sinyathelo naleso sinyathelo bheka ukuthi abantwana bayalandela, kanti-ke futhi phinda phinda imiyalezo kaningi njengoba kudingekile, ube unika usizo kulabobantwan abaludingayo).

- IZIKEBHE: Manje khomba izikebhe. Zibale. Bhala emigqeni engamachashaza inani lalezo zikebhe. (Bheka ukuthi imigqa engamachashaza eyasetshenzisiwa. Phinda umbuzo kusukela egamini elithi "zibale...", okungenani kanye).

- IZINKOMISHI: Bheka izinkomishi. Ake sithi ezimbili zalezinkomishi ziyafa. Bhala ukuthi zingaki ezingasala. Ake sithi ezimbili zalazinkomishi ziyafa. Bhala ukuthi zingaki ezingasala.

- UHLA LWE ZINAMBA: Bheka uhla lwe zinamba. Eyodwa yalezi namba icashisiwe. Bhala leyonamba ocabanga ukuthi hhiyo ecashisiwe. Yibhale emgqeni engamachashaza. Eyodwa yelezinamba ecashisiwe. Bhala leyonamba ocabanga ukuthi hhiyo ecashisiwe. Yibhale emgqene engamachashaza.

- OSWIDI: Bangaki abantwana abangathola amaswidi amabili emunye. Bangaki abantwana abangathola amaswidi amabili emunye.

- OLOFU BEZINKWA: Bangaki olofu bezinkwa angabanabo uma uthenga omunye ulofu. Bangaki olofu bezinkwa ongabanabo uma uthenga ulofu.

- IZIMPHAWU: Bheka uphawu lokuqala. Kulezimphawu ezilandelayo, bheka uphawu elifana ncimishi nophawu lokuqala. Bheka uphawu olufana ncimishi nophawu lokuqala.

- AMAKHEKHE: Mangaki amakhekhe angasala uma uhhafu walawo makhekhe edliwa? Mangaki amakhekhe angasal uma uhhafu walawo makhekhe edliwa?

- ONOGWAJA: Manje tholo onogwaja engxenyeni engaphezulu elandelayo. Bhal ukuthi bangababangaki abangaba khona uma bephindwaphindwa kabili kulelinani abahhilo. Bhala ukuthi bangababangaki abangaba khona uma be phindwaphindwa kabili kulelinani abahhilo.

- ONXANTATHU: Nginephepha eliyisikwele, ngase ngisika ingxenye noma ucezu A. Bhala ingxenye noma ucezu lwephepha olungasala uma ngisika ucezu A. Bhala ingxenye noma ucezu olungasala uma ngisengisike ucezu A.

- IZINAMBA: Ujeke ngamunye onohlamvu ngaphanxi kwawo. Bhala uhlamvu likajeke ocishe ugcwale. Bhala uhlamvu likajeke ocishe ugcwale.

- UHLA LWEZINAMBA: Iyiphi inamba ocabanga ukuthi icashisiwe. Iyiphi inamba ocabanga ukuthi icashisiwe. Ibhale emgqeni ongamachashaza.

- IZINDISHI: Indishi ngayinye onohlamvu ngaphansi kwawo. Bhala uhlamvu lwendishi ephakathi nendawo ngobukhulu. Bhala uhlamvu lwendishi ephakathi nendawo ngobukhulu.

- ORAWUNDI: Bhala uhlamvu oluphakathi korawundi ababili kuphela. Bhala uhlamvu oluphakathi korawundi ababili kuphela.

2. Ikhasi elingaphambili, isigaba sokubala.

Lesisigaba, kanye nesihambisano naso esingemuva, saziwa ngokwenza isibonelo ebhodini. Kufanele izingane zifunde lesibonelo kakhulu. Lokhu kuqiniseka ukungabikhona kokudideka, okungenzeka umangabe uthisha esebenzisa amagama afana lalawa (hlanganisa, yenza, susa, cezula, thatha, njalonjalo), ekungasekwenzeke ukuthi izingane aziwazi noma azikazi ziwezwe. Kwesinye isikhathi, lapho izingane ziphuma ezikoleni noma kothisha abangafana, uthisha kungamele anikeze incazelo ehlukile. Lungisa isaziso ngendlela efanele kubantwana abadadlana.

