THE POSSIBLE EFFECT OF FOOD SUPPLEMENTS IN THE EARLY GRADES ON INTELLIGENCE SCORES

CARLA FEENSTRA

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THE POSSIBLE EFFECT OF FOOD SUPPLEMENTS IN THE EARLY GRADES ON INTELLIGENCE SCORES

by

CARLA FEENSTRA

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Department of Educational Psychology
Faculty of Education
University of Pretoria

SUPERVISOR
Dr. Suzanne Bester

CO-SUPERVISOR
Prof. Kobus Maree

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Philippians 4 verse 13: “I can do everything through him who gives me strength”.

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DECLARATION

I, Carla Feenstra (student number 27283314) hereby declare that all the sources used or quoted have been indicated and acknowledged by means of complete references in the reference list and that this study titled: **The possible effect of food supplements in the early grades on intelligence scores** is my own work. This dissertation was not previously submitted by me for any degree at another university.

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C. Feenstra
Oktober 2011

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SYNOPSIS

The possible effect of food supplements in the early grades on intelligence scores

by

Carla Feenstra

Supervisor: Dr. Suzanne Bester
Co-supervisor: Prof. Kobus Maree
Department: Department of Educational Psychology
Degree: Masters Degree in Educational Psychology

The purpose of this study was to investigate whether a meal supplement fortified with micronutrients would, statistically, significantly improve the intelligence scores of Grade 3 and 4 learners. The data collection procedures in this study took the form of a pre-test – post-test control group design. The Paper and Pencil Games (PPG) Level 3, a standardised psychological test, was administered before and after the respondents were exposed to the meal supplements. For a treatment period of 16 weeks the experimental group received the meal supplement fortified with micronutrients and the control group the meal supplement without any added micronutrients. Data analysis took the form of statistical analysis to determine whether the meal supplements consumed by those in the experimental group could significantly contribute to improving their intelligence scores.

The results indicated statistically significant increases in scores, between the pre-test and post-test on the various scales of the PPG, of both the experimental and control group on the one hand, but no statistically significant differences between the two treatment groups on the post-test on the other. The null hypothesis that there are no (statistically significant) differences between the average post-test scores (V, NV, and T) of the experimental and control groups could not be

rejected. However, the increase between the pre-test and post-test stanine scores of the two treatment groups has led to recommendations for further research.

KEY CONCEPTS

- Micronutrients
- Psychological testing
- Learner
- Malnutrition
- Cognitive development
- The Paper and Pencil Games Level 3
- True experimental design
- Pre-test – post-test control group design

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CHAPTER 1
ORIENTATION

1.1 INTRODUCTION AND BACKGROUND TO THE STUDY

Existing literature extensively reports the effect of nutrition on children's brain development, cognitive ability and/or performance, and the link between the aforementioned (Hughes & Bryan, 2003; McCann, Hudes & Ames, 2006; Schmitt, Benton & Kallus, 2005; Westenhoefer et al., 2004). These three areas of research are usually approached from two distinct viewpoints, each with a unique focus. According to Hughes and Bryan (2003) one specific area of interest for researchers relates to the identification of key *nutrients*[1] linked to cognitive performance and brain development. The second area relates to the effect of *micronutrient*[2] *deficiencies* on the brain's development as well as on children's cognitive performance (Black, 2003; Grantham-McGregor, 1995).

With respect to the first area of interest various studies exist. These report the impact of nutrition on specific cognitive abilities such as attention, speed of information processing, memory and executive functions (Hughes & Bryan, 2003; Westenhoefer et al., 2004). In a study by Sandstead et al. (1998, as cited in Hughes & Bryan, 2003), a group of 6- to 9-year-old Chinese children, who had received either zinc or a combination of zinc and micronutrients, demonstrated improved visual attention compared with a group of children who received a micronutrient supplement only. Another study by Mwanri, Worsley, Ryan, and Masika (2000, as cited in Hughes & Bryan, 2003), on rural African children, reported an improvement in their executive functioning in areas such as their ability to inhibit task-irrelevant information, mental flexibility and self-monitoring after receiving supplementation enriched with iron, vitamin A, or a combination of the two.

[1] "The process of providing or receiving nourishing sunstances" (Pearsall & Trumble, 2002, p. 999).
[2] "A chemical element or substance required in trace amounts for the growth and development of living organisms" (Pearsall & Trumble, 2002, p. 913).

The link between nutrition, brain development and general cognitive ability or performance has been researched extensively. According to McCann et al. (2006) 34 studies have been conducted to determine the specific relationship between the dietary availability of choline[3] during development and neurological functioning or performance in offspring. Evidence from these studies suggests that choline supplementation during development results in improved performance of offspring in cognitive or behavioural tests and neurological functional indicators (McCann et al., 2006).

Regarding the second viewpoint, which focuses on the effect of micronutrient deficiencies on the brain's development as well as on children's cognitive performance, the following is found in the literature. According to Hughes and Bryan (2003) the impact of nutrition on these respects depends largely on the timing of the nutritional intervention. This statement is supported by literature on brain development in the field of psychology. According to D. A. Louw, Van Ede and Louw (1998) a child's brain develops throughout his or her life and various cognitive abilities are acquired each year. Consequently, inadequate nutrition during any time of a child's life can have a broad effect on the brain's development of the frontal lobes, myelination[4] of neurons and dopamine[5] levels, but also on the cognitive abilities that emerge during these times (Hughes & Bryan, 2003). One could conclude that if a disruption occurs in acquiring a certain cognitive ability, owing to that part of the brain not developing fully because of malnutrition, it is possible that the child's intellectual profile could be weakened. This may be linked with Isaacs and Oates' (2008) statement that where a child's biological environment is inadequate in terms of the essential dietary supply of micronutrients, this affects his or her brain development, cognitive functioning and scholastic achievement.

Grantham-McGregor (1995) concur that children who suffer from early childhood malnutrition exhibit poorer IQ levels, cognitive functioning as well as scholastic

[3] "A basic nitrogenous organic compound occurring widely in living matter" (Pearsall & Trumble, 2002, p. 258).
[4] "A white fatty substance which forms an insulating sheath around certain nerve-fibres" (Pearsall & Trumble, 2002, p. 956).
[5] "A compound found in nervous tissue, acting as a neurotransmitter and a precursor of other substances including adrenalin" (Pearsall & Trumble, 2002, p. 421).

achievement and manifest greater behavioural problems. Some of the behavioural abnormalities found were that the children seemed to be less active and uninterested in exploring their environments, whereas their behaviour improved after the issue of malnutrition had been addressed. McCann et al. (2006) observe that people throughout the world, and especially the poor who are undernourished, lack micronutrients in their diet. White (2009) points out that South Africa is no exception and that many South African children's micronutrient requirements are not being met.

Research clearly illustrates a link between nutrition, brain development, general cognitive ability, specific cognitive abilities and behaviour, with many studies specifically focusing on the effect of micronutrient supplementation on cognitive functioning (Benton, 2001; Gewa et al., 2009; Kumar & Rajagopalan, 2007, 2008; Solon et al., 2003; Van Stuijevenberg et al., 1999; Vazir et al., 2006, as cited in White, 2009). White (2009) comments that micronutrient supplementing is continuously being researched; however, this research study will be the first to compare the effect of maize-based meal supplements fortified with micronutrients on the general cognitive abilities of Grade 3 and 4 learners who stem from a low socio-economic community, in the South African context. The study further aims to contribute in helping the National School Nutrition Programme (NSNP) to consider multiple micronutrient interventions (maize-based meal supplements) not only to alleviate short-term hunger, but also to address micronutrient deficiencies so that children can reach their full mental and physical potential (White, 2009).

One element of the research is thus to investigate the effect of the two meal supplements on the learner's general cognitive abilities, which constitutes the aim of my study. To this end it focuses on assessing a group of learners' intelligence scores before and after they receive the maize-based meal supplements, with added micronutrients for the treatment period of 16 weeks, in comparison with a group of learners who receive the meal supplement with no added micronutrients. For the purpose of this study, henceforth reference will be made to the two respective treatment groups as the experimental group and the control group: the experimental group comprises the group of learners who will receive the meal

supplement with added micronutrients and the control group, the group of learners who will receive the meal supplement with no added micronutrients.

Another element of the research study is to investigate the effect of the enriched maize-based meal supplements on Grade 3 and 4 learners' iron[6] status (measured by haemoglobin[7]) and their nutritional status. This study is conducted by the Department of Human Nutrition, Faculty of Health Sciences at the University of Pretoria (White, 2009). This study will report specifically on the facet of the cognitive performance of the research respondents. However, the results from the findings on this second element of the research study, will not be reported on in this dissertation since these findings fall outside the scope of this dissertation.

1.2 RATIONALE FOR THE STUDY

Many studies have investigated the effects of nutrition on cognitive performance (Hughes & Bryan, 2003; Isaacs & Oates, 2008; Schmitt et al., 2005), but not many have been conducted in the South African context. During my postgraduate studies I developed a fascination with psychometrics and the principles and practices of effective assessment as a means to obtain information on children's development and their functional abilities. It was for this reason that I became involved with this research study where I would be required to conduct psychological assessments of children's cognitive performance, in an attempt to understand the effect of nutrition on cognition for this group of children. I believe that this is a valuable contribution, as researchers have emphasised that the accurate assessment of cognitive performance is critical for detecting the effect of micronutrient deficiency on cognition (Hughes & Bryan, 2003; Schmitt et al., 2005).

1.3 STATEMENT OF PURPOSE AND RESEARCH QUESTION

The primary purpose of this study is to investigate whether a meal supplement fortified with micronutrients will statistically significantly improve the intelligence scores of Grade 3 and 4 learners.

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[6] "A tonic or dietary supplement" (Pearsall & Trumble, 2002, p. 743).
[7] "A red oxygen-carrying protein containing iron, present in the red blood cells of vertebrates" (Pearsall & Trumble, 2002, p. 631).

This statement implies the following research question:

Do the intelligence scores of Grade 3 and 4 learners improve statistically significantly after receiving a meal supplement fortified with micronutrients when compared with a group of Grade 3 and 4 learners who received a meal supplement without any added micronutrients?

1.4 RESEARCH HYPOTHESIS[8]

For the purpose of this study the following hypotheses are formulated:

- H_{01}: There are no (statistically significant) differences between the average post-test scores (V, NV, and T) of the experimental and control groups.
- H_{a1}: There are (statistically significant) differences between the average post-test scores (V, NV, and T) of the experimental and control groups.

1.5 CONCEPT CLARIFICATION

In the following section the key concepts of the study will be clarified.

1.5.1 EFFECT

According to Hawkins (1996), an effect can be defined as a change produced by a particular action or cause.

1.5.2 MICRONUTRIENTS

Micronutrients commonly refer to vitamins and minerals found in food (King & Burgess, 1993; Venkatesh Mannar, 2003). King and Burgess (1993) more fully explain the term by emphasising that because of the human body's requirements for small quantities of vitamins and minerals (micrograms or milligrams a day), these are termed micronutrients (Venkatesh Mannar, 2003). Certain types of vitamins and minerals cannot be produced by the human body and therefore should be supplemented by an individual's diet. According to Venkatesh Mannar

[8] Statistical hypotheses are formulated in Chapter 4 of the study.

(2003) food fortification, the process of adding micronutrients to food "is increasingly recognised as an effective means of delivering micronutrients through commonly consumed foods" (p. 2613). The micronutrients in this study are more specifically part of the Standard DEO VOLENTO™ formula which is a lactose-free, gluten-free enteral feed, providing 1kcal/ml and 9g protein per 250 ml Tetra Pack portion. The two different meal supplements the experimental group and control group will receive are:

1. Standard DEO VOLENTO™ fortified with micronutrients (Experimental group)
2. Standard DEO VOLENTO™ without any added micronutrients (Control group).

For numerous reasons micronutrients are vital to the human body. Venkatesh Mannar (2003) points out that micronutrients are "necessary for the regulatory systems in the body, for efficient energy metabolism and for other functions such as cognition, immune system, and reproduction" (p. 2613). King and Burgess (1993) are in agreement, adding that the body also uses micronutrients to help chemical processes take place and to build the body, produce fluids and repair tissues. Venkatesh Mannar (2003) warns that when the intake of micronutrients is insufficient, this could lead to more serious conditions, such as impaired work capacity, learning disabilities, illness and even death.

1.5.3 PSYCHOLOGICAL TESTING

Psychological assessment can be described as a "judgmental process whereby a broad range of information, often including the results of psychological tests, is integrated into a meaningful understanding of a particular person" (G. Domino & Domino, 2006, p. 2). When only tests are used to gather information Foxcroft and Roodt (2009) however prefer the term psychological testing, as testing is regarded as only one of the key elements of psychological assessment (Neukrug & Fawcett, 2006). G. Domino and Domino (2006) state that although psychological testing is seen as an integrated part of psychological assessment, it can still be done in isolation by professionals to assess individuals. In this study I will focus on

psychological testing as a construct, since psychological testing was used as a data collection strategy.

1.5.4 INTELLIGENCE SCORES

According to Schmitt et al. (2005) several psychology tests provide information on an individual's overall cognitive ability. These tests, after administration, yield a single, composite outcome measure, called IQ, which as Goldfinger and Pomerantz (2010) indicate, stands for "intelligence quotient, implying that intelligence is conceptualised as a ratio between intellect and age" (p. 35). For the purpose of this study the focus will remain on psychometric intelligence, which in the words of Foxcroft and Roodt (2009) implies the use mainly of "standardised psychological tests to measure levels of functioning on psychologically defined constructs" (p. 129), in this particular study that of intelligence. In other words, according to the psychometric view, "intelligence is defined as what intelligence tests measure" (Foxcroft & Roodt, 2009, p. 129). Goldfinger and Pomerantz (2010) add that it is the intelligence test, and the scores yielded, that usually indicate the theories of intelligence which underlie the test, which is important for interpretation. In this study the Paper and Pencil Games (PPG) Level 3, a standardised psychological test, will be used to obtain the respondents' IQ scores.

1.5.5 LEARNER

The South African Schools Act, 1996 (No. 84 of 1996) describes a learner as "any person receiving education or obliged to receive education in terms of the act" (p. 2). When the term learner is used in this study, reference will be made specifically to children who are between 8 and 10 years of age and who are enrolled in Grades 3 and 4 at the time of the research.

1.6 RESEARCH METHODOLOGY

Figure 1.1, on the next page, offers a graphic summary of the research process pertaining to this study. The figure illustrates the various steps involved so as to provide the reader with a quick overview of the research methodology employed.

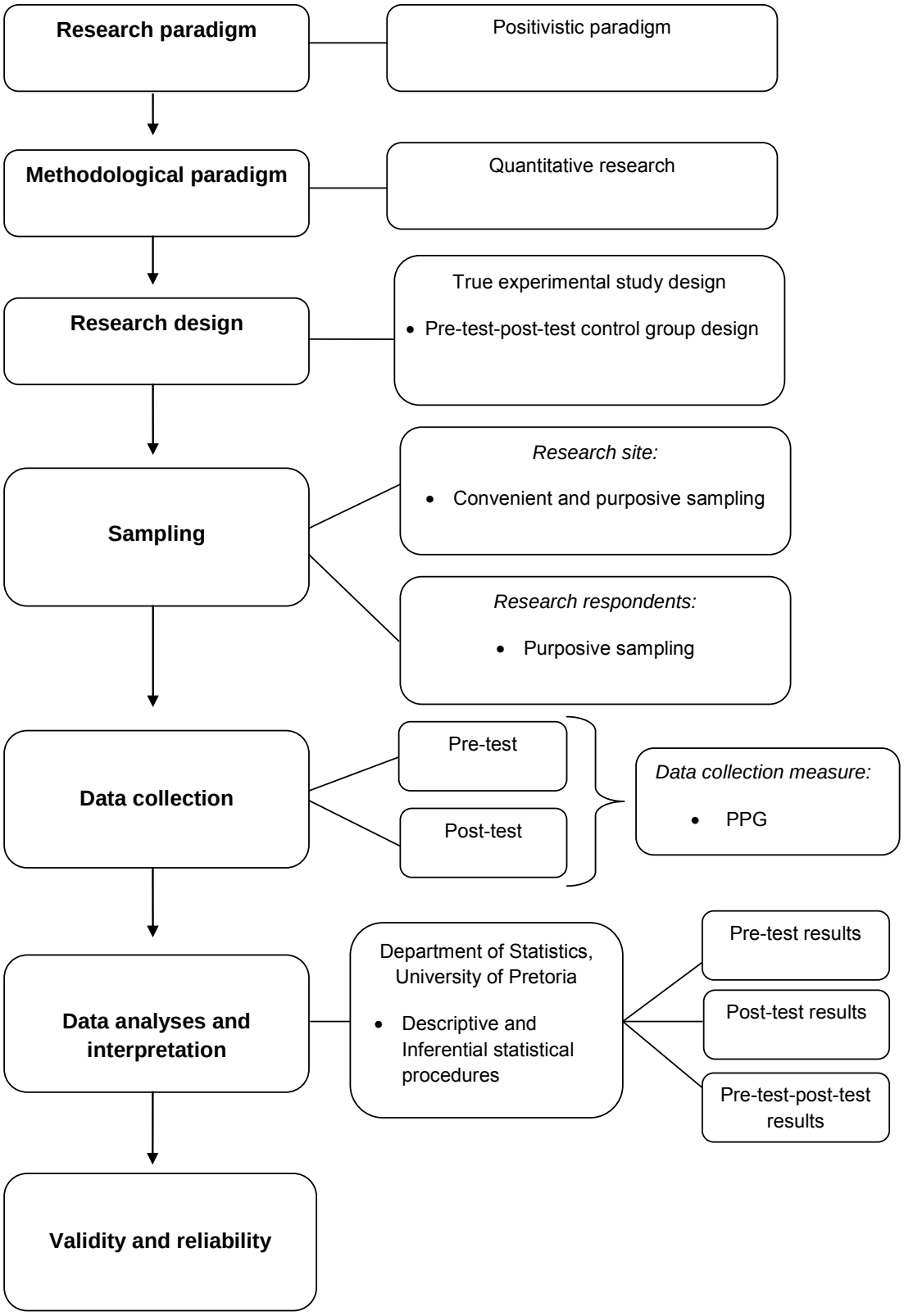

FIGURE 1.1: The research process[9]

[9] The research methodology in the study is discussed comprehensively in Chapter 4.

1.7 ETHICAL CONSIDERATIONS

According to Strydom (2005a) research in the social sciences may lead to unique ethical problems, as human beings are the objects of study. Henn, Weinstein, and Foard (2009) add that these ethical questions can be linked not only to the subject matter (what is researched*),* but also to the conduct of the research (how it is done). Ethics thus applies to those issues pertaining to the researcher's behaviour, but also to the consequences of the research for the respondents, eventually affecting every stage of the research process (Greener, 2011; Henn et al., 2009).