Buka ebhodini. Kuthini lokhu? (Bhala 1+1=) Yebo. Ithini impendulo. Kuhle. (Bhala impendulo). Manje kuzomele wenze izibalo eziningana, ezithi azifane nalesi. Uzobhal impendulo yakho emigqeni engamachashaza. Qala-ke manje. (Bheka isikhathi, vumela imizuzu eyishakalombili, 8. Hambahamba ekulasini, ukhuthaze izingane ukuthi zeqale ngokufanele, balungise uma bephindaphinda izibalo noma besebenzisa indlela okungsiyona. Bamise emveni kwemizuzu eyishagalombili (8).

3. Ikhasi elingasemuva, isigaba ekukhulunywa kuso.

- IZINHLANZI: Khomba izindishi esinesinhlanzi . (Bheka). Iyinye ngayinye enohlamvu ngaphasi kwayo. (Yima). Bhala uhlamvu lwendishi enezinhlanzi eziningi kuyo. Bhala uhlamvu lwendishi enezinhlanzi eziningi kuyo.

- IZINYONI: Bheka izinyoni. Akesithi eyodwa iyandiza. Bhala ukuthi singaki ezingasala. Akesithi eyodwa iyandiza. Bhala ukuthi singaki ezingasala.

- IZIKWELA NORAWUNDI: Bhala ukuthi zingaki izikwela ezineziphambano. Bhala ukuthi zingaki izikwela ezineziphambano.

- ITRAGI: Bheka itragi. Kukhona amasondo ongenakuwabona kwenye ingxenye yetragi. Bhala ukuthi mangaki amasondo letragi enawo uma esehlangene wonke. Bhala ukuthi mangaki amasondo letragi enawo uma esehlangene wonke.

- OSHOKOLETI: Bheka oshokoleti. Bhala ukuthi bangaki abantwana abangab nohaffu kashaokoleti emunye. Bhala ukuthi bangaki abantwana abangaba nohhafu kashokoleti emunye.

- IZIHLAHLA: Bheka izihlahla. Isihlahla ngasinye sinohlamvu ngaphansi kwaso. Bhala uhlamvu lwesihlahla esingesokuhlanu ukusuka esigzotsheni esikagesi. Bhala uhlamvu lsesihlahla esingesokuhlanu ukusuka esigxotsheni esikagesi.

- IMMESE NEZIMFOLOGO: Bangaki abantu abangaba nommese nemfologo eyedwa. Bangaki abantu abangaba nommese nemfologo eyedwa.

- AMASAKA EZITINI: Manje bheka amasaka ezitini. Kunezitini eziyishumi esakeni ngalinye. Kunezinye ezingaphandle. Bhala ukuthi zingaki izitini ezikhona sezizonke. Kunezitini eziyishumi esakeni nglinye. Kunezinye ezingaphandle. Bhala ukuthi zingaki izitini ezikhona sezizonke.

- IWASHI: Manje thola iwashi esikhaleni esilandelayo esingenhla. Sithini isikhathi esikhonjiswa noma esishiwo yileliwashi. Sibhale emugqeni ongamachashaza. Bhala isikhathi esishiwo yileliwashi.

- OLAYINI: Bheka ulayini wokuqala. Manje-ke bheka olayini abalandelayo. Bhala uhlamvu likalayini ofana ncimishi nalowo wokuqala. Bhala uhlamvu likalayini ofana ncimishi nalowo wokuqala.

- ORAWUNDI: Bhala uhlamvu likarawundi omkhulu kunorawundi ongu E, ube umcane kunorawundi ongu B. Bhala uhlamvu likarawundi omkhulu kunorawundi ongu E, ube umcance kunorawundi ongu B.

- AMABHOLA: Iphepha lako liyakutshela ukuthi uSipho wayenabhola amangaki. UThembi wayenenani lamabhola eliphindaphindwe kabili kulelonani likaSipho. Bhala ukuthi ayemangaki amabhola ababenawao esewonke. Iphepha lakho liyakutshela ukuthi uSipho wayenamabhola amangaki. UThembi wayenenani lamabhola eliphindaphidwe kabili kulelonani likaSipho. Bhal ukuthi ayemangaki amabhola ababenawo esewonke.

- IZITINI: Zingaki izitini eqoqweni. Zingaki isitini eqoqweni.

- AMABHOKISI: Iphepha lakho liyakutshela ukuthi umthengi wayenamabhola amangaki. Akesithi lomthengi udayisa amathathu nohhafu. Bhala ukuthi mangaki amabholkisi azosala nawo emveni kokuba esedayise amathathu nohhafu.

- IZINAMBA: Bhala inamba ehlukile kunezinye. Bhala inamba ehlukile kunezinye.

4. <u>Ikhasi elingemva, isigaba sokubala.</u>

(Bheka imiyalezo lapho kwaziswa khona isigaba sokubala, ephepheni elingaphambili lokubala. Lingisa isaziso ngendlela efanele, kubantwana abadadlana).

Bheka ebhodini. Kuthini lokhu? (Bhala 2-1 =) Yebo. Ithini impendulo? Kuhle. Manje kuzofanele wenza izibalo eziningana ezifana nelezi. Unesikhathi esanele. Sebenza noma bhala ngokuchophelisisa. Qala-ke manje. (Bheka isikhathi, banike imizuzu eyisishagalombili. Hambamamba ekilasini, ugqugquzele abantwana ukuba baqale. Umangabe umntwana ehlanganisile esikhundleni sokususa, kilesha impendulo yakhe, bese umsiza aqale phansi. Lokukubheka kudingekile ngisho namubantwana abadala. Bamise emveni kwemizuzu eyisishagalombili.

APPENDIX G

SAMPLE OF THE ANSWER BOOKLET THAT WAS USED

RAVENS COLOURED PROGRESSIVE MATRICES (ANSWER SHEETS)

SECTION A	SECTION Ab	SECTION B
1.	1.	1.
2.	2.	2.
3.	3.	3.
4.	4.	4.
5.	5.	5.
6.	6.	6.
7.	7.	7.
8.	8.	8.
9.	9.	9.
10.	10.	10.
11.	11.	11.
12.	12.	12.

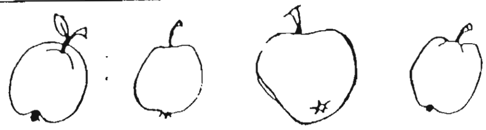
APPENDIX G

SAMPLE OF THE ANSWER BOOKLET THAT WAS USED

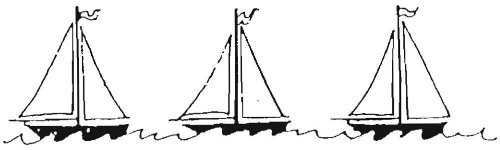
RAVENS COLOURED PROGRESSIVE MATRICES (ANSWER SHEETS)

SECTION A	SECTION Ab	SECTION B
1.	1.	1.
2.	2.	2.
3.	3.	3.
4.	4.	4.
5.	5.	5.
6.	6.	6.
7.	7.	7.
8.	8.	8.
9.	9.	9.
10.	10.	10.
11.	11.	11.
12.	12.	