The respondents in this study will be involved in various research activities or procedures for data collection, each of which brings unique issues to the fore for ethical consideration. Firstly, the study includes clinical data as data will be collected by means of the PPG. Secondly, data collection involves the use of experimental methods. Haemoglobin status, a criterion for participating in the study, leads to the respondents being exposed to two specific research procedures, namely deworming and obtaining capillary blood samples by finger pricks (White, 2009). Following White's (2009) guidelines, the capillary blood samples will be taken before and after the treatment period for the measurement of iron status, and the respondents will be dewormed before the study to eliminate hookworm infection. In the paragraphs that follow the key ethical issues pertaining to this research study will be discussed. An outline of how the researchers plan to address the issues to protect not only themselves, but more importantly the respondents, is included as well (Henn et al., 2009; Piper & Simons, 2011; Strydom, 2005a).

From the literature it is clear that there is no universally acceptable set of ethical principles that all researchers can follow explicitly to ensure ethical practice; as Henn et al. (2009) in Babbie (2010) indicate, researchers all have different interests and perspectives regarding the social world. Nonetheless, there does seem to be an overlap between traditional or common ethical concepts associated with conducting ethical social research, which forms the framework for discussion in this study (Babbie, 2010; Greener, 2011; Henn et al., 2009; Piper & Simons, 2011). The following ethical principles will be used in this study, by the researcher: *(i)* informed consent, *(ii)* voluntary participation, *(iii)* avoidance of harm, and *(iv)* confidentiality

and anonymity. These principles will now be discussed, specifically the strategies that will be followed to ensure compliance.

1.7.1 INFORMED CONSENT

For this particular study, obtaining informed consent is the most important ethical consideration, especially with regard to the use of the intelligence scores. The research respondents as well as their parents and/or legal guardians will receive adequate information relating to the study during a parents' evening at the school and through a letter of consent. Researchers from the Departments of both Educational Psychology as well as of Human Nutrition will present at the said evening. The parents and their children will be informed in detail (the latter at age appropriate level) about the procedures that will be followed during the formal administration of the PPG and exactly how much time it will take to complete the battery (Claassen, 1996). The cognitive skills assessed will be comprehensively explained and the limitations of administering a cognitive test in a group environment and in isolation from a holistic assessment will be explained as well (Claassen, 1996; Foxcroft & Roodt, 2009).

Furthermore, parents will be notified that should they request their child's individual IQ scores to be made known to them, after obtaining written permission from them as parents, the individual results will be handed to the school intern psychologist or any other psychologist of their choice, to assist them as parents in further consultation.

The letters of consent more specifically outline aspects such as the purpose of the study, planned procedures, risks and discomfort involved, possible benefits as well as the credibility of the researchers and the publication of the research results (White, 2009). Informed consent will also be obtained from the school where the assessments are going to be conducted. Permission will also be obtained from the Gauteng Department of Education and Ethics Committees of the University of Pretoria[10].

[10] On 17 and 24 November 2009 Sunnyside Primary School, situated in Tshwane and the Gauteng Department of Education granted written permission for the research study to be conducted at the school, to the Department of Human Nutrition. Approval was obtained from the Ethics Committee of the Department of Human Nutrition as well as the Ethics Committee of the Faculty of Education.

1.7.2 VOLUNTARY PARTICIPATION

Participation in the study will be completely voluntary: the respondents and their parents and/or legal guardians will be clearly informed of their right to refuse participation or to withdraw at any time (Economic and Social Research Council, 2010, as cited in Greener, 2011). As mentioned previously both parties will be debriefed regarding the nature of the research using two different methods. The fact that the respondents in the study are minors makes it necessary for their parents and/or legal guardians to sign a letter of informed consent. The respondents will also be requested to sign an assent form, containing an age appropriate explanation clearly stating that they are aware that their participation in the study is voluntary.

1.7.3 AVOIDANCE OF HARM

First of all, for this particular study there is the potential risk that the parents and/or legal guardians of the respondents will hold unrealistic expectations about the information measured by the PPG. The risk will be addressed during the informed consent phase by the researcher clearly explaining to the parents the cognitive skills that will be measured, the procedures involved during group assessment, the limitations thereof and the manner in which feedback will proceed if requested. Furthermore, throughout the process of testing, the standard procedures stipulated by the PPG will be followed because the researcher and assistant (at the time of the research both intern psychologists registered with the HPCSA[11]) are adequately trained in assessment practices, ensuring that the group assessment will be administered according to the correct standards.

In the second place, potential risks are also associated with deworming the children and obtaining the capillary blood samples. According to White (2009) the respondents will be dewormed prior to the start of the treatment period to eliminate hookworm infection by administrating a single dose of Mebendazole (500 mg tablet) which could cause side-effects during the excretion of worms, especially in cases of severe infestation. Such side-effects include symptoms such as abdominal pain, diarrhea, vomiting, headaches and agranulocytosis (low white cell

[11] Health Professions Council of South Africa.

count). Adverse reactions include exanthema (widespread rash), urticaria (itchy skin) and angio-oedema (swelling of the larynx leading to airway obstruction) (Rossiter, 2010; White, 2009). In the case of side-effects arising, the individuals will be referred to health workers. Furthermore, the guidelines published by the World Health Organisation, that people who are ill on the day of the test should not receive drugs, will be implemented (White, 2009). White (2009) explains that this is not because of any danger of side-effects, but rather as a precautionary measure to avoid any misunderstanding that the drug caused the illness.

Capillary blood samples will also be obtained from the respondents by finger prick to determine their haemoglobin concentrations (White, 2009). White (2009) acknowledges that the procedure could cause anxiety for some respondents and that the risk will be addressed by explaining the procedure in detail to the respondents so that they are aware of its gentle nature. The device Accu-Check® Safe-T-Pro Uno will be used, to carry out the finger pricks. It is described as a single-use lancing device which is safety engineered to avoid accidental re-use, piercing of a finger and to eliminate cross-contamination (White, 2009). According to White (2009) all students involved with the measurement of the respondents must be adequately trained so that a standardised method could be followed. Lastly, all procedures will be conducted under sterile conditions.

1.7.4 CONFIDENTIALITY AND ANONYMITY

The respondents will be assured of confidentiality and/or anonymity throughout the study. During the sample selection phase they will be debriefed.

During data collection, confidentiality and/or anonymity will be ensured: a double blind research design will be used as a strategy to ensure that neither the researcher nor the respondents will be aware of the treatment they are receiving. Each of the two treatment groups will be allocated a colour, one representing the experimental group and the other the control group. Each respondent will receive a name badge in the colour of the treatment group they belong to, containing their name and subject number. The name badge will indicate the supplement the child will receive, which will be distributed at first break during school days. The strategy will be completed by also disguising the two meal supplements, labelling and

packaging the two products identically. The best before date for each meal supplement will be the only method of differentiating between the two products (White, 2009). The code will be revealed after completion of the study, before the data are sent to the Department of Statistics at the University of Pretoria. The researchers will also ensure that no parents, respondents or teachers at the school will gain access to the test booklets of the PPG during administration or the treatment period, by being present at all times and keeping the booklets locked up safely.

During the dissemination phase of the study confidentiality and/or anonymity will be ensured: the names of the respondents or their individual results will not be published. Only the scores of the group will be made available. After completion of the study the original PPG test booklets will be kept at the Department of Educational Psychology at the University of Pretoria for safety reasons. However the results of the study will be made known to the respondents and their parents after its completion by means of an informal discussion or, if requested, written feedback.

1.8 CHAPTER OUTLINE

The framework for the course of the remainder of this study is indicated below:

Chapter 2

Chapter 2 focuses on the theoretical framework of the study. Brain development and the age appropriate cognitive characteristics of the respondents are explored. Relevant literature concerning the influence of nutrition and malnutrition on brain development and cognitive functioning is discussed. A section of the chapter is also devoted to the assessment of cognition.

Chapter 3

In this chapter, the research process for the current study is discussed comprehensively. The methodological paradigm, with a specific focus falling on the research paradigm and research design, is described; this is followed by a discussion explaining the method of data collection and the validity and reliability

thereof. The framework for data analysis is presented while the validity and reliability of the research findings are also discussed in this chapter.

Chapter 4

Chapter 4 is devoted to the presentation and interpretation of the research results. The statistical analyses of the research results are discussed in terms of the pre-test results, the post-test results and the pre-test – post-test results, which mainly take the form of graphs and tables.

Chapter 5

This chapter involves a summary of the study in order to substantiate the deductions and recommendations made. This is followed by verification of hypotheses and a discussion of the limitations of the study. Lastly, possible contributions of the study are stated and recommendations for future research are made.

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CHAPTER 2
LITERATURE STUDY

2.1 INTRODUCTION

Statistics reveal that at least 200 million children in developing countries are faced with the challenges of poverty, where the majority lives in South Asia and Sub-Saharan Africa (Grantham-McGregor et al., 2007). According to Walker et al. (2007) it is the pressing issue of poverty and the associated risk factors such as malnutrition, poor health, deficient care and unsatisfactory home environments that prevent children from reaching their full potential. The adverse effects of the said influences on child development across the board have been researched: the results have demonstrated poor cognitive, motor, and social-emotional development (Grantham-McGregor et al., 2007). Grantham-McGregor et al. (2007) furthermore state that poverty is most strongly associated with poor cognitive development and educational performance; negatively impacting on scholastic achievement and resulting in far reaching effects. These often lead to lower incomes, high fertility and poorer care of children, contributing to the continuing cycle of poverty across generations (Grantham-McGregor et al., 2007).

The loss of the developmental potential of children in the domains referred to above can be linked to the specific developmental stage at which the impact occurs. According to Snowman and McCown (2011) this is because during each stage of child development certain skills and characteristics develop unique to that specific stage. Brain development during the prenatal stage is characterised by rapid growth in size and structure, as well as a high generation of “neurons, glial cells, and neural connections” (Schunk, 2011, p. 51). It is estimated that a newborn child possesses over a million developed synapses, and that the rapid growth of the brain continues into early childhood. Furthermore, major structural alterations in the brain occur especially during the teenage years (Jesen, 2005, as cited in Schunk, 2011), when competencies such as abstract reasoning and problem solving as well as the ability to control impulses develop. According to Snowman

and McCown (2011) during Grades 3 and 4 children show an increased development in their cognitive skills.

It is thus clear that the issue of poverty and associated risk factors need to be addressed to ensure the optimal brain and cognitive development of children so that they can reach their full potential and flourish academically. Continuous research is necessary to (a) investigate the ongoing far reaching effects of the given aspects on children's brains and cognitive development and (b) the effectiveness and potential value of interventions such as meal supplementation programmes to address these issues.

2.2 THE ROLE OF NUTRITION IN BRAIN DEVELOPMENT AND COGNITIVE FUNCTIONING

According to Meadows (2006) researchers should keep in mind that understanding something as complex as cognitive development, involves accounting for several factors which could cause change and variation; establishing how these factors may differ from individual to individual and the developmental stage at which impact occurs (Walker et al., 2007).

According to Benton (2008b) a link between nutrition, more specifically children's diets, and their cognitive development emerged from findings relating to the rapid development and growth of the brain and factors influencing the latter. Benton's statement is supported by literature which connects nutritional intake to brain growth and functioning (Benton, 2008a, 2010; Laus, Vales, Costa & Almeida, 2011).

The link between diet and brain development can be traced back to prenatal developement as well as that during a few weeks after birth (Benton, 2008a, 2008b, 2010). Due to the rapid growth of the brain, especially during the periods highlighted above, the diet must supply the necessary nutrients with which it is formed or else adverse effects may arise in terms of the brain's structure and functioning (Benton, 2008b, 2010; Gordon, 1997; Laus et al., 2011). An individual's diet should provide sufficient protein, fat, carbohydrates, vitamins and minerals as it

is believed that these are, in simple terms, the building blocks from which the human brain develops (Benton, 2010; Haskell et al., 2008).

According to Benton (2008a, 2008b, 2010) the strongest brain growth is associated with the last trimester of pregnancy and the first 2 years after birth, but research has shown that some development still occurs in adolescence and that even the adult brain is capable of adapting to change. This is of importance since developmental theorists, such as Piaget in his model of cognitive development, clearly state that cognitive development follows a sequence of stages and that during each stage children acquire or achieve certain cognitive skills (Bukatko & Daehler, 2004; Callaghan, 2005; Harwood, Miller & Vasta, 2008; Meadows, 2006), thus acknowledging that during child development there are critical and sensitive periods for development (Benton, 2008b, 2010).

Micronutrients such as iron and iodine have been specifically linked to brain maturing, where iron is needed for myelination and neurotransmitter[12] synthesis, while iodine, constituting part of the thyroid hormones, contributes to the growth, development, function and maintenance of the central and peripheral nervous systems (Beard & Connor, 2003; Benton, 2008a; Delange, 2000, as cited in Eilander et al., 2010).

Nutrition also affects the brain, in its day to day functioning (Benton, 2008b, 2010). The human brain relies on diet, firstly to provide a sufficient amount of glucose, as the brain has a limited supply of energy (Benton, 2005, as cited in Benton, 2010). Secondly, it needs enough micronutrients for optimal metabolic[13] activity, because it is the most metabolically active organ in the body (Benton, 2010). Thus, its functioning is influenced by diet in terms of the supply of nutrients it receives.

Two important aspects of diet are the nutritional value of meals and the pattern of meal consumption (Benton, 2008b). According to Rampersaud, Pereira, Girard, Adams and Metzl (2005) eating breakfast has been linked to an improvement in

[12] "A chemical substance released from a nerve fibre that effects the transfer of an impulse to another nerve or muscle" (Pearsall & Trumble, 2002, p. 975).
[13] "The chemical processes that occur in a living organism in order to maintain life" (Pearsall & Trumble, 2002, p. 907).

cognitive functioning, in terms of memory, test grades and school attendance. Similar findings were reported by Mahoney, Taylor, Kanarek and Samuel (2005, as cited in Benton, 2008b) who found that the consumption of breakfast among children 9 to 11 years of age enhanced their cognitive performance 1 hour after eating, in comparison to those fasting. Findings from other studies include a significant improvement in vigilance tasks and memory after eating breakfast (Busch, Taylor, Kanarek & Holcomb, 2002; Vaisman, Voet, Akivis & Vakil, 1996, as cited in Benton, 2008b). Some studies also report on the size of breakfast and the benefits thereof. A study conducted on Swedish children, who ate a larger breakfast, found that these children presented better verbal fluency (Wyon, Abrahamsson, Jartelius & Fletcher, 1997, as cited in Benton, 2008b).

In terms of the nutritional value of meals, a study conducted by Gale et al. (2008) has found that infants whose diet comprised fruit, vegetables and home-prepared foods, obtained higher intelligence scores on an IQ test and more specifically on the verbal- and full scale. They also demonstrated better memory performance at age 4. One may conclude that if an individual suffered from malnutrition the optimal metabolic functioning of the brain during sensitive periods of cognitive development would be influenced, which could lead to lasting negative consequences in that individual's life (Benton, 2008b, 2010).

2.3 THE EFFECT OF MALNUTRITION ON BRAIN DEVELOPMENT AND COGNITIVE FUNCTIONING

Malnutrition of children is a global problem affecting approximately 150 million children (Laus et al., 2011; UNICEF, 2006, as cited in Fanjiang & Kleinman, 2007). This is especially true for developing countries (ibid). It is estimated that one quarter of children younger than 5 years of age are already being affected by malnutrition (ibid). The issue remains of major concern and receives much attention from researchers (Fanjiang & Kleinman, 2007; Grantham-McGregor & Baker-Henningham, 2005; Laus et al., 2011; Pollitt, 1990, as cited in Grantham-McGregor & Olney, 2006; UNICEF, 2000, as cited in Galal, Ismail & Foster, 2005).

Laus et al. (2011) cited De Onis and Blössner (1997) who described malnutrition as "an imbalance between the supply of protein and energy and the body's demand

for them to ensure optimal growth and function" (p. 591). Malnutrition is often due to a poor diet and/or micronutrient deficiencies, which have been proven to impair brain development and cognitive performance (Demetri, 2001, as cited in D. Petranovic, Batinac, Petranovic, A. Ruzic, & Ruzic, 2008; Fanjiang & Kleinman, 2007; Laus et al., 2011; Melanson, 2008).

Malnutrition has been associated with a decrease in "the number of neurons, synapses, dendritic arborisation, and myelination, all of which result in decreased brain size" (Laus et al., p. 591). Furthermore, malnutrition might cause the cerebral cortex to be thinned while overall the growth rate of various processes within the brain is slowed down (Laus et al., 2011; Peeling & Smart, 1994, as cited in Gordon, 1997). Georgieff (2007, as cited in Benton, 2010) adds that malnutrition has also been linked to damage in the hippocampus[14]. According to Laus et al. (2011) all these changes in the central nervous system of the brain, due to malnutrition, explain some of the delays or deficits children exhibit in their cognitive development (Gordon, 1997). Various delays and deficits in this regard have been identified by researchers. A discussion of these follows.

According to Benton (2010) researchers investigating children who are malnourished have found that these individuals display short term as well as long term cognitive problems (Grantham-McGregor & Baker-Henningham, 2005). Identified difficulties include poorer cognition and school achievement; slower language development; lower IQ scores; delayed reaction times during tasks; memory problems; learning deficiencies; attention problems as well as weaknesses in analytic and reasoning skills (Benton, 2010; Fanjiang & Kleinman, 2005; Grantham-McGregor & Olney, 2006; Laus et al., 2011; Walker, Chang, Powell, & Grantham-McGregor, 2005, as cited in Eilander et al., 2010). The poorer performance in cognition is however more often related to a deficit in the total score, than specific cognitive deficits (Benton, 2008b, 2010; Grantham-McGregor & Baker-Henningham, 2005; Grantham-McGregor, 1995, as cited in Fanjiang & Kleinman, 2005). Some studies adopted a narrower focus, emphasising correlations between a specific micronutrient deficiency and impaired cognitive functioning. A discussion follows.

[14] "The elongated ridges on the floor of each lateral ventricle of the brain, thought to be the centre of emotion and the autonomic nervous system" (Pearsall & Trumble, 2002, p. 668).

A study conducted by Grantham-McGregor and Ani (2001, as cited in Grantham-McGregor & Olney, 2006) has reported an association between anaemia caused by early iron deficiency in children and poor cognition and school achievement later during childhood. Another study indicated a deficiency in Vitamin B12 and lower scores on cognitive tests for Dutch learners and learners living in Guatemala (Allen et al., 1999, as cited in Eilander et al., 2010; Louwman et al., 2000).

For the purpose of this study the correlation between malnutrition and brain development, as well as the possible effects of malnutrition on children's cognitive functioning, specifically school performance and intelligence, were emphasised. I reported specifically on studies examining the possible biological mechanisms by which malnutrition affects development, as opposed to studies examining the link between malnutrition and the child's social and physical environmental conditions (Grantham-McGregor, Powell, Walker, Chang & Fletcher, 1994; Laus et al., 2011). Hereafter, nutritional supplementation studies will be discussed which investigate the effects of food supplementation as an intervention to improve the development and cognitive performance of children (Pollitt, Gorman, Engle et al., 1993, as cited in Grantham-McGregor & Olney, 2006).