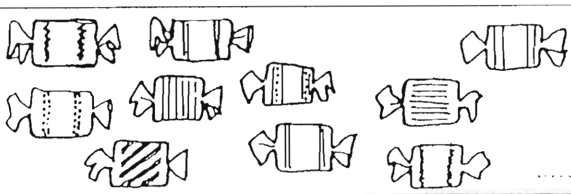
FORM A GROUP MATHEMATICS TEST D. YOUN

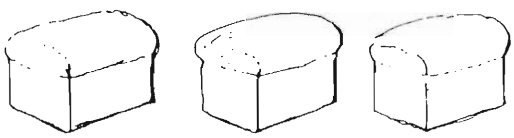


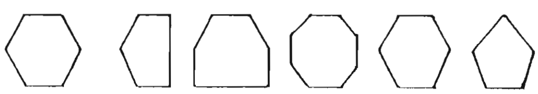
A B C D



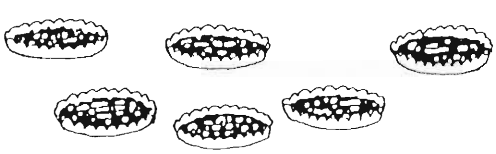
21, 22, 23, ____, 25

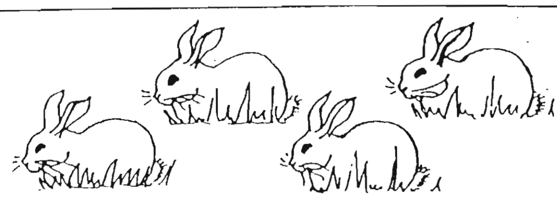


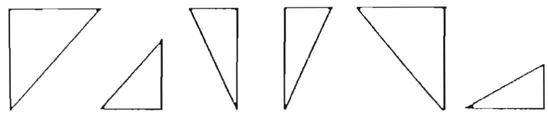




A B C D E





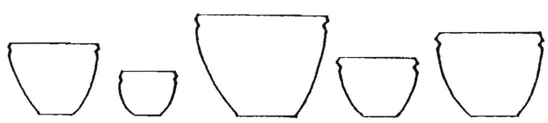


A B C D E F

26 63 48 19 71

A B C D E

10, 13, 16, ____, 22



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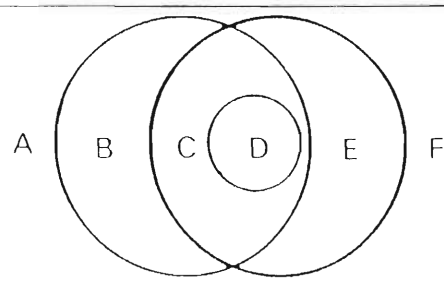
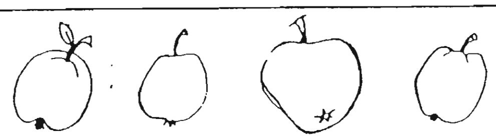
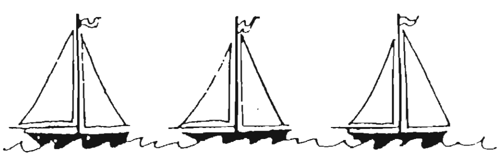
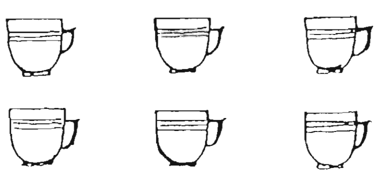


FORM A GROUP MATHEMATICS TEST D. YOUNG



A B C D





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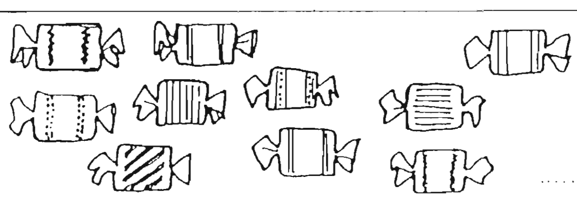

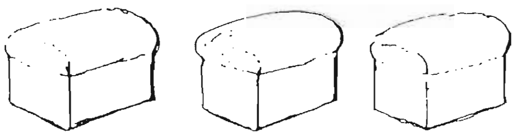

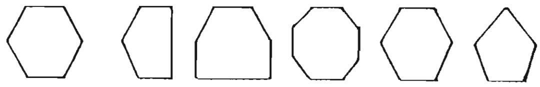

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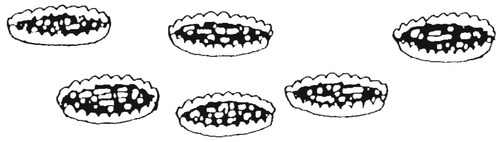

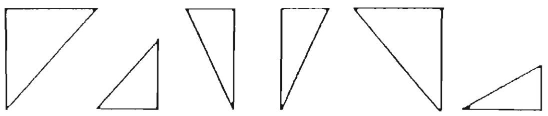

A B C D E F

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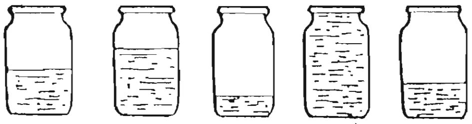