2.4 THE EFFECTS OF DIETARY SUPPLEMENTATION ON COGNITIVE FUNCTIONING

Various supplementation studies were found each with a unique formula, including studies focusing on the effects of supplementing the diets of pregnant mothers as well as breastfeeding and the use of milk formulas to improve the cognitive development of children (Fanjiang & Kleinman, 2007; Gordon, 1997; Laus et al., 2011). As these study populations often investigate infants, the studies involving breastfeeding and milk formulas will not be discussed in this literature review. The focus will remain on those which include children of school going age.

Laus et al. (2011) cited a study conducted by Pollitt et al. (1993) who found that protein-calorie supplementation during early childhood improved psychoeducational performance, specifically on tests of knowledge, numeracy, reading and vocabulary. Pollitt and his colleagues also reported that early protein supplementation has later effects in life, and found it led to better educational

achievements. A second study was cited by Laus et al. (2011), conducted by Whaley et al. (2003), whose findings included an improvement in respondents' "ability to organise perceptual detail; reasoning by analogy and form comparisons; and arithmetic ability" (p. 593), after receiving supplementation with an animal source of food. However, no improvement was noted for verbal comprehension. Whaley et al. (2003, as cited in Laus et al., 2011) concluded that the supplementation improved cognitive performance, but not across all domains of cognitive ability.

Both supplementation studies reported by Laus et al. (2011) established a positive correlation between food supplements and children's cognitive performance. Findings in Grantham-McGregor and Baker-Henningham (2005) are in contrast with the studies above. These researchers found that only supplementation which begins before a child's second birthday, has time and again been proven beneficial, as opposed to malnourished children receiving supplements after 2 years of age. These results indicated minor or no long-term benefits.

Taras (2005) specifically reviewed published supplementation studies and the link between iron deficiency and children's academic and cognitive performance. The area identified by Taras (2005) is of specific interest for this study, as respondents' iron status, measured by haemoglobin concentrations, was one of the inclusion criteria for participating in our study. Taras (2005) reported that children with an iron-deficiency, but who were not anaemic, performed poorer academically, specifically achieving lower scores in mathematics. On the other hand children with iron deficiency anaemia proved to be at a disadvantage academically across the board and exhibited problems in cognition. Therapy in terms of iron supplements seemed to improve the academic performance of respondents who were anaemic, but no benefits were found for those whose iron was normal (Taras, 2005). Melanson (2008) is in agreement, stating that children with an iron deficiency who receive supplementation, show improvements in scholastically related outcomes. This links up with two studies cited by Eilander et al. (2010) who found that intervention programmes, specifically including the micronutrients iron and iodine, have demonstrated improvements in children's intelligence scores (Grantham-

McGregor & Ani, 2001; Sachdev, Gera & Nestel, 2005, as cited in Eilander et al., 2010).

However, supplementation studies have not comprised the only avenue explored by researchers to address malnutrition, as some studies have indicated that educating parents about adequate nutrition reduces rates of malnutrition (Galal et al., 2005). Galal et al. (2005) have also investigated the role that schoolteachers can play in reducing the effects of malnutrition among learners and found that teachers felt that they could contribute significantly as they believed their learners see them as role models. Grantham-McGregor and Baker-Henningham (2005) concur with Galal and his colleagues who assert that psychosocial stimulation has proven to be beneficial in addressing the development of malnourished children. Another avenue explored by researchers to address and improve learners' nutritional intake is to investigate school breakfast and lunch programmes, especially in communities with a low socio-economic status (Melanson, 2008).

To conclude, it is clear, in terms of the present topic, that nutrition can be seen as both the cause of the problem (malnutrition), but also a possible solution, in the light of the various supplementation studies above, as is the case in this study (Benton, 2010).

2.5 THE ASSESSMENT OF CHILDREN'S COGNITIVE SKILLS

According to Harold and Hay (2005) cognitive development refers to "how a person perceives, thinks and gains an understanding of his or her world through the action and co-action of genetic and learned factors" (p. 4). D. Louw and Louw (2007) add that the factors referred to by Harold and Hay (2005) include "perception, learning, memory, thinking, decision-making, imagination, creativity, language and intelligence" (p. 7). It is important, though, to remember that children are unique and that there is considerable variation in how they perceive and think about the world around them (Snowman & McCown, 2011). One way of determining the ways in which children differ from another is often undertaken through the process of intelligence testing, where their various abilities are being tested (ibid). As explained in Chapter 1, several psychology tests after administration yield a total IQ score which provides information on learners' overall cognitive ability (Goldfinger &

Pomerantz, 2010; Schmitt et al., 2005). Aspects relating to intelligence testing as well as the concept of intelligence for this study will now be clarified and discussed. According to Tlali (2008) psychologists often hold opposing views regarding the concept of intelligence, making it a complex and controversial topic for discussion (G. Domino & Domino, 2006; Huffman, 2007). Tlali (2008) further states that their understanding of the complex term can repeatedly be traced back to their particular theoretical and conceptual framework regarding intelligence. Wechsler (1975, as cited in Snowman & McCown, 2011) defines intelligence as "the global capacity of the individual to act purposefully, think rationally, and deal effectively with the environment" (p. 112). Keeping the former in mind, Snowman and McCown (2011) believe that the IQ score obtained after testing reflects only one facet of an individual's global capacity, as their ability to act on academic tasks is only evaluated in one environment, that of the classroom. These authors elaborate and explain that individuals display intelligent behaviour in other contexts and that various characteristics contribute to intelligent behaviour (ibid).

The above argument, that intelligence solely involves the sum of one's tested abilities, results in the construct intelligence being categorised into different types of intelligence, sometimes also worded as perspectives on intelligence namely, biological, psychometric and social or emotional intelligence, each with a unique focus (Armour-Thomas, 2003; Foxcroft & Roodt, 2009). In short, biological intelligence refers to the objective measurement of the brain's structure and functioning, whereas social or emotional intelligence focuses on an individual's adaptive behaviour within his or her context (Foxcroft & Roodt, 2009). For the purpose of this study, however, psychometric intelligence constituted the operational framework of the term intelligence. Psychometric intelligence is defined as "what intelligence tests measure" (Foxcroft & Roodt, 2009, p. 129). Standardised psychological tests are usually used to measure psychometric intelligence (ibid). In the current study the PPG was used to assess the intelligence of the Grade 3 and 4 learners.

According to Sternberg (2003, as cited in Passer & Smith, 2007) the psychometric approach to intelligence adopts a unique focus, employing specific theories (Gleitman, Reisberg & Gross, 2007; Tlali, 2008). The psychometric approach

"attempts to map the structure of intellect and to discover the kinds of mental competencies that underlie individual differences in test performance" (Passer & Smith, 2007, p. 332). In order to describe how people differ from one another intellectually, the mental constructs that underlie the intelligence tests need to be investigated (Passer & Smith, 2007; Tlali, 2008). The PPG is based on certain psychometric methodologies, which will now be explored.

2.6 THE PAPER AND PENCIL GAMES LEVEL 3 (PPG)

The PPG is based on the premise that in order for an individual to learn new things a combination of cognitive processes is required, being measured through performance on various item types (Claassen, 1996). This belief held by the test developers of the PPG is associated with Charles Spearman's theory of general intelligence, sometimes also referred to as the g factor (Gleitman et al., 2007; Huffman, 2007; Passer & Smith, 2007; Tlali, 2008). Spearman's g factor more specifically refers to intelligence as "a composite of related mental abilities that in combination represent a general intelligence factor" (Van Eeden, 1991). According to Wechsler (1958, as cited in Van Eeden, 1991) a more reliable picture of an individual's intellectual ability is obtained by measuring his or her performance on various tasks requiring intelligence thus the test battery should be differentiated. In this study the PPG was used, the subtests of which cover a wide field and include a variety of aspects of behaviour requiring competency in verbal and non-verbal mental abilities.

The PPG includes five subtests, probing such matters as verbal reasoning, comprehension, figural and quantitative skills, all of which are representative of intelligence. This is clearly illustrated by the correlation tables in the PPG manual indicating that the scores on each subtest correlate with scores on the other subtests (Claassen, 1996). Gleitman et al. (2007) confirms that this type of pattern indicates a high level of consistency in how individuals perform on the various subtests of the test, suggesting that the subtests all overlap with each other in the skills they require. This overlap further substantiates the claim that there is a common element shared by all components of IQ tests, making it possible to calculate a general intelligence score (Gleitman et al., 2007).

The total score obtained on the PPG represents the underlying factor of general intelligence. This total score is however made up of two primary mental ability scores, i.e. the Verbal and Non-Verbal scores. The fact that the PPG yields a total score, indicating a child's general intelligence or overall cognitive ability, made it appropriate for this study. Nevertheless the use of the PPG offered other advantages for the study's sample as well.

The PPG is standardised for the South African population and can be used for pupils with lower levels of functioning (Claassen, 1996). The former is most advantageous as it leads to the usability of the PPG for children who experience language difficulties, as is often the case among the study's respondents, due to a high influx of immigrant learners. The figural representations used in the test ensure that the test largely rests on a child's non-verbal skills as opposed to their verbal ones. The PPG nonetheless does still measure a child's verbal mental abilities and is therefore not completely non-verbal.

From the above it is now clear that in the field of psychology intelligence is commonly measured through the use of intelligence tests and that the former can be described as psychometric intelligence (King, 2008). The use of the PPG as measuring instrument for this study was also briefly discussed. The PPG and its validity and reliability are discussed in more detail in Chapter 3, as these criteria prove to be important in the measurement of intelligence, indicating whether an intelligence test is sound or not (Huffman, 2007; King, 2008).

2.7 FACTORS AFFECTING ASSESSMENT RESULTS

With reference to the discussion in Chapter 1 regarding the difference between psychological testing and psychological assessment, it was clear that psychological testing is regarded as only one of the numerous activities included in psychological assessment. Foxcroft and Roodt (2009) explain that this is because a test score obtained from psychological testing provides only a sketchy picture of an individual's functioning as not all the contexts within which the individual functions, are considered. The authors further point out that people operate in a number of different contexts simultaneously, such as the biological context, the intrapsychic context and the social context, all of which have a bearing on assessment results

(Foxcroft & Roodt, 2009). Thus, for scores to be regarded as meaningful they need to be looked at in the various contexts within which an individual function, which form part of the process of psychological assessment. The researcher acknowledges, and concurs with, Foxcroft and Roodt (2009), but as psychological testing was the main objective of the study rather than psychological assessment, the discussion will centre on "methodological considerations such as test administration, which may also influence test performance and therefore have a bearing on the interpretation of test scores" (Foxcroft & Roodt, 2009, p. 239; Armour-Thomas, 2003). According to Foxcroft and Roodt (2009) an individual's performance on a psychological test can be manipulated by numerous factors, which will now be examined and discussed.

The first aspect that assessors need to consider is the role of test administration and standardised procedures (Foxcroft & Roodt, 2009). These authors argue that although manuals for psychological tests often highlight, to assessors, the importance of following standardised instructions exactly, the need occasionally arises to adjust instructions slightly because all assessment situations are unique. According to Foxcroft and Roodt (2009) in certain assessment situations, especially those involving children, people with disabilities and brain injured individuals, "flexibility and minor adjustments to test procedures are often desirable or even necessary" (p. 249). The said authors however stipulate the rule that these adaptations should not be casual or by chance, but carried out intentionally for a specific purpose.

Secondly, before a test score can be accepted as a true reflection of an individual's ability and or abilities various potential sources of error need to be explored (Foxcroft & Roodt, 2009). As mentioned earlier, an individual's score on a test cannot be regarded as meaningful if the professional has not considered his or her personal information and results from other measures. Foxcroft and Roodt (2009) emphasise the main reason: that measurement error needs to be taken into account.

In the third place Foxcroft and Roodt (2009) highlight the value of assessors being well prepared for assessments. One important aspect associated with

preparedness is establishing rapport with clients, especially when children are being assessed. Should an assessor not be well prepared this affects the building of rapport as his or her attention is directed more to test procedures than the client, which according to Foxcroft and Roodt (2009) in the end affects test performance as the client's ability may be underestimated. A second aspect to which assessors should be sensitive is the effect of their own expectations on the respondent's performance (Foxcroft & Roodt, 2009).

The fourth consideration, which examines the status of the respondents, involves several aspects such as their level of anxiety and motivation, their intentions to fake good or bad results, cheating and practice effects (Foxcroft & Roodt, 2009). According to Foxcroft and Roodt (2009) it is safe to assume that most individuals being tested experience some degree of anxiety, which could have a negative effect on their performance. Furthermore, if respondents are not motivated to take the test, their performance could also be influenced. The second aspect, faking, where respondents intentionally perform more poorly is not always possible to detect, especially if only one measure is used, because the individuals' performance cannot be compared to other sources of information (Foxcroft & Roodt, 2009). Faking bad is however controlled to some degree in the construction phase of psychological measures (Foxcroft & Roodt, 2009). The aspect of faking bad is however more closely associated with personality measures, where indivduals manipulate the assessor by pretending to be someone they are not.

Cheating among respondents, the third aspect, is considered a great challenge, especially during the assessment of large groups as it is difficult for the assessor to detect. Lastly, the aspect of practice effects needs to be considered. According to Reeve and Lam (2007, as cited in Foxcroft & Roodt, 2009) "practice effects can be sizeable, but there has been insufficient research to explore the reasons for the gains made due to re-taking the same test" (p. 252).

Before undertaking any interpretation of the respondents' assessment results, the PPG's content validity and construct validity need to be investigated, which brings us to the fifth construct discussed by Foxcroft and Roodt (2009). Test developers of the PPG went to great lengths to prevent test and item basis, by developing a

culture-fair test. Two types of culture-fair tests have been developed (King, 2008; Passer & Smith, 2007). The one where the questions are familiar to individuals from all socio-economic and ethnic backgrounds and a second which contains only non-verbal questions (King, 2008). Test developers of the PPG worked towards a common ground for all pupils, by developing sets of items for the test which would be familiar to all. Furthermore, the PPG item types were developed to rely as little as possible on individual's language abilities, as the instructions are read to the learners and the items are mainly based on the use of pictures (Claassen, 1996). The content and construct validly of the PPG has been established and is discussed in detail in the methodology section of this dissertation (Chapter 3).

In this study various strategies will be employed by the researcher to minimize the effect of the above mentioned factors as far as possible. In the first place, if any adaptations to the standardised administration procedures of the PPG are necessary they will be noted by her. Secondly, the standard error of measurement scores of the PPG will be noted before the interpretation of results. Thirdly, the researcher will be well prepared for the assessments and a double blind study design will be employed to control her expectations, as she will not be aware which learners are in the experimental group and which are in the control group. Thereby, the respondents will not be limited or encouraged in their responses. Feelings of anxiety will be addressed by interacting with the respondents in a calm manner, while the purpose of the study and the benefits involved will be explained during the informed consent phase, to keep the respondents motivated (Foxcroft & Roodt, 2009).

Cheating will be minimized as far as possible, firstly by ensuring that no respondents gain access to the PPG before the day of assessment or on this day. Secondly, the respondents will be reminded before the testing commences to respond honestly and without the help of a friend for the duration of the assessment, and lastly items with two responses will not be taken into account during the scoring. During testing, the learners will also use wooden boards as partitions and an assistant will be present at all times to help with invigilation.

2.8 CONCLUSION

In this chapter children's brain development and cognitive functioning was discussed in an integrated approach across nutrition and malnutrition. From the literature it is clear that there is a link between nutrition, brain development as well as cognitive functioning, where malnutrition adversely affects these. The effects of malnutrition on children's cognitive functioning have sparked concern, and studies investigating the effects of nutritional supplementation to improve children's cognitive development have been published. These are of particular interest as they clearly connect with the purpose of my study. Chapter 2 had five specific objectives: *(i)* to highlight the pressing issue of poverty and the associated risk factor of malnutrition on children's developmental potential, *(ii)* to inform the reader about the correlation between nutrition and children's brain development and cognitive functioning, *(iii)* to discuss the risk factor of malnutrition in this respect, *(iv)* to review the literature for studies conducted on the correlation between malnutrition and cognition, specifically the improvement thereof via supplementation, and *(v)* to discuss the processes involved in the measurement of cognitive functioning, in this particular study of intelligence.

The literature contained in this survey will now be used to correlate the authors' findings with those of this particular study, either to confirm their findings, disagree with these or perhaps contribute to the existing literature by making a new discovery.

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CHAPTER 3
METHODOLOGY

3.1 INTRODUCTION

Chapter 3 includes a discussion of the research process and methodology utilised in this study. Its quantitative nature is explained by referring to the choice of research paradigm and design. Furthermore, the sampling methods used in selecting the research site and respondents are elaborated on and data collection considered. Lastly, the data analysis procedures are described and the validity and reliability of the study, particularly threats to internal and external validity, are explored and discussed.

3.2 RESEARCH PARADIGM

This study was based on a positivistic paradigm, which has certain ontological and epistemological implications (Terre Blanche & Durrheim, 2006). The ontological and epistemological implications of positivism are summarised by Gray (2009), Walliman (2006) and various other authors in their classification of it. Positivism is classified by the authors as an objective approach, where reality consists of what is available to the senses. They add that the inquiry should be based on scientific observation, and that ideas only deserve their incorporation into knowledge if they can be put to the test of empirical evidence (French, Yardley & Sutton, 2004; Gray, 2009; Hayes, 2000; Walliman, 2006). The purpose of science is thus to develop explanations in the form of universal laws, establishing causes and effects (Punch, 1998).

The positivistic paradigm as a theoretical structure or framework of thought for understanding was pertinent to this study, as the set of beliefs/values of positivism was recognisable (Babbie & Mouton, 2001; Baillie & Miller, 2003; Hayes, 2000). In this study, objective data collection and interpretation methods were used by means of a standardised psychological measure and inferential statistics. The researcher thus approached the reality being researched as a single objective

reality, and as a researcher did not influence that which she aimed to observe. This procedure is in line with Nieuwenhuis (2007) and Walliman (2006) who point out that positivists strongly believe that the explanations of the causes of phenomena are independent of the intentions of people. In this study, this was further evident as the study relied on numerical data and not the respondents' personal accounts.

Although this study was conducted in terms of a positivistic paradigm, in an objective manner with a standardised test, there are certain variables that cannot be controlled in intelligence testing, as the assessment of intelligence is a highly complex operation (Matarazzo, 1990, as cited in Goldfinger & Pomerantz, 2010). The limitations of this study will be discussed in the final chapter.

3.3 RESEARCH DESIGN

The appropriate design for a study is usually revealed by the purpose of the study and the research questions being addressed (Gray, 2009). With the purpose of this study in mind it was clear that the researcher should apply a true experimental design in the form of a pre-test – post-test control group design. Such a design was appropriate as the three distinguishable characteristics of such a design applied to the current research study, namely, manipulation, control and randomisation (Cohen, Manion & Morrison, 2000; Maree & Pietersen, 2007). The respondents were randomly assigned to two treatment groups, described earlier. The aspect of randomisation in the pre-test – post-test design also offered an advantage as it ensured that the two groups were equivalent on statistical grounds, which allowed the researcher to utilise the pre-test as a check to see whether they actually were equivalent as regards to the dependent variable (Bless & Higson-Smith, 2000; Singleton & Straits, 2010).

As mentioned previously, research questions can also strengthen the choice of a design, as was the case in this research study. This statement is supported by Maree and Pietersen (2007) who affirm that experimental designs "have been developed to answer a specific kind of research question, namely the cause-and-effect question: Does a specific treatment have an effect on some dependent measure?" (p. 149). The pre-test – post-test control group design can be graphically illustrated as follows.

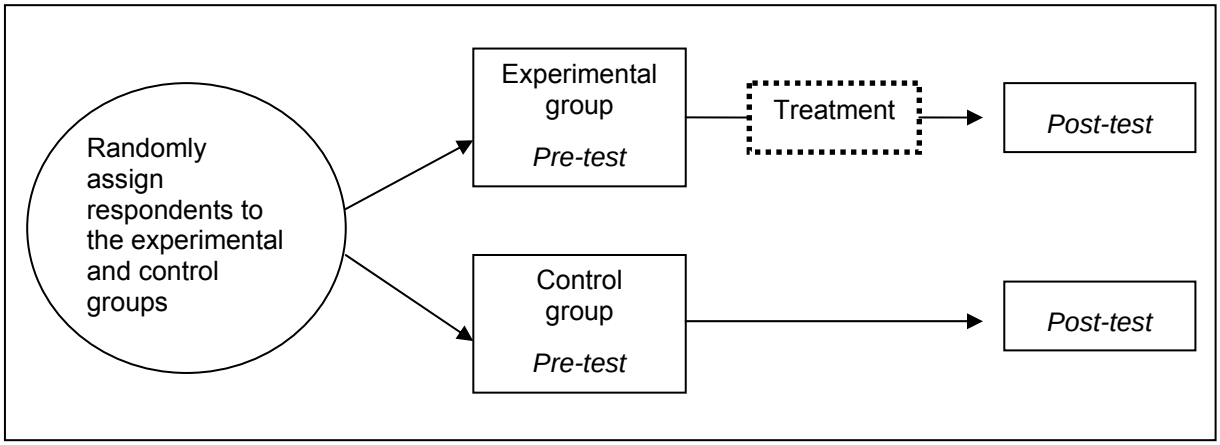

FIGURE 3.1: Pre-test – post-test Control Group Design (Copied from Maree & Pietersen, 2007, p. 150).

The pre-test – post-test control group design illustrated above can be applied to this particular study and is summarised in the table below.

TABLE 3.1: Pre-test – post-test Control Group Design for this study (Adapted from Maree & Pietersen, 2007, p. 150).

Random assignment to groups		Pre-test measurement	Treatment	Post-test measurement
Experimental group	Grade 3 and 4 learners at Sunnyside Primary.	PPG 15, 19 and 20 July 2010	Standard DEO VOLENTO™ fortified with micronutrients for 16 weeks	PPG 22, 23 and 29 November 2010
Control group	Grade 3 and 4 learners at Sunnyside Primary.	PPG 15, 19 and 20 July 2010	Standard DEO VOLENTO™ with no added micronutrients for 16 weeks	PPG 22, 23 and 29 November 2010
Time frame: July 2010 to November 2010				

To conclude, the respondents were randomly allocated to the experimental group and the control group. The pre-test took place before the respondents received the maize-based meal supplements. During the treatment period of 16 weeks, the experimental group received the meal supplement Standard DEO VOLENTO™ fortified with micronutrients, whereas the control group received the meal supplement Standard DEO VOLENTO™ without any added micronutrients. After the treatment period both groups were post-tested to determine their intellectual

scores, which was followed by a process of statistical evaluation of the results where the two groups were compared. The statistical comparison of the two groups on the post-test elicited an answer to the research question whether the treatment had an effect (Maree & Pietersen, 2007; Singleton & Straits, 2010). To control threats to internal validity, the research study utilised a double blind research design (White, 2009). This strategy is discussed in detail in Chapter 1, Section 1.8.4.

3.4 METHODOLOGICAL PARADIGM

The research methodology was quantitative in nature as the research was firstly conducted in a systematic manner. The researcher assessed the respondents at predetermined times both prior to and after the consumption of the meal supplements to determine a possible statistical significant difference between the experimental group and the control group. Secondly, the researcher made use of a standardised test which was administered, analysed and interpreted systematically in a standardised manner. The researcher remained objective in the study as she gathered data by means of a standardised instrument and test scores were used to determine the effect of micronutrients on the intelligence scores of the respondents (Maree & Pietersen, 2007).

Leedy and Ormrod (2001) add the following characteristic of quantitative research: they highlight the aim of the questions it poses, which is to answer queries on the relationships among variables with the purpose of explaining, predicting and controlling phenomena. The data collected from this study were used to provide statistical descriptions of the difference between the pre-test and post-test scores of the two groups.

After a rigorous study of the central characteristics of quantitative research and how these correspond with my study, several advantages were identified, the most important being that of quantitative measurement (Gray, 2009; Walliman, 2006). Durrheim and Painter (2006) mention that the translation of phenomena into variables hold specific advantages for the researcher. In this study, the fact that numbers may be manipulated by mathematical operations was most advantageous as it allowed the researcher to combine the stanine scores, obtained from the PPG,

of the groups. The scores could then be exposed to statistical operations to determine the achievements of the groups.

According to Punch (1998), after a researcher has identified a measuring instrument, an important aspect is to assess its value or quality in the particular research situation, focusing on the psychometric characteristics of the instrument, namely reliability and validity. Punch (1998) describes the meaning of quantitative measurement validity by formulating the simple question: “How do we know that this instrument measures what we think it measures?” (p. 100). In other words, one asks about the degree to which an instrument measures what it aims to measure.

The PPG, which is classified as a group test, measures figural, quantitative and verbal skills strongly related to scholastic success. The measure provides a fairly objective assessment of a learner’s reasoning ability, making a clear distinction between all levels of ability, but is specifically aimed at the lower levels of functioning. In practice, the PPG is generally used for screening purposes: professionals are made aware that for learners scoring low on the PPG a thorough evaluation is needed (Claassen, 1996).

The PPG is based on the following principle:

> *To learn new things, pupils must be able to perceive accurately and to recognize and recall what has been perceived. They also have to think logically, to understand relationships, to abstract from a set of particulars, and to apply generalizations to new and different contexts. It is assumed that these processes are measured through performance on test items with pictorial, verbal, figural and quantitative content. The variety of cognitive skills necessary to perform well on the test could be described as general scholastic reasoning ability* (Claassen, 1996, p. 2).

The PPG-Level 3 items are grouped into five subtests and provide a score for the Verbal (V) scale, Non-Verbal (NV) scale, and Total (T) scale. The V scale consists of two subtests, namely *(i)* Verbal and Quantitative Reasoning and *(ii)* Comprehension. The NV scale consists of three subtests, namely *(i)* Figure Series, *(ii)* Pattern Completion and *(iii)* Number Series. The scores obtained on the V scale and the NV scale constitutes the T scale (Claassen, 1996). The fact that the PPG

yields a T scale score furnishes proof that the PPG endorses the presence of a single, overall intelligence. As discussed in Chapter 2, it was the theorist Charles Spearman who argued that intelligence is a singular construct, which he termed the g-factor or *g* for general, global, overall intellectual ability. From the PPG a V scale score and a NV scale score are also obtained: it is the scores of these scales which indicate support for the existence of more specific intellectual abilities. The latter are also explained by one of Spearman's theories, termed specific intelligence or *s* (Goldfinger & Pomerantz, 2010; Tlali, 2008).

For my particular study the PPG was thus appropriate as the actual contents of the test, specifically the various PPG item types, were all relevant to the construct intelligence, they were standardised for Grade 3 and 4 learners and from the PPG's aim it was clear that it serves as a screening test of general cognitive ability (Claassen, 1996).

3.5 VALIDITY AND RELIABILITY OF THE PPG

Delport (2002) suggests a useful classification scheme to categorise the validities underlying measurement, namely content validity, criterion validity and construct validity. Furr and Bacharach (2008) add that evidence of all three types is needed to establish validity. The researcher made use of this classification scheme to enhance the internal validity of the study.

Content validity for the PPG is demonstrated, as it is evident from the principle upon which the PPG is based that the test addresses the full range of cognitive skills associated with intelligence (Claassen, 1996; Colton & Covert, 2007). Thus, the PPG can be considered valid as there is a close relationship between the concept of intelligence and the operational measurement of intelligence on the PPG. To further ensure validity, during development of the test much thought and research was put into the selection and inclusion of item types with pictorial, verbal, figural and quantitative content so that the items were most closely related to the cognitive skills considered important for the construct intelligence. This was carried out through the process of item analysis and factor analysis (Claassen, 1996; Colton & Covert, 2007).

Two types of criterion validity are found in the literature: one concerned with where the criterion variable exists in the present (concurrent) and the other with where the criterion variable will not exist until later (predictive) (Punch, 1998). The concurrent validity of the PPG was demonstrated by the test developers, as they correlated the PPG's T scale score with teachers' evaluations of respondents' intellectual ability, and also correlated the T scale score with scores from other tests such as a standardised scholastic achievement tests in Mathematics (Claassen, 1996; Punch, 1998).

As stated previously, to learn new things learners must employ a variety of cogntive skills. Anastasi (1990, as cited in Claassen, 1996) argues that these complex abilities or skills are commonly assessed through their performance on items such as the following: *(i)* Classification of words, pictures or figures, *(ii)* Series completion, *(iii)* Pattern completion, *(iv)* Detecting similarities or differences, *(v)* Analogies, *(vi)* Complying with complex instructions, *(vii)* Number manipulations, *(viii)* Quantitative reasoning, *(ix)* Verbal comprehension and *(x)* Matrixes (Bernard, 2000). Construct validty for the PPG is established as the PPG item types include items highlighted by Anastasi. These types are specifically categorised into Verbal item types and Non-Verbal item types. The various kinds of items included in the former types are: *(i)* The following of directions, *(ii)* Verbal reasoning, *(iii)* Arithmetic reasoning and *(iv)* Verbal comprehension. The latter types are *(i)* Classification, *(ii)* Figure series, *(iii)* Number series and *(iv)* Pattern completion (Claassen, 1996).

Various methods were used by the test developers to assess the reliability of the PPG: test-retest reliability, internal consistency reliability, and a standard error of measurement of the test (Durrheim & Painter, 2006). The approach for establishing test-retest reliability was made possible by again administering the PPG test to a sub-sample of pupils after a two week time period had elapsed, in order to determine test-retest correlations. The correlations were slightly lower than the Kuder-Richardson (KR_{20}) reliability coefficients reported in the PPG manual (Claassen, 1996). According to Claassen (1996) test-retest correlations are frequently lower than KR_{20} reliability coefficients as more factors unrelated to the test may influence test performance differently on different occasions. The increase in mean scores in the retest was however less than one stanine (Claassen, 1996).

The method used for testing internal consistency in the PPG was the split-half method as this approach is typically utilised to assess the reliability of tests, rather than questionnaires or other instruments (Claassen, 1996; Colton & Covert, 2007). The KR_{20} formula specifically was used in the PPG for estimating all possible split-half method correlations (Claassen, 1996). According to Colten and Covert (2007) the KR_{20} reliability estimates offer an efficient and systematic method of calculating all possible split-half correlations without going through all the steps. This method was further appropriate for the PPG test, as the PPG only measures a single construct and because the test items are dichotomous items (Colton & Covert, 2007). The KR_{20} reliability coefficients can be found in the PPG manual (Claassen, 1996).

For the PPG the standard error of measurement is given in terms of stanines for all three of the PPG scales, and is reported in the PPG manual (Claassen, 1996). The standard errors of measurement indicate that 95% of observed scores can be expected to fall within 1 stanine of the true score which they attempt to indicate. According to Claassen (1996) the chances are slim that the score obtained from the same learner on different occasions will deviate by more than one stanine.

3.6 SAMPLING

3.6.1 RESEARCH SITE

The study was conducted at an inner city school in Pretoria, Sunnyside Primary School. The school is situated in the Tshwane district of Gauteng Province, South Africa. The majority of learners attending this school stem from low socio-economic circumstances, while the school also faces challenges such as a large influx of immigrant learners. The researcher made use of convenience as well as purposive sampling to select the research site (White, 2009). Firstly, the school was chosen and employed as a research site purely for logistical ease (Gray, 2009; White, 2009). Secondly, the selection of the school was based on the trait that the school had an existing school feeding programme in place, but still displayed a need for an extended programme of this kind (Gray, 2009; White, 2009).

3.6.2 RESEARCH RESPONDENTS

The respondents involved in the study were learners from the Grade 3 and 4 classes at the aforementioned school. Purposive sampling was used to select the respondents, based on the standardised test being used (Gray, 2009; Strydom, 2005b). The Grade 3 and 4 learners were identified as possible respondents, as learners from this age group could perhaps be able to understand a group test situation better than younger ones since most schools start formal examinations during these grades. They had, furthermore, been exposed to receiving formal education in English for four years and were, thus, perhaps more comfortable with this language of instruction during the test situation.

The PPG was administered in English; respondents who were English-literate were therefore selected. The research study determined the aspect of language proficiency by using a validated questionnaire obtaining socio-demographic information (White, 2009).

A further criterion for inclusion in the study was the learner's iron status, measured by haemoglobin concentrations. Children with low to normal haemoglobin values (Hb>9.5 g/dL), also referred to as mild anaemia, were included (White, 2009). In accordance with White (2009) learners recording the lowest haemoglobin values were included to obtain the sample for the study.

The haemoglobin concentrations were determined by capillary blood samples which were obtained by finger pricks before the start of the study (White, 2009). White (2009) states that in order to correct the prevalence of anaemia children need iron supplementation and therefore hypothesised that the micronutrient supplementation consumed during the study would correct mild anaemia among the sample. Venkatesh Mannar (2003) supports White's hypothesis by asserting the importance of micronutrients for various other body functions such as cognitive functioning. The last criterion, for inclusion in the study, was that learners should currently not be taking any micronutrient supplementation (White, 2009).

The study sample thus comprised boys and girls between 8 to 10 years of age who were all English-literate and matched according to grade, class, age, gender and

haemoglobin status, and then randomly assigned to one of the two respective treatment groups. The research study aimed for a sample size of 160 respondents at the start of the study, whereafter some learners dropped out from treatment, leading to a sample size of 107 respondents in the post-test[15].

3.7 PLANNING FOR DATA ANALYSIS

In this study the PPG results were numerically processed; the data were statistically analysed and interpreted to investigate the hypothesis as formulated in the study (Hayes, 2000). Research support in this regard was obtained from the Department of Statistics at the University of Pretoria.

Swift (2006) describes some of the preceding processes involved before the main quantitative data analysis can take place, one being the preparation stage. This stage is described as getting the data into shape for analysis and involves creating a form in which to reproduce the data. This form enables the researcher to clearly summarise what has been studied and makes the data readily available for analysis to answer the main research question. The concepts that arise from these objectives are: data reduction, data representation and data transformation which stem from Miles and Huberman's (1994, as cited in Punch, 1998) framework for qualitative data analysis.

3.7.1 DATA REDUCTION

In this study the research data were obtained from the process of administering and scoring the PPG, based on the guidelines stipulated in the PPG manual. The completed test booklets were examined to identify incompleteness and errors in the marking of responses, as a check for errors/omissions forms part of the prescribed scoring process of the PPG. Lastly, the raw data for each respondent in the V scale, NV scale and T scale were transformed to a stanine score by locating the norm scores in the PPG manual (Claassen, 1996; Kumar, 2011).

[15] The drop-out rate is discussed in more detail in Section 3.8.

3.7.2 DATA DISPLAY

For the purpose of this study the steps involved were firstly, to code the test booklets by using numbers to differentiate the pre-tests from the post-tests. Secondly, the data were reduced from the initial pre-test results versus the data obtained in the post-test. Thirdly, the data were tabulated according to the respondents' individual scores on the V scale, NV scale and T scale. Raw scores as well as stanine scores were tabulated. Lastly, the data were separated into the experimental group and the control group (Punch, 1998). (Refer to Appendix A).

3.7.3 DATA ANALYSIS

Descriptive and inferential statistical analysis of data were utilised, which is discussed more comprehensively in Chapter 4. In short, the descriptive methods employed in this study to arrange the data into a more interpretable form were frequency distributions, which are regarded as a useful way to summarise scores acquired on single variables (Durrheim, 2006). The use of frequency distributions in the study offered a major advantage as these revealed the most important properties of the distribution, namely its shape, spread and central tendency (Maree & Pietersen, 2007). In this study the median and mean for each scale on the PPG were calculated and presented for the pre-test as well as the post-test (Durrheim, 2006). The median was arranged in ascending order and the mean scores which were compared comprised the respondents' stanine scores achieved on the PPG (Jackson, 2003).

Measures of central tendency were used to describe the distribution, but in order to compare scores within and between distributions, an estimate of the variability, or spread of scores, is needed (Kubiszyn & Borich, 2007). The measurement of variance, i.e., standard deviation, which accompanies the mean is also presented in Chapter 4. "Measures of variability help us estimate how compressed or expanded the distributions are" (Kubiszyn & Borich, 2007, p. 218) or how they vary from the measure of central tendency, and assist in estimating "the degree to which the observations for a variable are dissimilar to each other" (Durrheim, 2006, p. 197).

Inferential statistical analysis on the other hand aims at generalising observations made on a sample, to a whole population (Rachad, 2003). Inferential analysis was carried out in the study to possibly contribute to the current literature, either by means of a new discovery or the validation of an existing already researched concept. Rachad (2003) mentions some of the prerequisites for drawing conclusions from a sample, one being a representative sample in which all the relevant qualities of the population are adequately represented. In this particular study the researcher attempted to increase the chances of a representative sample by selecting the sample randomly. Furthermore, inferential statistical analysis includes two important techniques, *(i)* estimation of the corresponding population parameters and *(ii)* hypothesis testing (Rachad, 2003).

Hypothesis testing took place by comparing the mean scores, obtained on the pre-test on the various scales of the PPG, with the mean scores obtained on the post-test and statistically analysing the difference. If a statistical significant difference is noted, this might lead to the assumption that micronutrient supplementation caused the difference. According to Punch (1998) it is however important to note that differences could come about by chance, and that the answer to the question is in terms of probability level. Inferential statistical analysis allows the researcher to calculate statistics from the sample data and then use statistical inference tables to determine the likelihood of the change. If the probability level is small, i.e., less than 0.05 or 5%, one can conclude that there is a significant difference between the averages of the sample (Durrheim, 2006). If what the researcher finds to be true in his or her sample is also true in his or her population, and it is not a chance result, but real, it is termed statistically significant (Punch, 1998).