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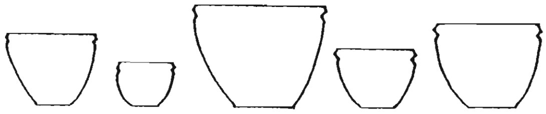
10, 13, 16, , 22



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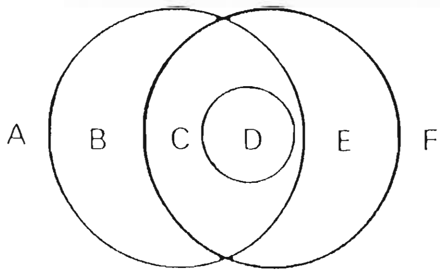

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7	+	9	=	....
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11	+	18	=	....
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62	+	37	=	....
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26	+	27	=	....
60	+	69	=	....
35	+	46	=	....
114	+	178	=	....

2	+	1	=	....
5	+	4	=	....
8	+	3	=	....
17	+	5	=	....
7	+	9	=	....
44	+	10	=	....
11	+	18	=	....
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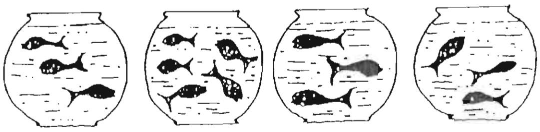

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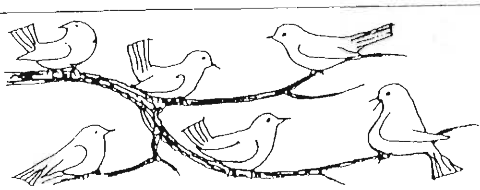

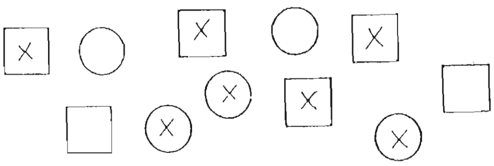

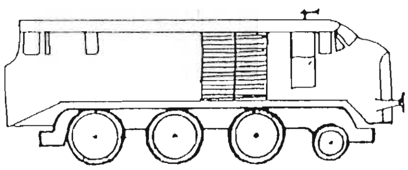

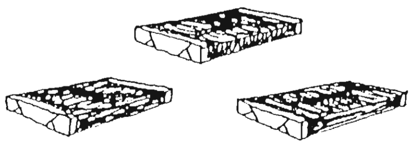

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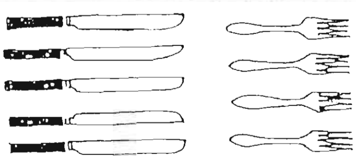

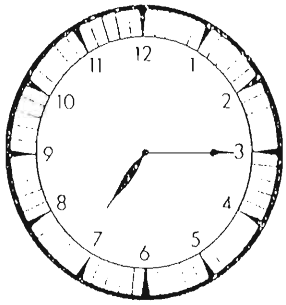

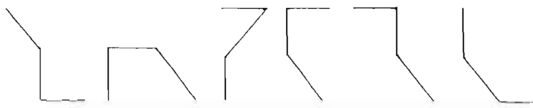

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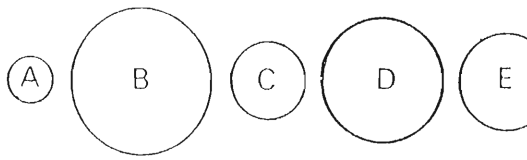

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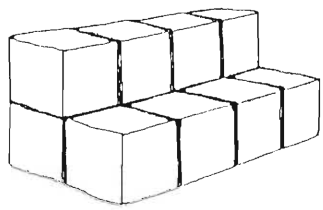
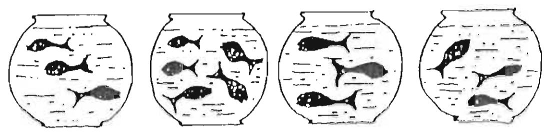