Lastly, a study of the data summaries and the averages of the two treatment groups revealed that the data were not normally distributed, but skewed. According to Heiman (2001) non-parametric tests are usually used with skewed distributions of interval or ratio scores, but parametric procedures can still be applied even if the data only comes close to meeting the assumptions, as parametric procedures are robust. With a robust procedure, even if one does not fulfil the assumptions of the procedure perfectly, only a negligible amount of error will be present in the inferences one draws. This allows the researcher to utilise a parametric test even if

the data represent a population that is approximately normally distributed, as is the case in this study (Heiman, 2001). The sample size was also big enough to allow the use of parametric tests, specifically *t*-tests.

3.8 VALIDITY AND RELIABILITY OF THE DATA

Roberts and Priest's (2006) stipulation that when designing research projects, it is important to consider issues such as reliability and validity will now be discussed. In research there are two main kinds of validity to be considered, namely internal and external validity (Bless & Higson-Smith, 2000; Maree & Pietersen, 2007). Accurate experiments, if carried out properly, tend to have high internal validity, signifying that the changes observed were probably caused by the treatment and not merely related to it. However, although controlled experiments exhibit the virtue of high internal validity, they display the liability of low external validity as one wonders if the very carefully controlled study conditions would enable the researcher to generalise the results, and to what extent (Bernard, 2000; Maree & Pietersen, 2007). Bernard's (2000) comment that, before external validity can be determined, threats to internal validity should be explored first, is therefore relevant. The threats to internal validity are vast in number: Bernard (2000) and Gorard (2003) group these threats under eight important headings. Those which pertain to this study will now be discussed.

The first is the history confound, which refers to "any independent variable, other than the treatment, that (1) occurs between the pre-test and the post-test in an experiment and (2) affects the experimental groups differently" (Bernard, 2000, p. 109). In this study, the procedures stipulated in the PPG for the administration of the test were followed explicitly on both occasions to control the threat of co-varying events. Secondly, during the scoring process the norm scores of the PPG were used, permitting a true comparison of the results, as the internal and external validity of the PPG has been established. An expected change in the stanine score of a learner between the pre-test and post-test, after some time had elapsed, was considered by the administrators of the PPG. Variables that could contribute to such change were examined, and that score was established on the norm scores of the PPG. One can thus conclude that if a change is noted besides that of the

norm scores of the PPG, there is a possibility that it has occurred because of the consumption of the micronutrient supplementation.

The second confound, namely maturation, has an effect during long-term as well as shorter experiments and will now be examined (Babbie, 2007). Experiments in general require the passage of time, as the post-treatment measure is only administered some time after the experiment. Gorard (2003) warns that the elapsed time between the pre-test and the post-test may mean that the differences being noted by the researcher simply stem from factors related to time. In this particular study the fact that respondents grow older, change and become more experienced as regards to curriculum content was noted (Babbie, 2007; Bernard, 2000). It is understood that any change or improvement in the intelligence scores of the respondents for this study may have been due to the maturation of the group, but this threat was controlled by employing the PPG, which is a standardised test.

Testing, the third confound, referring to “the process of testing and retesting influencing the respondents’ behaviour and thereby confounding the experimental results” (Babbie, 2007, p. 230), also needs to be addressed. The testing situation in this particular study was controlled as far as possible, firstly by selecting Grade 3 and 4 learners as they were perhaps more familiar and comfortable with a testing situation and secondly by explicitly following the guidelines of the PPG during assessments to ensure ethically correct assessment practices.

Gorard (2003) as cited by Adair (1973) who found that random errors in recording and analysing results too often seem to favour the experimental hypothesis. This threat has been countered in the study, by the strategy of employing a double blind study design as explained in Chapter 1. Thus, my behaviour as the assessor could not give cues to the experimental group to respond in the way expected from them. The instrumentation confound, which is closely linked to testing, was also eliminated as the measuring instrument was not changed in the particular study (Bernard, 2000).

The fourth confound, statistical regression, is now discussed. Regression to the mean occurs when experiments are conducted on subjects who start out with extreme scores on the dependent variable (Babbie, 2007). This threat has been

accounted for in the study, as sampling was not performed at the extreme, because random selection of participants took place.

Lastly, respondents might not complete their participation in a study, which leads one to the last threat internal validity, namely: mortality (Bernard, 2000). The researcher carried out a calculation to determine sample size and power. A sample size of 63 in each group would have been sufficient to determine a difference of 2 points on the PPG, assuming a standard deviation of 4 points, a power of 80%, and a significance level of 5%. The number was increased to 80 learners per group to allow for a predicted drop-out, from treatment, of around one quarter (White, 2009). Although the study made provision for a 25% drop-out rate, the actual rate was larger. This was due to respondents being absent on the days of testing, even on the additional days scheduled, some leaving the school and some terminating their participation in the study. This threat to internal validity was nonetheless controlled to some degree as the PPG was used.

Internal validity only accounts for some of the complications faced by experimental researchers; there are also problems of external validity. Babbie (2007) cited Campbell and Stanley (1963) as identifying four forms of this issue. The first exists if there is an interaction between the testing situation and the experimental stimulus. In the particular study one could argue that by using the same standardised test for both the pre-test and the post-test the subjects were sensitised to the content and therefore performed better in the post-test. For this study there may indeed be a threat to external validity. Several methods could improve the external validity of the study: by using a standardised test with different forms for the pre-test and post-test or utilising the Solomon four group design, which involves four groups of subjects, randomly assigned from a pool (Babbie, 2007).

Secondly, the generalisability of responses needs to be considered (Tredoux & Smith, 2006). Generalising the findings to a broader context did not fall within the scope of this study. The data were described for this study population only. The study is exposed to an external validity threat, as the sample exhibits little demographic variation. The respondents all come from the same school and from only two of the twelve school grades. According to Tredoux and Smith (2006) a

method of effectively reducing the threat is to replicate the findings with a different sample or wait for a fellow researcher to replicate the study's findings.

Thirdly, the question needs to be asked whether the results achieved by the intervention can be generalised to other, similar, forms of intervention. If careful attention is not paid to the conditions that affect generalisability, a threat to external validity would arise (Tredoux & Smith, 2006). Lastly, generalising to other operationalisations of the outcome measure needs to be considered. In the particular study the effect of maize-based meal supplements fortified with micronutrients (independent variable) on the intelligence scores (dependent variable) of Grade 3 and 4 learners, using the PPG, was measured. The use of an alternative test could reveal further topics for investigation and the results could be compared to the current study to note similarities or differences. This threat is again minimised to some degree as the PPG was used.

The reliability of the PPG has been determined, meaning the results can be regarded as dependable (Claassen, 1996; Roberts & Priest, 2006). Repeating the test with the same sample is impossible, however, as one cannot unexpose the respondents to the meal supplements. A solution to the issue of the repeatability of the test might be to use a similar sample; this could be included in the recommendations for further research.

3.9 CONCLUSION

For a study to be classified as quantitative research, researchers need to keep a distant relationship between themselves and the respondents, remaining objective at all times (Maree & Pietersen, 2007).

Furthermore, in quantitative research the focus is placed on gathering facts by collecting data that is numerically based and which is open to analytical methods (Walliman, 2006). In this chapter, the quantitative nature of the study was explained and discussed. The results of the study will now be discussed in Chapter 4, which will be followed by an interpretation of the results against the relevant literature in Chapter 5.

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CHAPTER 4
QUANTITATIVE ANALYSIS

4.1 INTRODUCTION

This chapter is devoted to the presentation and interpretation of the research results. It includes a brief outline of the scoring and data processing procedures that were followed in the study, but is largely devoted to the statistical analyses of these results. The latter are explained and discussed in terms of the pre-test results, the post-test results and the pre-test – post-test results. Graphs and tables will be used to explain the research results, while the tabulated data summaries of the results are included in Appendix A.

In order to orientate the reader, the research hypotheses which directed the study are again stated below:

H_{01}: There are no (statistically significant) differences between the average post-test scores (V, NV, and T) of the experimental and control groups.

H_{a1}: There are (statistically significant) differences between the average post-test scores (V, NV, and T) of the experimental and control groups.

In the case of this particular study the alternative hypothesis is directional and presumes that the meal supplement fortified with micronutrients can contribute to significantly improving the intelligence scores of the experimental group. The results from the pre-test – post-test scores were statistically analysed to determine whether the use of meal supplements fortified with micronutrients could improve the performance of the respondents on the PPG. Next, the scoring procedures of the PPG and the ways in which the data were processed will be discussed.

4.2 SCORING PROCESS OF THE PPG-LEVEL 3

Standard procedures for scoring the PPG were followed. The PPG consists of a V scale, NV scale and T scale, consisting out of five distinctive subtests. The test contains 120 items, divided into 50 Verbal item types, 50 Non-Verbal item types and 20 practice examples. Each correct item on the PPG subtests earns a mark. A total is calculated for all the subtests and transferred to the back of the test booklet in the form of raw scores. The scores for subtest 2 and 4 are added to obtain the raw score for the V scale. Parts 1, 3 and 5 are added to obtain the raw score for the NV scale. The V scale and NV scale scores are added together to obtain the T scale raw score. The various raw scores are then transformed to a norm score using the norm tables in the PPG manual, and a stanine for each individual scale is obtained (Claassen, 1996).

After the scoring process had been undertaken by the researcher, the PPG test booklet data were processed by summarising and organising the data in table format (refer to Appendix A). The data summaries contain two tables: one for the experimental group and one for the control group. Both tables indicate the respondents' scores during the pre-test as well as the post-test. The PPG-results of the respondents will be discussed below.

4.3 STATISTICAL ANALYSES AND INTERPRETATION OF THE DATA

Two types of statistical procedures in the analysis of the data were employed by the researcher to make a principled argument. Firstly, descriptive statistics to describe the variables and, secondly, inferential statistics to determine whether relationships exist between the variables in the populations from which the samples were obtained (Durrheim, 2006; Gravetter & Forzano, 2009; Rachad, 2003).

4.3.1 PRE-TEST RESULTS

From the data summaries (Appendix A) the researcher will initially reflect on the deductions that can be made from the descriptive statistical analysis procedures. For the purpose of this study the data are explained by looking at the results of the two respective treatment groups, separately. The variables are summarised one at

a time, by considering the respondents' performance on the various scales of the PPG (Johnson & Christensen, 2004). Frequency distributions are presented in the form of histograms (Durrheim, 2006; Johnson & Christensen, 2004; Punch, 1998). For each of the frequency distributions, measures of central tendency, namely mean and median, are calculated and presented. Figure 4.3 (a) - (c) graphically represents the respondents' stanine scores during the **pre-test** on the **V scale**, **NV scale** and the **T scale** for the experimental group and the control group. The **pre-test** results on the various scales of the PPG, for the experimental and control group can be summarised as follows.

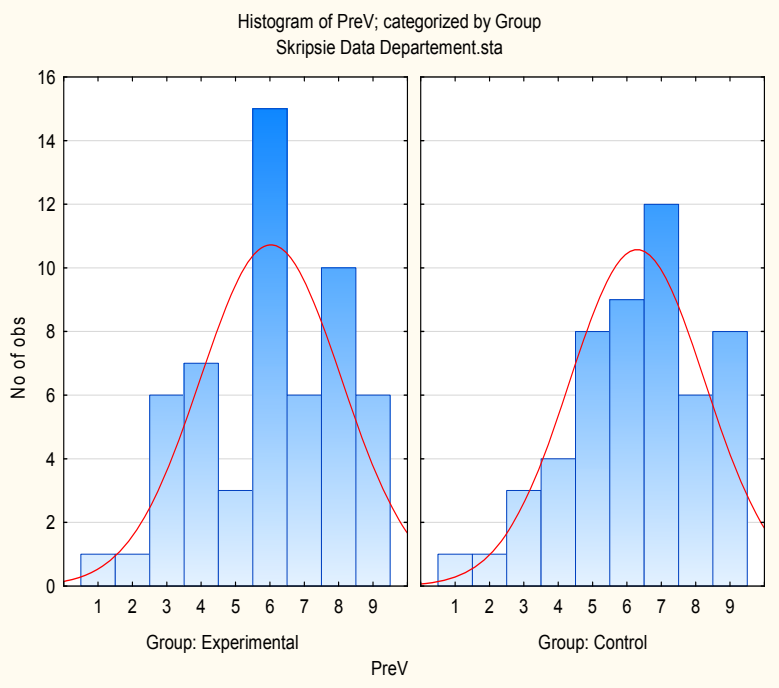

FIGURE 4.3a: Average pre-test V scale stanine scores for the experimental and control group

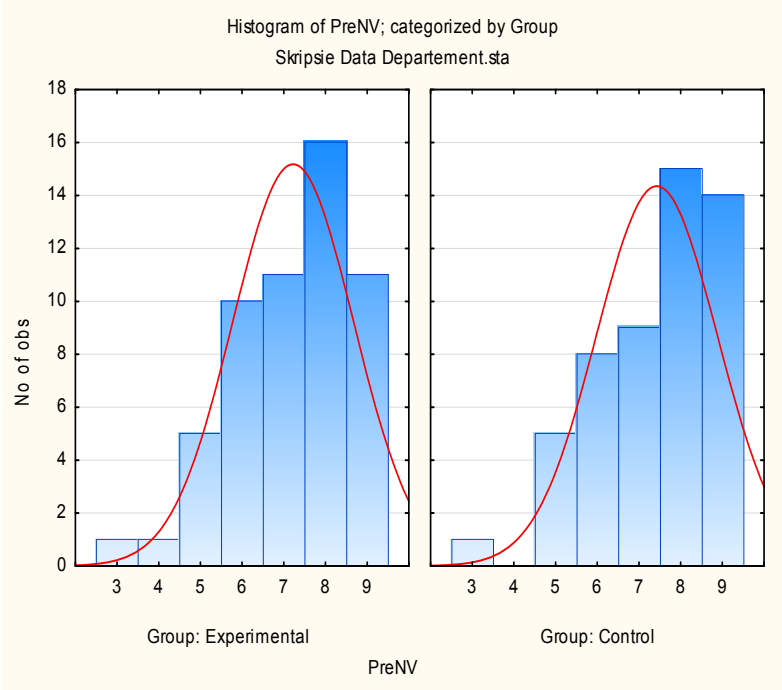

FIGURE 4.3b: Average pre-test NV scale stanine scores for the experimental and control group

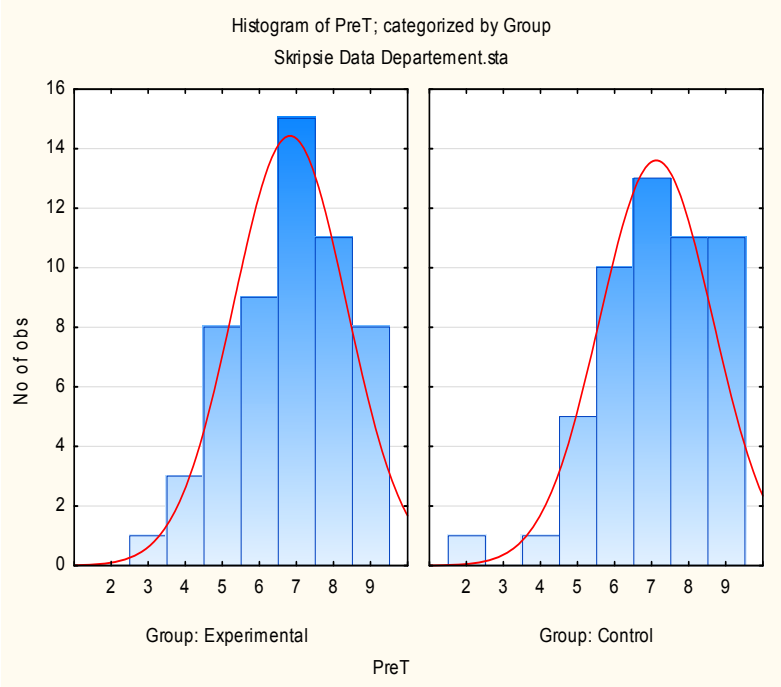

FIGURE 4.3c: Average pre-test T scale stanine scores for the experimental and control group

The central tendencies and measures of spread for the selected data are presented in Table 4.3, which follows.

TABLE 4.3: Central tendencies and measures of spread for both treatment groups during the pre-test on the various scales of the PPG

	Pre-test					
	Experimental group			Control group		
Variables	**V scale**	**NV scale**	**T scale**	**V scale**	**NV scale**	**T scale**
Average (Mean)	6.0	7.20	6.80	6.27	7.40	7.10
Median	6.0	7.0	7.0	6.50	8.0	7.0
Standard Deviation	2.05	1.45	1.52	1.96	1.45	1.52

The pre-test results also need to be exposed to the process of inferential statistical analysis, since data were used from two respective treatment groups. This is necessary, because any significant differences between the data of the two groups at the pre-test may affect the internal validity of the study. More specifically, a difference between the two groups' average stanine scores on the pre-test on the various scales of the PPG would indicate that the respondents were not properly allocated randomly, and that a difference was present at the start of the study between the two groups, thus posing a threat to the internal validity of the study.

Parametric tests, specifically *t*-tests, were used in this particular study to determine any significant differences between the two respective treatment groups in the pre-test as well as in the post-test (Jackson, 2003). In order to perform the *t*-test to determine differences in means it was firstly necessary to consider the underlying assumptions of the test. According to Pietersen and Maree (2007) the *t*-test assumes the normality of the outcome variables, but since large samples had been selected this was not a concern. Secondly, Pietersen and Maree (2007) add:

> *The validity of a t-test relies on whether there is a difference in the spread (variance) of the variables in the two groups and depending on whether it can be assumed that the spread is the same or not, a different calculation of the t-test is performed* (p. 227).

Thus, the Levene's test for homogeneity of variance precedes the *t*-test. According to Field (2005) one needs to determine that the variance of the various outcome variables is the same in each of the treatment groups. The Levene's test thus tests the hypothesis that the variances in the groups are equal (Field, 2005).

TABLE 4.4: Results from the Levene's test to detect whether the variances in the groups are equal for the pre-test stanine scores

Variable	Std Dev Experimental group	Std Dev Control group	Levene F(1,df)	p Levene
Pre-V scale	2.05	1.96	0.01	0.92
Pre-NV scale	1.45	1.45	0.01	0.91
Pre-T scale	1.52	1.52	0.05	0.82

The Levene's test will be significant if the p-value $p \leq .05$, concluding that the null hypothesis is incorrect and that the variances are significantly different; therefore the assumption of homogeneity of variances is violated. The Levene's test is non-significant if the p-value $p > .05$, in which instance the null hypothesis cannot be rejected, meaning that the differences between the variances are zero; therefore the assumption is tenable (Field, 2005). In the study the p-values are all greater than .05, indicating that the variances are equal during the pre-test.

Various pre-test hypotheses are formulated as the researcher is interested in the mean scores of the two treatment groups and whether a significant difference exists at the start of the study. The pre-test hypotheses for the various scales are formulated as follows:

V scale:

- H_{01}: There is no (statistically significant) difference between the average pre-test V scale stanine scores of the experimental and control groups.
- H_{a1}: There is a (statistically significant) difference between the average pre-test V scale stanine scores of the experimental and control groups.