9 boxes

11 7

5 4 13

3



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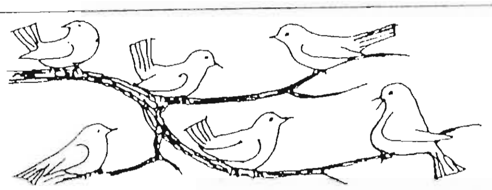

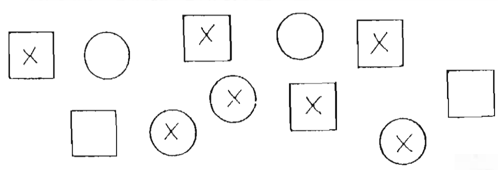

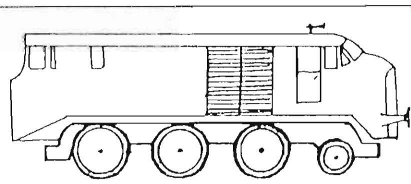

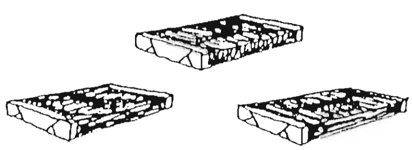

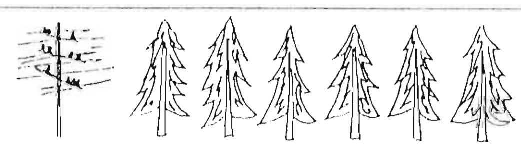

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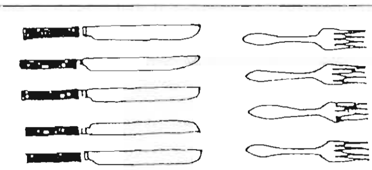

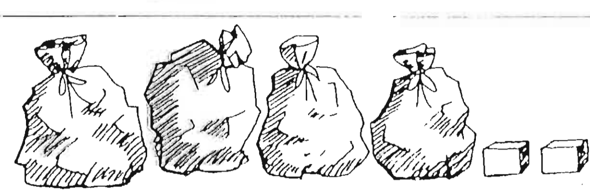

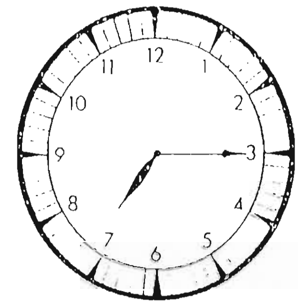

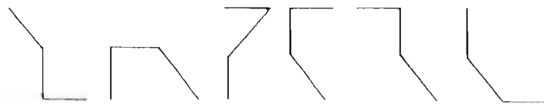

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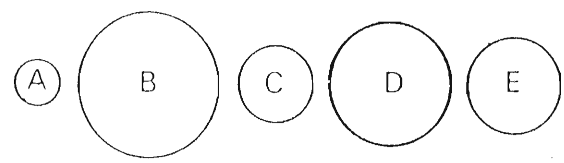

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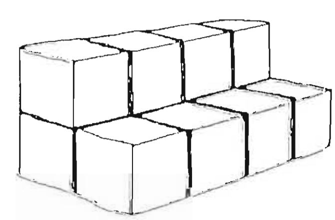

9 boxes

11 7
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20	−	14	=	....
42	−	7	=	....
38	−	18	=	....
40	−	16	=	....
73	−	21	=	....

APPENDIX H

THE CONSENT FORM THAT WAS SIGNED BY PARENTS

University of Natal
Faculty of Medicine
Department of Community Health
P. O. Box 17039
CONGELLA
4013

Bazali,

Izingane eziningi ziyashoda ngemisoco efana (Iron and Vitamin |A). Iningi lezingane endaweni yakini zinezikelemu kanye nesichenene. Lokhu kwenza impilo yabo ibentekenteke. Sicela imvume yakho ukuzihlola nokuzelapha. Onompilo bazobe bekhona ngesikahathi sokwelashwa.

Ngokujwayelekile azikho izinkinga kodwa uma usola ukuthi lokhukwelashwa kuyiphata kabi ingane yakho siza uxhumane .... clinic.