NV scale:

- H_{02}: There is no (statistically significant) difference between the average pre-test NV scale stanine scores of the experimental and control groups.
- H_{a2}: There is a (statistically significant) difference between the average pre-test NV scale stanine scores of the experimental and control groups.

T scale:

- H_{03}: There is no (statistically significant) difference between the average pre-test T scale stanine scores of the experimental and control groups.
- H_{a3}: There is a (statistically significant) difference between the average pre-test T scale stanine scores of the experimental and control groups.

TABLE 4.5: *T*-test to detect a difference between the two treatment groups' variables on the pre-test

Variable	Mean Experimental group	Mean Control group	t-value	P
Pre-V scale	6.0	6.27	0.69	0.49
Pre-NV scale	7.20	7.40	0.73	0.47
Pre-T scale	6.80	7.10	1.01	0.32

A p-value is statistically significant at $p \leq .05$, which would indicate that the averages between the two groups are different (significant). The p-values in the study are all greater than .05; therefore the null hypothesis (H_o) is not rejected and it is concluded that the two groups do not differ statistically significant with regard to their average stanine scores on the pre-test on the various variables. This is of importance, as it indicates that the respondents were randomly allocated, and that no difference was present at the start of the study, controlling threats to internal validity (Bless & Higson-Smith, 2000; Muijs, 2004).

4.3.2 POST-TEST RESULTS

The post-test results on the various scales of the PPG, for the experimental and control group can be summarised as follows. Figure 4.3 (d) – (f), which follows, graphically represents the respondents' stanine scores during the **post-test** on the **V scale**, **NV scale** and the **T scale** for the experimental group and the control group.

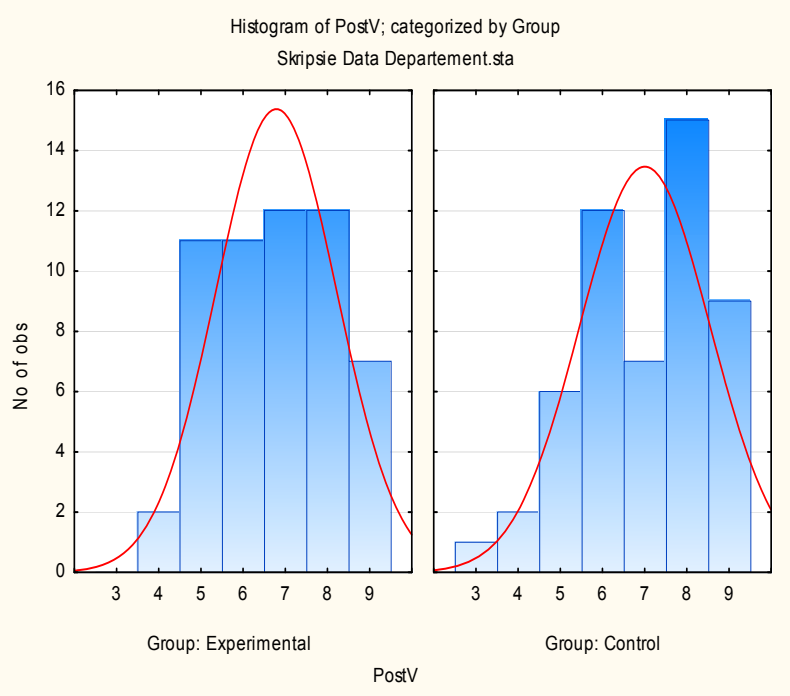

FIGURE 4.3d: Average post-test V scale stanine scores for the experimental and control group

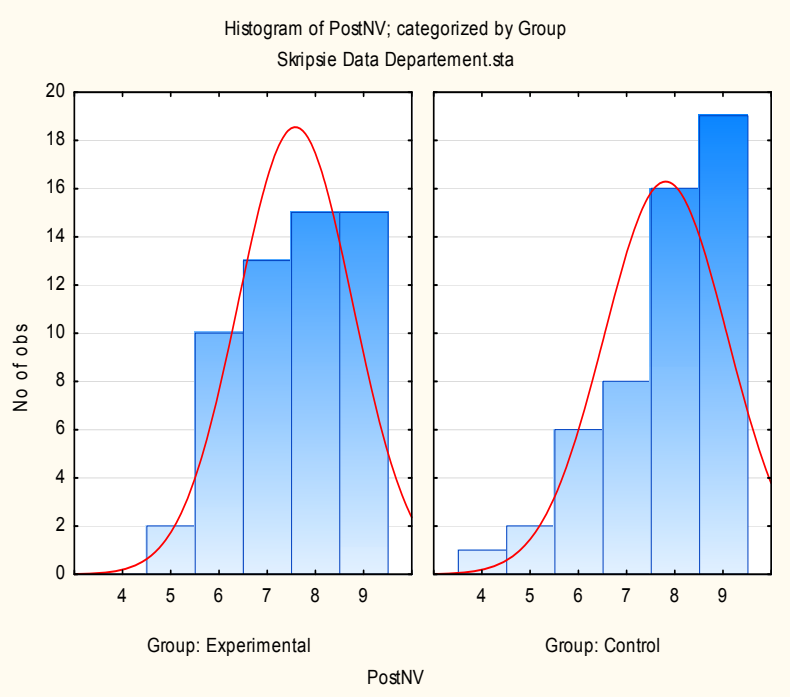

FIGURE 4.3e: Average post-test NV scale stanine scores for the experimental and control group

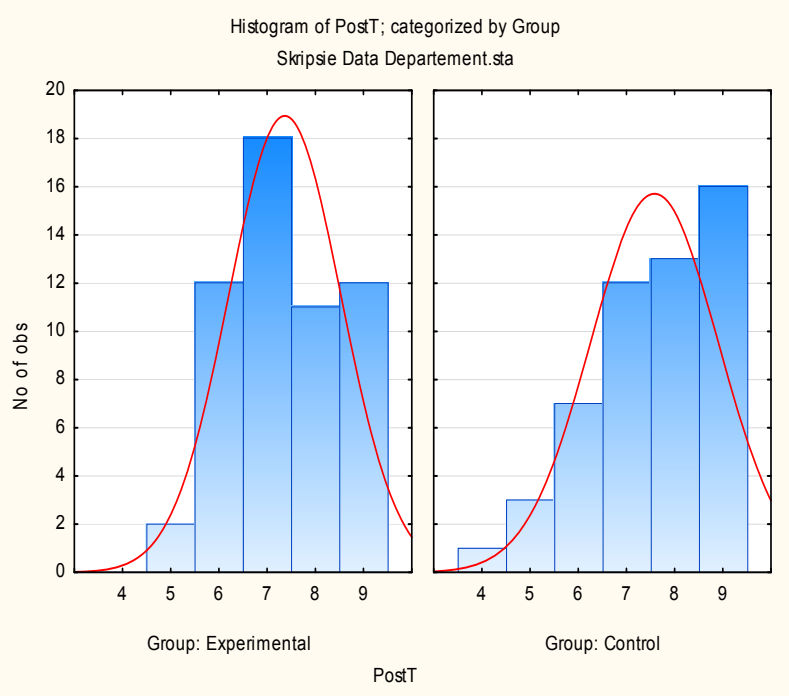

FIGURE 4.3f: Average post-test T scale stanine scores for the experimental and control group

The central tendencies and measures of spread for the selected data are presented in Table 4.6.

TABLE 4.6: Central tendencies and measures of spread for both treatment groups during the post-test on the various scales of the PPG

	Post-test					
	Experimental group			Control group		
Variables	**V scale**	**NV scale**	**T scale**	**V scale**	**NV scale**	**T scale**
Average (Mean)	6.76	7.56	7.35	6.98	7.79	7.56
Median	7.0	8.0	7.0	7.0	8.0	8.0
Standard Deviation	1.43	1.18	1.16	1.54	1.27	1.32

The post-test results were also exposed to the process of inferential statistical analysis. As mentioned previously, data were used from two respective treatment groups, making it necessary to search for any statistically significant differences between the data of the two groups.

The post-test stanine scores for both treatment groups were compared and analysed for any statistically significant difference between the average stanine scores on the different scales of the PPG. The Levene's test was first used to test the hypothesis that the variances in the groups are equal, followed by the *t*-test to determine differences in the means.

TABLE 4.7: Results from the Levene's test to detect whether the variances in the groups are equal for the post-test stanine scores

Variable	Std Dev Experimental group	Std Dev Control group	Levene F(1,df)	p Levene
Post-V scale	1.43	1.54	0.29	0.59
Post-NV scale	1.18	1.27	0.00	0.96
Post-T scale	1.16	1.32	0.99	0.32

The p-values are all greater than .05, meaning the variances were equal during the post-test.

The post-test comparisons for the various scales are formulated as follows:

V scale:

- H_{01}: There is no (statistically significant) difference between the average post-test V scale stanine scores of the experimental and control groups.
- H_{a1}: There is a (statistically significant) difference between the average post-test V scale stanine scores of the experimental and control groups.

NV scale:

- H_{02}: There is no (statistically significant) difference between the average post-test NV scale stanine scores of the experimental and control groups.
- H_{a2}: There is a (statistically significant) difference between the average post-test NV scale stanine scores of the experimental and control groups.

T scale:

- H_{03}: There is no (statistically significant) difference between the average post-test T scale stanine scores of the experimental and control groups.

- H_{a3}: There is a (statistically significant) difference between the average post-test T scale stanine scores of the experimental and control groups.

TABLE 4.8: *T*-test to detect a difference between the two treatment groups' variables on the post-test

Variable	Mean Experimental group	Mean Control group	t-value	p
Post-V scale	6.76	6.98	0.76	0.45
Post-NV scale	7.56	7.79	0.95	0.35
Post-T scale	7.35	7.56	0.89	0.38

The p-values are all greater than .05; therefore the null hypothesis (H_o) is not rejected and it is concluded that the two groups do not differ statistically significant with regard to their overall mean scores on the post-test in the various scales. In summary, the treatment groups did not differ statistically significant from each other at the beginning (pre-test) or end (post-test) of the study.

4.3.3 PRE-TEST – POST-TEST RESULTS

The pre-test – post-test results for the experimental and control groups follow:

V scale:

- H_{01}: There is no (statistically significant) difference between the pre-test and post-test V scale stanine scores of the experimental group.
- H_{a1}: There is a (statistically significant) difference between the pre-test and post-test V scale stanine scores of the experimental group.

NV scale:

- H_{02}: There is no (statistically significant) difference between the pre-test and post-test NV scale stanine scores of the experimental group.
- H_{a2}: There is a (statistically significant) difference between the pre-test and post-test NV scale stanine scores of the experimental group.

T scale:

- H_{03}: There is no (statistically significant) difference between the pre-test and post-test T scale stanine scores of the experimental group.
- H_{a3}: There is a (statistically significant) difference between the pre-test and post-test T scale stanine scores of the experimental group.

V scale:

- H_{01}: There is no (statistically significant) difference between the pre-test and post-test V scale stanine scores of the control group.
- H_{a1}: There is a (statistically significant) difference between the pre-test and post-test V scale stanine scores of the control group.

NV scale:

- H_{02}: There is no (statistically significant) difference between the pre-test and post-test NV scale stanine scores of the control group.
- H_{a2}: There is a (statistically significant) difference between the pre-test and post-test NV scale stanine scores of the control group.

T scale:

- H_{03}: There is no (statistically significant) difference between the pre-test and post-test T scale stanine scores of the control group.
- H_{a3}: There is a (statistically significant) difference between the pre-test and post-test T scale stanine scores of the control group.

The experimental group's results on the PPG can be summarised in Table 4.9 below.

TABLE 4.9: Experimental group's pre-test – post-test results

	Experimental group					
	Pre-test			**Post-test**		
	V scale	**NV scale**	**T scale**	**V scale**	**NV scale**	**T scale**
Average (Mean)	6.0	7.20	6.80	6.76	7.56	7.35
Median	6.0	7.0	7.0	7.0	8.0	7.0
Standard Deviation	2.05	1.45	1.52	1.43	1.18	1.16

The results of the research indicate that the average stanine scores of the respondents in the experimental group on the various scales of the PPG have altered during the treatment period of 16 weeks; they can also be graphically represented by Figure 4.3g below.

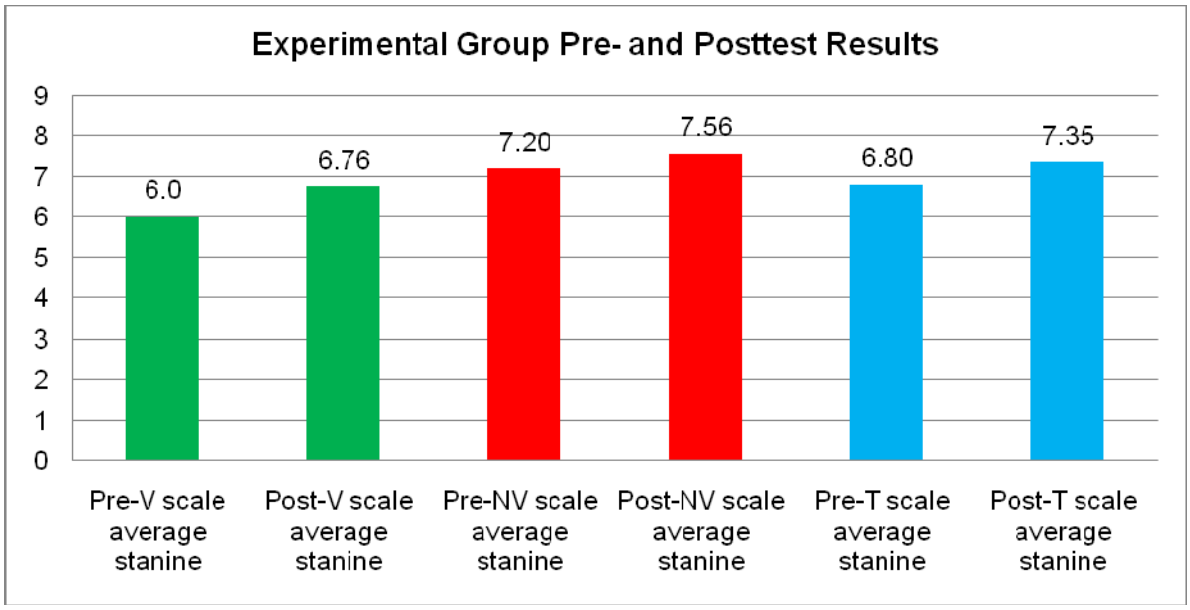

FIGURE 4.3g: Bar chart of average stanine scores for the experimental group pre-test versus post-test

Although a change is noted for the experimental group, the observed differences between the pre-test and the post-test average stanine scores on the various scales of the PPG will however need to be subjected to statistical analysis, to determine whether there are any statistically significant differences. These results will be interpreted in the following section.

Table 4.10 contains a summary of the control group's results during the pre-test and the post-test, which follows.

TABLE 4.10: Control group's pre-test – post-test results

	Control group					
	Pre-test			Post-test		
	V scale	NV scale	T scale	V scale	NV scale	T scale
Average (Mean)	6.27	7.40	7.10	6.98	7.79	7.56
Median	6.50	8.0	7.0	7.0	8.0	8.0
Standard Deviation	1.96	1.45	1.52	1.54	1.27	1.32

The results indicate that the mean scores of the respondents in the control group in the various scales of the PPG have also altered and can be graphically represented by Figure 4.3h below.

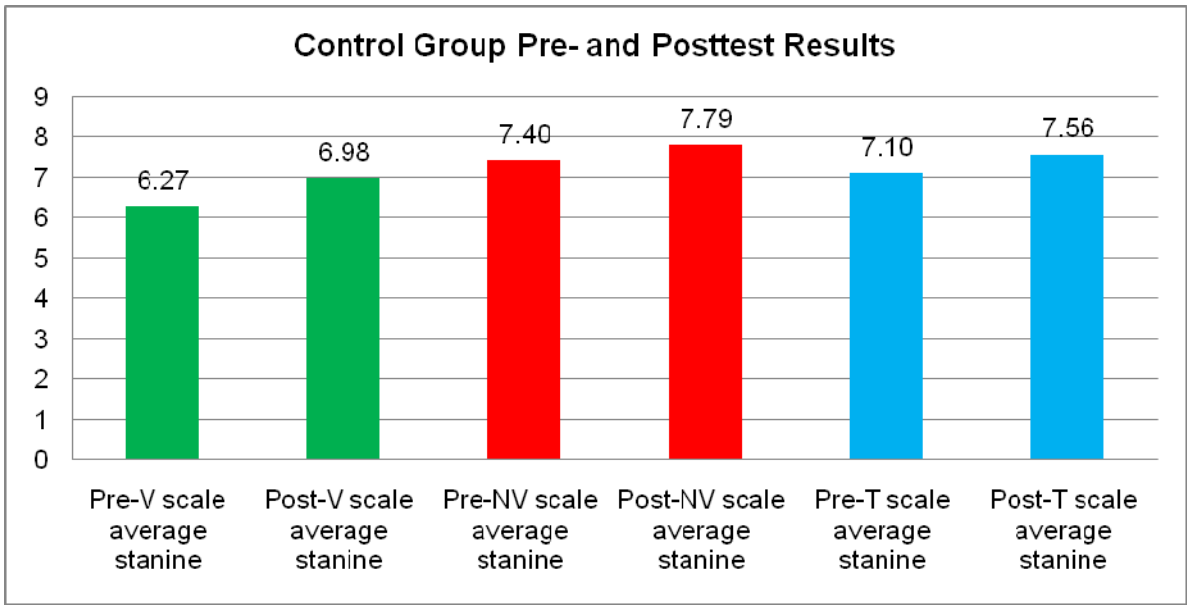

FIGURE 4.3h: Bar chart of average stanine scores for the control group pre-test versus post-test

As is the case in the experimental group, although a change is noted it may not be statistically significant, and it is therefore imperative to establish the significance thereof by subjecting the data to further statistical analysis.

In the following section, the results of the two respective treatment groups will be exposed to inferential statistical procedures, to determine whether a statistically

significant difference exists between the pre-test scores and the post-test scores on the various scales of the PPG.

4.3.3.1 Comparison of the pre-test – post-test average stanine scores on the various scales of the PPG for the experimental group

The average stanine scores of the two respective treatment groups on the various scales of the PPG during the pre-test and the post-test were compared using *t*-tests. The dependent *t*-test was employed because the independent variable was manipulated using the same participants; thus there were two experimental conditions, an experimental group and control group, where the same participants took part in both conditions (Field, 2005). Each respondent's stanine scores during the pre-test and the post-test on the various scales of the PPG were used.

When the possibility of a statistically significant difference between the various scales of the PPG is investigated for the experimental group, there is a statistically significant difference between the pre-test results and the post-test results on all of the PPG scales. A summary of the results is indicated in Table 4.11 below.