Mina .... mzali nginika imvume yomtwana wami............................... iminyaka .... ukuthi axilongwe futhi elashwe ngaba sebenzi base nyuvesi yase Natali.

Isayinwe ....

Usuku ....

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Isayinwe ....

Usuku ....

APPENDIX I

LETTERS OF PERMISSION GRANTED BY CIRCUIT INSPECTORS

G.P.-S. 81/142188 (Z 30)

MINUTE

REPUBLIEK VAN SUID-AFRIKA REPUBLIC OF SOUTH AFRICA

Verw. No./Ref. No.

Navrae/Enquiries:

Tel. No.

KANTOOR VAN DIE—OFFICE OF THE

Scottburgh Circuit
Box 83
Scottburgh
19

Die/The To All Affected Schools
SCOTTBURGH CIRCUIT

To whom it may concern.
The officials who visits your school have secured my expressed permission to work with you. Kindly allow them to have access to the required number of pupils so as to carry out their task.
Your co-operation will be highly appreciated

S.A. [illegible]
Circuit Inspector SCOTTBURGH.

DEPT. VAN ONDERWYS EN OPLEIDING
SOUTH COAST CIRCUIT MANAGER
145 SCOTT STREET
P.O. BOX 83
SCOTTBURGH
4180
TELEPHONE: 0323 - 81229
DEPT. OF EDUCATION AND TRAINING

APPENDIX I

LETTERS OF PERMISSION GRANTED BY CIRCUIT INSPECTORS

G.P.-S. 81/142188 (Z 30)

MINUTE

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SOUTH COAST CIRCUIT MANAGER
145 SCOTT STREET
P.O. BOX 83
SCOTTBURGH
4180
TELEPHONE: 0323 - 21229
DEPT. OF EDUCATION AND TRAINING

UHULUMENI WAKWAZULU
UMNYANGO WEMFUNDO NAMASIKO
DEPT. OF EDUCATION & CULTURE
UMZINTO CIRCUIT OFFICE
1995 -04- 24
PRIVATE BAG X0015
UMZINTO 4200
TEL: 0323 61947
KWAZULU GOVERNMENT SERVICE

TO PRINCIPALS OF SCHOOLS : UMZINTO CIRCUIT

THIS IS TO CONFIRM THAT THE BEARER MYRA TAYLOR AND FLORAH RANGONGO FROM THE UNIVERSITY OF NATAL CALLED AT THE CIRCUIT OFFICE TO SEEK PERMISSION TO CONDUCT A STUDY ON NUTRITION IN ALL THE SCHOOLS IN THE VULAMEHLO MAGISTRACY.

YOUR CO-OPERATION IN THIS ENDEAVOUR WILL BE HIGHLY APPRECIATED.

THANK YOU

CIRCUIT INSPECTOR

UHULUMENI WAKWAZULU
UMNYANGO WEMFUNDO NAMASIKO
DEPT. OF EDUCATION & CULTURE
1995 -04- 24
PRIVATE BAG
UMZINTO
KWAZULU GOVERNMENT SERVICE

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THANK YOU

CIRCUIT INSPECTOR

1418

Telegramadres: "LANDDROS"
Telegraphic Address: "MAGISTRATE"

Telefoon
Telephone 41140

Skakelkode
Dialling Code 0323

Privaatsak
Private Bag X5508

Poskode
Postal Code 4180

DEPARTEMENT VAN JUSTISIE • DEPARTMENT OF JUSTICE

REPUBLIEK VAN SUID-AFRIKA • REPUBLIC OF SOUTH AFRICA

Verwysings
Reference
22/1/1

Enq.: D.I. Dlamini

LANDDROSKANTOOR
MAGISTRATE'S OFFICE
Vulamehlo
SCOTTBURGH

1995.07.20

Dr C.C. Jinabhai
Department of Community Health
Box 7039
CONGELLA
4013

Dear Sir

COMMUNITY HEALTH: VULAMEHLO DISTRICT: YOURSELVES

It is hereby confirmed that your service was well accepted when intruduced to the Regional Authority on 7/7/95.

Yours faithfully

SECRETARY/~~CHAIRMAN~~: VULAMEHLO REGINAL AUTHORITY
/cnn