TABLE 4.11: Comparison of the pre-test – post-test averages for the experimental group on the various scales of the PPG

	V scale	
	Pre-test	**Post-test**
Mean (Averages)	6.0	6.76
Standard deviation	2.05	1.43
Sample	55	
Probability level (t test)	$p = 0.00$*	
Effect size	$r = 0.48$ (medium to high)	

	NV scale	
	Pre-test	**Post-test**
Mean (Averages)	7.20	7.56
Standard deviation	1.45	1.18
Sample	55	
Probability level (t test)	p = 0.01*	
Effect size	r = 0.31 (medium)	
	T scale	
	Pre-test	**Post-test**
Mean (Averages)	6.80	7.35
Standard deviation	1.52	1.16
Sample	55	
Probability level (t test)	p = 0.00*	
Effect size	r = 0.54 (high)	
Thus, the differences between the pre-test – post-test scores on all the PPG scales for the experimental group are statistically significant, because the p-values are all smaller than 0.05 (p<0.05).		

*: p<0.05

It is clear from Table 4.11 that the respondents in the experimental group performed statistically significantly better in the post-test than in the pre-test on all three scales, namely V scale, NV scale and T scale scores. In addition, effect sizes range from medium to high. These results therefore appear to be practically significant as well.

4.3.3.2 Comparison of the pre-test – post-test average stanine scores on the various scales of the PPG for the control group

The control group also shows a statistically significant difference between the pre-test results and the post-test results on all of the PPG scales. A summary of these results is indicated in Table 4.12 which follows.

TABLE 4.12: Comparison of the pre-test – post-test averages for the control group on the various scales of the PPG

	V scale	
	Pre-test	**Post-test**
Mean (Averages)	6.27	6.98
Standard deviation	1.96	1.54
Sample	52	
Probability level (t test)	p = 0.00*	
Effect size	r = 0.51 (high)	
	NV scale	
	Pre-test	**Post-test**
Mean (Averages)	7.40	7.79
Standard deviation	1.45	1.27
Sample	52	
Probability level (t test)	p = 0.01*	
Effect size	r = 0.37 (medium)	
	T scale	
	Pre-test	**Post-test**
Mean (Averages)	7.10	7.56
Standard deviation	1.52	1.32
Sample	52	
Probability level (t test)	p = 0.00*	
Effect size	r = 0.45 (medium to high)	
Thus, the differences between the pre-test – post-test scores on all of the PPG scales for the control group are statistically significant, because the p-values are all smaller than 0.05 (p<0.05).		

*: p<0.05

It is clear from Table 4.12 that the respondents in the control group performed statistically significantly better in the post-test than in the pre-test on all three scales, namely V scale, NV scale and T scale scores. In addition, effect sizes range from medium to high. These results therefore appear to be practically significant as well.

To summarise, there was a statistically significant improvement in the average scores on the post-test for all of the PPG scales, as regards both the experimental

group and the control group. As mentioned earlier in section 4.3.1, pre-test results, no difference was present at the start of the study between the two groups; in other words they performed similarly during the pre-test. Section 4.3.2 of the chapter, post-test results, determined there was also no difference between the two groups' performance on the post-test. Although both groups improved on the post-test, it is important to note that they improved equally, and that no statistically significant difference emerged on the post-test between the two groups.

4.4 CHAPTER SUMMARY

The results were discussed in Chapter 4. The pre-test results, post-test results and pre-test – post-test results, for both treatment groups, were presented and analysed to investigate the possibility of statistically significant differences between the two treatment groups' mean scores on the V scale, NV scale and T scale scores in the PPG. Inferential statistical procedures were employed for this purpose. The following results came to light:

a. The **two treatment groups** performed similarly in the pre-test. In other words, no statistically significant differences were found on any of the three sets of mean scores, namely the V scale, NV scale and T scale scores of the two treatment groups in the pre-test.

b. i. Statistically significant differences were found between the pre- and post-test mean scores of **the experimental group** on all three scores, namely the V scale, NV scale and T scale scores.

   ii. Statistically significant differences were found between the pre- and post-test mean scores of **the control group** on all three scores, namely the V scale, NV scale and T scale scores.

c. No statistically significant differences were found between either the V scale, the NV scale and T scale mean scores **of the two treatment groups** on the post-test.

In the next chapter the research results will be reviewed critically, by referring back to the relevant literature included in Chapter 2, so as to try and explain the equal improvement in the post-test stanine scores for the two respective treatment groups.

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CHAPTER 5
SUMMARY, FINDINGS AND RECOMMENDATIONS

5.1 INTRODUCTION

Chapter 5 includes a brief overview of the first four chapters of the study to substantiate the deductions and recommendations made. In addition, the limitations of the study are discussed and contributions highlighted. Lastly, the primary research question of the study is answered by following the general approach to hypothesis testing, which is either to reject or not reject the null hypothesis (Gavin, 2008; Pietersen & Maree, 2007).

5.2 OVERVIEW OF THE STUDY

The course of the research is briefly summarised in the section below.

5.2.1 CHAPTER 1: ORIENTATION

To provide the reader with a comprehensive picture of the study and the topic under investigation, namely **The possible effect of food supplements in the early grades**, Chapter 1 included a preliminary literature review, a background to the study and the rationale. In addition, the statement of purpose was described which implied the following research question:

Do the intelligence scores of Grade 3 and 4 learners improve statistically significantly after receiving a meal supplement fortified with micronutrients when compared with a group of Grade 3 and 4 learners who received a meal supplement without any added micronutrients? The research process pertaining to the study was illustrated by a graphic summary, explaining the various steps involved in the research process and the research methodology which were employed. Ethical considerations pertaining to my behaviour as the researcher and the consequences of the research for the respondents were also taken into account.

5.2.2 CHAPTER 2: LITERATURE STUDY

Chapter 2 focused on the literature overview. It included a discussion on the pressing issue of poverty and the related risk factor of malnutrition. Hereafter, the role of nutrition on brain development and cognitive functioning was explored, as well as the possible effects of malnutrition. Nutritional supplementation studies as a possible means for intervention, and these studies' findings, were also investigated. Furthermore, the assessment of children's cognitive development was addressed by discussing the concept of psychometric intelligence and related theories. The PPG as the measuring instrument and its use in the study was also explained. The chapter was concluded by discussing methodological considerations that may influence learners' test performance, which could in the end have a bearing on the interpretation of test scores.

5.2.3 CHAPTER 3: METHODOLOGY

A quantitative (positivist) research paradigm was adopted and a true experimental study design was employed during the study, which was discussed in detail in Chapter 3. The specific research design appropriate for the study, namely the pre-test – post-test control group design, was elaborated on. The research site, the respondents and the sampling methods that were used to select them were described. Data collection procedures, specifically the PPG as a data collection measure and its validity and reliability, were also discussed. The plan for data analysis was explained, whereafter the validity and reliability of the data and possible threats to these were considered.

5.2.4 CHAPTER 4: QUANTITATIVE ANALYSIS

My main aim was to determine whether the intelligence scores of Grade 3 and 4 learners improved statistically significantly after receiving a meal supplement fortified with micronutrients when compared with a group of Grade 3 and 4 learners who received a meal supplement without any added micronutrients. Should this be the case, it would be plausible to surmise that receiving the meal supplement **fortified with micronutrients** as opposed to receiving the meal supplement **not fortified with micronutrients** may have played the major role in the statistically

significant improvement in the intelligence scores of the experimental group (given that due steps were taken to ensure internal validity). These results were analysed in Chapter 4. The results were discussed in terms of the pre-test results, the post-test results and the pre-test – post-test results. The data were explained by looking at the results of the two respective treatment groups separately, but also simultaneously. Respondents' performances on each of the PPG scales, namely the V scale, NV scale and T scale were summarised in terms of experimental versus control group results.

5.3 HYPOTHESIS VERIFICATION

The following results emerged from the findings discussed in the previous chapter:

a. The **two treatment groups** performed similarly in the pre-test. In other words, no statistically significant differences were found on any of the three sets of mean scores, namely the V scale, NV scale and T scale scores of the two treatment groups in the pre-test.

b. i. Statistically significant differences were found between the pre- and post-test mean scores of **the experimental group** on all three scores, namely the V scale, NV scale and T scale scores.

   ii. Statistically significant differences were found between the pre- and post-test mean scores of **the control group** on all three scores, namely the V scale, NV scale and T scale scores.

c. No statistically significant differences were found between either the V scale, the NV scale and T scale mean scores **of the two treatment groups** on the post-test.

In answering the primary research question, the experimental group comprised the learners who received the meal supplement with added micronutrients as opposed to the control group who received the meal supplement with no added micronutrients. Although it was found that both groups improved on the post-test, no statistically significant differences emerged between the two treatment groups on the post-test. Thus, from the results it is clear that the null hypothesis cannot be rejected (Gavin, 2008; Pietersen & Maree, 2007).

No previous South African studies could be found that reported on the specific analysis presented in (c) (above). However, the results in (b) confirm the supplementation studies reported by Laus et al. (2011), who established statistically significant pre-test – post-test differences between experimental and control groups' scores. In contrast, my results refute the findings by Grantham-McGregor and Baker-Henningham (2005) who found that only supplementation within the first two years of life has regularly proven beneficial, in contrast to children receiving supplementation after two years. The inconsistency in research findings (as demonstrated above) with regard to supplementation studies and the benefits for cognitive ability according to Petranovic et al. (2008) can be ascribed to different cognitive measures being used by researchers or perhaps to the theory that the tests are not sensitive enough to measure cognition. The authors suggest standardisation of cognitive measures used to test cognition, such as an apparatus like Drenovac, a complex reactiometer.

5.4 LIMITATIONS OF THE STUDY

As mentioned in the earlier chapters Sunnyside Primary School attracts children from various demographic locations, including immigrant learners, which means that they are naturally inclined to experiencing language problems. The learners were not assessed in their first language, but in their language of instruction (English) and sometimes had trouble understanding the verbal instructions of the PPG. The standardised instructions of the PPG therefore needed to be slightly adjusted for the respondents in my study. Adaptations included mostly simplifying the language, by providing synonyms or explanations of words in cases where the majority of learners experienced problems with certain words. These subtle changes may have impacted negatively on both the internal and external validity of my study (Masling, 1960, as cited in G. Domino & Domino, 2006). Notwithstanding this comment, it should be noted that Foxcroft and Roodt (2009) acknowledge that these adjustments are sometimes deemed necessary when assessing children. The threat was controlled to some degree by making notes of the changes and consistently following the pre-test changes during the post-test as well. However, I am aware that Foxcroft and Roodt (2009), as well as Sattler and Theye (1976, as cited in G. Domino & Domino, 2006) contend that variation from standard procedures in intelligence testing is likely to affect children to some degree. The

adaptations to the instructions and their effect on the respondents cannot be ignored as potentially influential in the context of my study and may have adversely impacted the internal validity of my results.

In my study, the assessment venue, the school hall, posed a sound limitation as there was no microphone system available. This led to an echo in the hall. This possibly affected the respondents' understanding of the test instructions, especially during Subtest 2 of the PPG, as the instructions are not generic and differ considerably from the other subtests. This may have contributed to some discouragement among the respondents (Masling, 1960, as cited in G. Domino & Domino, 2006). Sattler and Theye (1976, as cited in G. Domino & Domino, 2006) confirm that discouragement may have a particularly negative effects on children and their performance on intelligence tests.

Lastly, administering a cognitive test in a group environment in isolation, instead of conducting such a test as a part of a holistic assessment (Foxcroft & Roodt, 2009), may be regarded as a limitation of my study.

5.5 GENERALISABILITY OF RESULTS OBTAINED FROM THE STUDY SAMPLE

The sample of this study included Grade 3 and 4 learners from Sunnyside Primary, displaying little demographic variation. This aspect limits the generalisability of my findings considerably.

5.6 CONTRIBUTIONS OF THE STUDY

Firstly, the vital issue of malnutrition in the South African context was foregrounded. Even though this aspect was not the primary focus of my study, I hope that this increase in awareness of socio-economic challenges in South African schools will in some small way contribute to reconsideration of the nature of existing school feeding programmes. Secondly, the study also emphasized the need to try and assess the impact of feeding schemes experimentally.

Secondary contributions of the study relate to the community within which the study was conducted and Sunnyside Primary School. As the data were collected by means of the PPG, in the first instance the parents and/or legal guardians of the respondents can gain access to the results via the school's intern psychologist or any other psychologist and receive feedback with regards to their individual child's cognitive ability. The children in the study were also dewormed before the study commenced, while those who were severely anaemic were identified; feedback was given to the parents and/or legal guardians to seek medical advice. In terms of the school, a group of learners in the school received a nutritional meal supplement for the duration of 16 weeks. Secondly, the school can also gain access to the results of this study, which it could use in future were it perhaps to consider a further evaluation of the school's existing school feeding programme. Lastly, the school also has the opportunity to use the results, to evaluate and perhaps make changes to its teaching methods or instruction, as it now has an idea of the general cognitive abilities of Grade 3 and 4 learners.

The researchers hope that these contributions will spark further research interest in the South African context using micronutrient supplementation to address some of the challenges children face, a major one being malnutrition and its adverse affects on the unfolding of their potential.

5.7 RECOMMENDATIONS FOR FUTURE RESEARCH

5.7.1 PSYCHOLOGICAL ASSESSMENT

As stated previously, test scores obtained from psychological testing only provide a limited understanding of an individual's functioning. However, obtaining these scores for specific purposes is still recognised, and used, by professionals as an acceptable manner to assess individuals. Regrettably, as a result of this, children are often not assessed as a whole because only one area of their development is assessed, in the case of this study the respondents' cognitive development. Other areas of development are not considered. It is suggested that, in assessments such as the one described in my study, data be collected by means of a complete psychological assessment strategy which yields a broad array of information

instead of the test results of one measure only. This would facilitate an expanded research focus, in which all the domains of a child's development are considered.

5.7.2 FACTORS CONTRIBUTORY TO CHANGE IN COGNITIVE DEVELOPMENT

The findings revealed statistically significant increases in scores between the pre-test and post-test on the various scales of the PPG of both the experimental and control group on one hand, but no statistically significant differences between the two treatment groups on the post-test on the other hand. However, only nutrition as a possible contributing agent to change was explored in this study. It seems plausible to suggest that the link between children's cognitive performance and their social and physical environmental conditions be explored in future studies as well.

5.7.3 ASSESSING COGNITIVE ABILITY FOLLOWING THE EXPOSURE TO A MEAL SUPPLEMENT AMONG DIFFERENT SAMPLE GROUPS

In this study the cognitive ability of Grade 3 and 4 learners from Sunnyside Primary School was assessed, a very specific sample group which leaves a vast spectrum of schools and school grades unexplored. This study's findings should be replicated within different school grades and in various forms of schooling. In addition, utilising a meal supplement alone as opposed to using this supplement fortified with micronutrients could be researched in different contexts, e.g. the private sector. Furthermore, the possible effect of utilising different meal supplements could be explored as well.

5.7.4 EMPLOYING DIFFERENT COGNITIVE MEASURES AND METHODS OF INTERVENTION

The respondents' cognitive ability was assessed in this study using the PPG. Employing other cognitive measures for the assessment of learners' cognitive ability should be considered.

Employing (a range of) different intervention methods, other than supplementation, such as educating parents and teachers on adequate nutrition to address malnutrition and the effects on children's cognitive ability could also be investigated.

5.8 CONCLUSION

Many thousands of South African learners suffer from poverty and malnutrition. The negative effects of this phenomenon have been conclusively demonstrated and include exclusion from the multiple opportunities offered in this country (Grantham-McGregor et al., 2007). It goes without saying that hungry children cannot be expected to achieve in accordance with their potential. In addition, food intake deficiencies impact negatively on cognitive development in particular (Grantham-McGregor et al., 2007). These findings have staggering short-, medium- and longer-term implications. Unless children's diets include the necessary (if not vital) nutrients, their achievement at primary school will be negatively affected and a vicious cycle created. Their chances of achieving at secondary school are likewise compromised, as are their chances of achieving at tertiary level – and in life itself.

It seems essential to focus on ways in which to improve the unfortunate situation in which so many of our learners find themselves. In my study, superficially, I attempted to determine whether the intelligence scores of Grade 3 and 4 learners improve statistically significantly after receiving a meal supplement fortified with micronutrients when compared with a group of Grade 3 and 4 learners who received a meal supplement without any added micronutrients. However, after having travelled this journey with the little children who are caught in a sad poverty trap I want to conclude by confirming that I have come to the realisation that the findings of my study have a much broader impact than the results seem to suggest.

Allow me to explain: At the heart of the matter lies the issue of social responsibility. What do we do now that we have established that the **post-test** intelligence scores of Grade 3 and 4 learners did not improve statistically significantly, after the said intervention? I believe that whereas it is hugely important to conduct and report on research on these and related issues in the way described here, and to make a case for feeding schemes to be enhanced at our schools (especially those in the poorest parts of our country), it is equally important to realise that giving of ourselves as much and as often as possible, to impact positively on the declining socio-economic situation in South Africa, is the ideal starting point.

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APPENDICES

APPENDIX A
Data Summaries

APPENDIX B
Assent Form

APPENDIX C
Consent Form

APPENDIX D
Ethical Clearance Certificate

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APPENDIX A
DATA SUMMARIES

Table 1: Experimental group

		Pre-test						Post-test					
		PPG scales						PPG scales					
Class	ID Code	Raw NV	Raw V	Raw T	NV	V	T	Raw NV	Raw V	Raw T	NV	V	T
3M	1	48	47	95	9	9	9	50	47	97	9	9	9
	2	18	38	56	3	6	4	30	39	69	5	6	5
	3	45	44	89	8	8	8	48	45	93	9	8	9
	4	48	38	86	9	6	8	50	42	92	9	7	9
	6	48	43	91	9	8	8	49	43	92	9	8	9
	7	50	30	80	9	4	7	46	34	80	8	5	7
3MS	14	44	36	80	7	6	7	47	40	87	8	7	8
	15	47	40	87	8	7	8	48	39	87	9	6	8
	17	45	44	89	8	8	8	45	42	87	8	7	8
	18	46	47	93	8	9	9	46	40	86	8	7	8
	22	46	45	91	8	8	8	44	47	91	7	9	8
	23	36	27	63	6	3	5	43	35	78	7	5	7
	24	48	36	84	9	6	7	46	39	85	8	6	7
	26	47	12	59	8	1	4	45	29	74	8	4	6
	28	32	36	68	5	6	5	36	38	74	6	6	6
3S	33	37	26	63	6	3	5	44	33	77	7	5	6
	34	48	44	92	9	8	9	49	46	95	9	9	9
	35	42	42	84	7	7	7	41	45	86	7	8	8
3TS	38	43	44	87	7	8	8	46	43	89	8	8	8
	40	43	36	79	7	6	7	48	44	92	9	8	9
	41	31	36	67	5	6	5	35	39	74	6	6	6
4CM	46	43	37	80	6	5	6	44	37	81	6	5	6
	48	48	40	88	8	6	7	44	45	89	6	8	7
	49	45	36	81	7	4	6	45	39	84	7	5	6
	51	46	40	86	7	6	7	45	43	88	7	7	7
	52	49	49	98	9	9	9	49	50	99	9	9	9
	55	48	31	79	8	3	6	45	37	82	7	5	6
	56	49	40	89	9	6	7	46	44	90	7	7	7
	59	47	39	86	8	5	7	47	42	89	8	6	7
	60	49	48	97	9	9	9	48	49	97	8	9	9
	62	47	48	95	8	9	9	47	47	94	8	8	8
4M	63	40	44	84	5	7	6	42	40	82	6	6	6
	65	47	47	94	8	8	8	48	41	89	8	6	7
	66	46	42	88	7	6	7	47	46	93	8	8	8
	67	50	50	100	9	9	9	48	48	96	8	9	9
	69	44	35	79	6	4	6	42	39	81	6	5	6
	73	38	31	69	5	3	4	41	40	81	6	6	6
	74	44	42	86	6	6	7	49	41	90	9	6	7

		Pre-test						Post-test					
		PPG scales						PPG scales					
Class	ID Code	Raw NV	Raw V	Raw T	NV	V	T	Raw NV	Raw V	Raw T	NV	V	T
N	78	48	46	94	8	8	8	50	47	97	9	8	9
	79	48	41	89	8	6	7	46	44	90	7	7	7
	80	48	42	90	8	6	7	50	44	94	9	7	8
	83	44	43	87	6	7	7	49	42	91	9	6	8
	86	47	46	93	8	8	8	49	50	99	9	9	9
4T	88	45	32	77	7	3	5	45	43	88	7	7	7
	90	46	38	84	7	5	6	45	44	89	7	7	7
	91	48	44	92	8	7	8	49	38	87	9	5	7
	93	45	36	81	7	4	6	47	43	90	8	7	7
	95	44	32	76	6	3	5	46	39	85	7	5	7
	97	30	27	57	4	2	3	38	43	81	5	7	6
	98	41	40	81	6	6	6	42	47	89	6	8	7
	100	50	47	97	9	8	9	50	46	96	9	8	9
	103	43	36	79	6	4	6	47	39	86	8	5	7
	104	42	33	75	6	4	5	45	33	78	7	4	5
	105	40	35	75	5	4	5	42	37	79	6	5	6
	107	45	44	89	7	7	7	42	47	89	6	8	7

Table 2: Control group

		Pre-test						Post-test					
		PPG scales						PPG scales					
Class	ID Code	Raw NV	Raw V	Raw T	NV	V	T	Raw NV	Raw V	Raw T	NV	V	T
3M	5	41	36	77	7	6	6	43	38	81	7	6	7
	8	50	48	98	9	9	9	50	47	97	9	9	9
	9	45	46	91	8	9	8	50	47	97	9	9	9
	10	36	35	71	6	5	6	36	35	71	6	5	6
	11	45	41	86	8	7	8	49	46	95	9	9	9
	12	48	41	89	9	7	8	48	41	89	9	7	8
	13	49	46	95	9	9	9	48	49	97	9	9	9
3MS	16	43	32	75	7	4	6	47	37	84	8	6	7
	19	39	38	77	6	6	6	42	38	80	7	6	7
	20	45	35	80	8	5	7	48	37	85	9	6	7
	21	41	39	80	7	6	7	47	45	92	8	8	9
	25	42	27	69	7	3	5	46	28	74	8	3	6
	27	32	23	55	5	2	4	43	33	76	7	5	6
	29	48	40	88	9	7	8	43	40	83	7	7	7
	30	44	39	83	7	6	7	44	44	88	7	8	8
	31	45	44	89	8	8	8	48	47	95	9	9	9
3S	32	45	42	87	8	7	8	48	40	88	9	7	8
	36	49	39	88	9	6	8	49	43	92	9	8	9

		Pre-test						Post-test					
		PPG scales						PPG scales					
Class	ID Code	Raw NV	Raw V	Raw T	NV	V	T	Raw NV	Raw V	Raw T	NV	V	T
3TS	37	45	35	80	8	5	7	47	43	90	8	8	8
	39	48	45	93	9	8	9	48	45	93	9	8	9
	42	33	40	73	5	7	6	42	40	82	7	7	7
	43	47	46	93	8	9	9	46	44	90	8	8	8
4CM	44	47	45	92	8	8	8	48	46	94	8	8	8
	45	39	36	75	5	4	5	39	37	76	5	5	5
	47	48	44	92	8	7	8	47	43	90	8	7	7
	50	44	39	83	6	5	6	47	42	89	8	6	7
	53	50	47	97	9	8	9	46	49	95	7	9	9
	54	46	33	79	7	4	6	41	39	80	6	5	6
	57	50	39	89	9	5	7	50	42	92	9	6	8
	58	47	49	96	8	9	9	48	47	95	8	8	9
	61	49	47	96	9	8	9	50	47	97	9	8	9
4M	64	48	31	79	8	3	6	50	41	91	9	6	8
	68	44	40	84	6	6	6	41	41	82	6	6	6
	70	43	31	74	6	3	5	41	35	76	6	4	5
	71	49	40	89	9	6	7	50	45	95	9	8	9
	72	44	43	87	6	7	7	48	46	94	8	8	8
	75	50	48	98	9	9	9	48	49	97	8	9	9
	76	38	38	76	5	5	5	44	34	78	6	4	5
4N	77	47	49	96	8	9	9	47	49	96	8	9	9
	81	49	50	99	9	9	9	49	45	94	9	8	8
	82	47	41	88	8	6	7	49	45	94	9	8	8
	84	26	24	50	3	1	2	32	38	70	4	5	4
	85	46	37	83	7	5	6	48	40	88	8	6	7
	87	47	44	91	8	7	8	50	45	95	9	8	9
4T	89	44	44	88	6	7	7	39	42	81	5	6	6
	92	46	39	85	7	5	7	49	39	88	9	5	7
	94	42	44	86	6	7	7	42	41	83	6	6	6
	96	49	43	92	9	7	8	47	43	90	8	7	7
	99	40	35	75	5	4	5	47	44	91	8	7	8
	101	49	46	95	9	8	9	49	48	97	9	9	9
	102	47	43	90	8	7	7	47	40	87	8	6	7
	106	45	42	87	7	6	7	46	45	91	7	8	8

APPENDIX B
ASSENT FORM

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Denkleiers • Leading Minds • Dikgopolo tša Dihlalefi

LEARNER'S ASSENT FOR PARTICIPATING IN THE RESEARCH STUDY

A research project of the University of Pretoria

Project title: The possible effect of food supplements in the early grades on intelligence scores.

To be read to children under the age of 18 years.

Why am I here?

Sometimes when we want to find out something, we ask people to join something called a project. In this project you will consume a maize-based ready-to-use meal supplement (let's call it a maize sip for short). Before we ask you to be part of this study we want to tell you about it first.

This study will give us a chance to gather information on the effect of this maize sip on learning and concentration abilities (scholastic abilities) and the amount of iron in the bodies of children. It will also tell us if it improves the nutritional status in children like you. We are asking you to be in this study because your parent/guardians have agreed that you can be part of our study.

What will happen to me?

If you want to be part of our study you will participate in some procedures and undergo a test, where you answer some questions.

About 160 children are going to take part in this study, and the study will last 16 weeks, over the last two school terms of the year. During that time you will have to

consume (it will be like drinking a milkshake) one of two maize sips 5 days a week for the 16 week study period at a specific place at your school. The sip you will receive will be determined by chance, like flipping a coin and neither you nor we will know which sip you are drinking until after the 16 weeks.

We will also measure your weight and height and assess your learning and concentration abilities (scholastic abilities). This will be done before you start taking the sip and after 16 weeks. At the beginning and end of the study, we will also take a tiny amount of blood (5 drops) from your finger. This may hurt a little, but it will only take a minute. These tests will take about 3 hours in total, but will only take place twice during the whole study. You will receive de-worming medication, 1 tablet, once-off before the start of the study.

Will the project hurt?

Maybe, just a little bit when they take a tiny amount of blood (5 drops) from your finger. After taking the de-worming medication the following unpleasant feelings can occur (although this does not happen often): temporary stomach pain, diarrhea and vomiting; breaking out with a rash and hives; headaches, a sudden fever, shaking and a sore throat. We will give you a sickness diary in which you or your parents must record every time you are ill. It is very important that you tell your doctor, nurse or your parents if you don't feel well at anytime during the study. The games we are going to play to look at your scholastic abilities will be called *Paper and Pencil Games*. These games will take us a bit long (3 hours), but we will take a break. All of your answers will be kept a secret and none of your friends or your teachers will know what answers you gave in the *Paper and Pencil Games*. We will practice a lot before we start any game and you will be allowed to ask questions if you are unsure.

Will the study help me?

We hope this study will help your body to be healthy and maybe to concentrate and learn better at school, but we don't know if this will happen.

What if I have any questions?

You can ask any questions you have about the study. If you have questions later that you don't think of now you can phone Dr. Zelda White at 082 738 2916 or Miss. Carla Roets at 084 240 4374 or you can ask them next time they come to visit you here at your school.

Do my parents/guardians know about this project?

This study was explained to your parents/guardians and they said you could be part of the study if you want to. You can talk this over with them before you decide if you want to be in the study or not.

Do I have to be in the project?

You do not have to be in this project. No one will be upset or cross with you if you don't want to do this. If you don't want to be in the project, you just have to tell Dr. Zelda White or Miss. Carla Roets. You can say yes or no and if you change your mind later you don't have to be part of the project anymore. It's up to you. You don't have to give us your answer now, take your time and read through the form again before you decide.

(a) Writing your name on this page means that **you would like to be in the project** and that you **know what will happen to you** in this study. If you decide to quit the project all you have to do is tell Dr. White or Miss. Roets.

Signature of the learner: _____ Date: _____

Signature of the researcher: _____ Date: _____

If you have any further questions with regards to this study you can phone any of the investigators, Dr. Zelda White or Miss. Carla Roets. If you have a question about your rights as a participant, you can contact the University of Pretoria, Faculty of Education Ethics Committee at 012 420 5656.

APPENDIX C
CONSENT FORM

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA
Denkleiers • Leading Minds • Dikgopolo tša Dihlalefi

PARENT/GUARDIAN CONSENT FOR PARTICIPATION OF A MINOR IN THE RESEARCH STUDY

A research project of the University of Pretoria

Project title: The possible effect of food supplements in the early grades on intelligence scores.

Introduction and invitation to participate

Your child is invited to participate in this study. This information leaflet is to help you to decide if you want to allow your child to participate in this study. Before you give consent for your child to take part in this study you should fully understand what is involved so that you can make an informed decision. Once you have decided if you want your child to take part in this study, you will be asked to sign this consent form, giving your child permission to be in the study.

The research study is being undertaken by Dr. Zelda White from the Faculty of Health Sciences, Department of Human Nutrition, University of Pretoria. The assessment of your child's scholastic aptitude (intelligence scores) will be done by Dr. Suzanne Bester, Prof. Kobus Maree and Carla Roets from the Department of Educational Psychology, University of Pretoria. If you have any questions, which are not fully explained in this leaflet, do not hesitate to ask any of the investigators. You should not agree for your child to take part unless you are completely comfortable and satisfied with all the procedures involved. In the best interest of your child's health, it is strongly recommended that you discuss or inform your personal physician about your child's participation in this study, wherever possible.

You can also contact the investigator to obtain the contact details of school medical services or government funded medical services.

Before signing this informed consent form, we would also like to invite you to a parent information session, where all aspects of the study will be explained to you by the investigators on the 9th and 16th of February 2010. During this session you will be briefed on the nature and purpose of the study, risks and discomfort involved, possible benefits as well as a demonstration of all the procedures that the children will be involved in. You will also have the opportunity to ask the investigators questions. The same aspects of the study will be explained to the children in their classrooms and their assent to participate will also be obtained.

Description of the research

The purpose of this study is to investigate the effect of a ready to use maize-based meal supplement enriched with micronutrients on the iron status (amount of iron in the body) and scholastic aptitude (intelligence scores) of primary school children. By doing so we wish to learn more about the role of a maize-based meal supplement in addressing two of the primary aims of the National School Nutrition Program (NSNP) namely:

- Enhancing active learning capacity through improved cognitive (intellectual) performance; and
- Addressing micronutrient (vitamin and mineral) deficiencies by improving iron status.

During the study your child will consume one of the following types of meal supplements 5 days a week for 16 weeks:

1. Standard Maize-based ready-to-use “TetraPak” meal supplement fortified with added vitamin and minerals.
2. Maize-based ready-to-use “TetraPak” meal supplement with a similar energy and macronutrient profile as the standard product, but without any added vitamin and minerals.

The meal supplement allocated to your child will be determined by chance, like flipping a coin. Although the supplement with added vitamins and minerals could

have additional benefits to the children who consume them all the groups will receive the same basic nutritional benefits from the maize-based meal supplements to satisfy their daily nutritional requirements. Neither your child nor the researchers will know which supplement is consumed by your child and this information will only be revealed at the end of the study. You are welcome to obtain any additional information on the meal supplements from the researchers.

Duration of the trail

If you want your child to be part of our study he/she will spend some time with us participating in various procedures and completing a specific psychological test. If you decide to allow your child to take part he/she will be one of approximately 160 children. The study will last up to 16 weeks.

Procedures to be followed

Your child will receive de-worming medication as part of the study procedures when participating in the study. One Vermox® 500 mg tablet will be administered as a single dose. This study involves answering some socio-demographic questions with regard to your child and household. This information will assist us in understanding your child's physical home environment and their nutritional care. Your child's weight and height will be measured as well.

We will then measure your child's ability to learn and concentrate (cognitive performance). This will be done in a group format. There will be 80 children per group and the children will be asked to complete a test called the *Paper and Pencil Games (PPG) Level 3*. The test measures figural, quantitative and verbal skills related to your child's scholastic achievement. The cognitive skills necessary to perform well in the test describes your child's general scholastic reasoning ability. The test will help the investigator to look at your child's general scholastic reasoning ability (intellectual performance), specifically their intelligence. An intelligence score will be obtained. The test will be administered during two sessions– once before your child has taken one of the meal supplements and after your child has taken one of the meal supplements for 16 weeks. The sessions each will take about 3 hours.

Blood samples will also be obtained from the fingers' tiny blood vessels (capillary) by a finger prick and will be used to determine haemoglobin concentrations, which indicates the iron status (amount of iron in the body) of your child. Children with a mild to normal iron status will be included in the study.

The weight and height, cognitive assessment and blood samples will be taken twice during the study, the first assessments from the 15th of July 2010[16] and the second assessments from the 22nd of November 2010.

We will give your child a sickness diary in which you must record every time your child feels ill. It is important that you let the investigator know of any medicines (both prescriptions and over-the-counter medicines), alcohol or other substances that your child is currently taking.

Limitations, risks and discomfort involved

The de-worming medication could cause side-effects in cases of massive infestation, when excretion of worms may occasionally cause temporary symptoms such as stomach pain, diarrhea and vomiting. Headaches have been reported and agranulocytosis can occur. Agrunulocytosis is a short term condition that represents a severe lack of one of the major class of infection fighting white blood cells (one of the cells the body makes to help fight infections), and may clinically present with sudden fever, rigors and sore throat. Adverse reactions such as breaking out with a rash and hives have been observed in some cases.

Your child may experience some discomfort during the taking of blood (5 drops) from the finger by means of a finger prick. In order to protect your child this procedure will be performed under sterile conditions by experienced personnel. A total of 10 drops of blood will be collected over the course of the entire study. Your child will need to take off their shoes and excess clothing to be weighed and for their height to be taken accurately and this may cause some discomfort.

[16] Informed consent was obtained for the study during the month of February 2010. Data collection only commenced on the 15th of July 2010 and the 22nd of November 2010, due to the unavailability of medication.

Limitations with regards to the cognitive assessment are that the results may not be used for diagnostic/remedial purposes. The results obtained are not a holistic view of your child's abilities. The results obtained are strictly for the purpose of statistical analysis. The results will however be made available upon your request and after written permission by yourself to a registered practicing psychologist who could advise you on further use of these results and any possible further assessment required to provide a holistic view of your child's development. You could also make use of the intern psychologist at Sunnyside Primary School should you require further academic support to your child.

If your child experiences any discomfort we will speak to your child and make sure he/she understands what is going on and still feels comfortable to continue with the study.

The information obtained during the study will be kept private.

Benefits

If your child has a very low iron status (moderate to severely anaemic), we will notify you and your child will be referred for treatment and not included in the study. Children included in the intervention study will be de-wormed. Children will also receive a daily fortified or unfortified meal supplement. The meal supplement could potentially improve your child's nutritional status and cognitive performance, and in turn their school performance. We cannot however guarantee this. The supplement will only be provided during the study period, even if the study shows an improvement in your child's cognitive abilities. Nutrition education will however be provided to you and/ your child after completion of the study to enable you and/ your child to make better food choices to improve their nutritional and/ micronutrient status. There are no financial benefits to this study.

Has this study received ethical approval?

A research protocol was submitted to the Faculty of Health Sciences Research Ethics Committee, University of Pretoria and approval has been granted by the committee. The study has been structured in accordance with the Declaration of Helsinki (last update: October 2000), which deals with the recommendations

guiding doctors in biomedical research involving human/subjects. A copy of the Declaration may be obtained from the investigator should you wish to review it.
A research protocol was also submitted to the Faculty of Education, Department of Educational Psychology, Research Ethics Committee, University of Pretoria to obtain written approval.

What are your child's rights as participant in this study?

Participation in this study is purely voluntary and both the parents/guardians as well as the child may refuse to take part in the study or stop at any time without giving any reason. If the child decides not to participate or wants to stop taking part in the study after they said yes, this will not affect you or the child in any way.

Questions and information

Please feel free to ask anything you don't understand and take your time before making a decision about whether or not you want to give permission for your child to take part in the study. If you have questions concerning this study later that you don't think of now you can contact:

Dr. Zelda White Tell: 012 354 1993 Cell: 082 738 2916
Carla Roets Cell: 084 240 4374.

Confidentiality

All information obtained during the course of this study will be kept strictly confidential and will only be available to the investigators of the study. All the results obtained in this study will be stored in locked files in research offices at the University of Pretoria. The results will be published or presented in such a fashion that patients remain unidentifiable.

Informed consent to participate in this study

I hereby confirm that I have been informed about the nature, conduct, risks and benefits of this study. I have also read or have had someone read to me in a language that I understand the above information regarding this study and that I understand the information that has been given to me. I am aware that the results and information about this study will be processed anonymously. I may, at any stage, without prejudice, withdraw my consent for my child to participate in this

study. I have had sufficient opportunity to ask questions and (of my own free will) declare that my child may participate in this study.

Parent/Guardian Name: _____ (Please print)

Parent/Guardian Signature: _____

Date: _____

Child obtaining informed consent: _____ (Please print)

Date: _____

Witness's Name and Signature: _____

Date: _____ (Please print)