THE EFFECT OF PREMATURITY ON VISUAL PERCEPTUAL SKILLS AMONGST SCHOOL-AGE CHILDREN IN GRADE 4-6 AT PULAMADIBOGO SCHOOL IN MANKWENG, LIMPOPO PROVINCE

by

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MINI-DISSERTATION

Submitted in partial fulfillment of the requirements for the degree of

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DEDICATION

I dedicate this study to the three most beautiful women in the world to me, my mother-Prof Sheila Mmusi, her shadow and her mirror image. You have paved the way for me to be educated, thank you for picking me up when I fall flat on my face, for believing in me, encouraging me and supporting me in all my endeavours. I love you Mommy. To my late grandmother, Gladys Boitumelo Makgwale “Dee Mama”. This is your legacy.

DECLARATION

I declare that **THE EFFECT OF PREMATURITY ON VISUAL PERCEPTUAL SKILLS AMONGST SCHOOL-AGE CHILDREN IN GRADE 4-6 AT PULAMADIBOGO SCHOOL IN MANKWENG, LIMPOPO** is my own work and that all the sources I have used or quoted have been indicated and acknowledged by means of complete references and that this work has never been submitted for any other degree at any other institution.

………………………………… **………………………………**

Mmusi-Landela LK (Mrs) **Date**

ACKNOWLEDGMENTS

I want to thank the following people for their respective contributions to this dissertation:

My mother, Prof Sheila Mmusi for always believing in me.

My husband, “Bokkie”, thanks for your support and taking care of the kids when I was away working towards this project. Love you always.

My sisters, Keamogetse “Fufs” Mmusi, Rudzani “B1” Muthambi and Motlalepula “B2” Mthonthsi for believing that we will have a graduation party this year!

My three darling children, who were all born prematurely. I did this for you, Kopano (my calm water) Gogontle (my beautiful butterfly) and Bohlale (my warm ray of sunshine), it is a blessing to be your mom and watch you grow up, thank you for your unconditional love.

A special thank you to my supervisors, Prof Linda Skaal and Prof Solani Mathebula for their patience, guidance, support and encouragement.

The Limpopo Province: Department of Education, for giving me permission to conduct the study.

The Principle of Pulamadibogo primary school, Mr Moduru for his willingness to allow his learners to partake in the study.

The Teachers and parents of the grade 4-6 learners at Pulamadibogo Primary school in Mankweng, Limpopo

ABSTRACT

Background

Children born preterm and low birth weight may have long-term negative consequences for visual function, compared with children born at full term. Visual memory (sensory), perceptual skills and learning are of fundamental importance for a range of functions and everyday activities, such as normal classroom learning, school performance and social interactions and may contribute to academic difficulties.

The purpose of this study was to investigate the effect of gestational age and birth weight on visual perceptual skills.

The study was approved by the University of Limpopo, Turfloop Research Ethics Committee. The Department of Education, Limpopo Province granted permission to conduct the study. Written informed consent was obtained from parents of the children and the study adhered to the tenets of the Helsinki Declaration.

Research Methodology

Data collection was completed using the Test of Visual Perceptual Skills-3rd edition (TVPS-3). Two groups of respondents participated in the study. Children born before 37 weeks' gestational age, with birth weight <2500g who were in Grades 4-6 in 2016 (n= 40) and the second group comprised of children born after 37 weeks' gestational age with birth weight ≥2500g in Grade 4-6 in 2016 (n=40).55 females and 25 males participated in the study.

Results

The results indicated that children born preterm performed better than full-term born children in four of the seven subtests of the TVPS-3, namely, visual memory, visual spatial skills, visual sequential memory and visual figure ground. Children born preterm achieved a higher overall percentile rank in overall visual perceptual processing skills.

Key words

Birth weight, full-term, preterm, visual perception, TVPS-3

DEFINITION OF KEY CONCEPTS

Form constancy: The ability to perceive positional aspect differences and recognize objects when they are in a different orientation or format (Martin, 2006).

Low birth weight: Low birth weight (LBW) is defined as birth weight less than 2,500 grams (up to and including 2,499 grams) (WHO, UNICEF, 2004).

Preterm: Preterm is defined as babies born alive before 36 weeks and 6 days of pregnancy are completed. There are sub-categories of preterm birth, based on gestational age (WHO, 2014).

Vision: The special sense by which objects, their form, colour and position in the external world are perceived, the stimulus being light from the objects striking the retina in the eye (Schapero, Cline & Hofstetter; 1968).

Visual closure: The ability to recognize an object, letter or number without seeing the whole object (Martin, 2006).

Visual discrimination: The ability to notice detail differences such as shape, size, colour, or other dimensional aspects (Martin, 2006).

Visual figure ground: The ability to focus on a selected target and ignore irrelevant images (Martin,2006).

Visual memory: The ability to remember forms (letters) and sequences of forms (words) and recognize them quickly when seen again (Martin, 2006).

Visual perception: The process by which we obtain firsthand information about the world around us. Perceptual learning is an increase in the ability to extract information from the environment. This increase comes with experience and practice and through stimulation from the environment (Gibson,1969).

TABLE OF CONTENTS **PAGE NO**

CHAPTER 3
METHODOLOGY

CHAPTER 4
DATA PRESENTATION AND ANALYSIS

CHAPTER 5

DISCUSSION OF RESULTS

ANNEXURES

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ELBW:	Extremely Low Birth Weight
LBW:	Low Birth Weight
PPROM:	Preterm Premature Rupture of Membranes
RVDLT:	Rey Visual Design Learning Task
TVPS-3:	Test of Visual Perceptual Skills, 3rd Edition
TREC:	Turfloop Research Ethics Committee
VA:	Visual Acuity
VLBW:	Very Low Birth Weight
WHO:	World Health Organization

CHAPTER 1

INTRODUCTION TO THE STUDY

1.1 INTRODUCTION AND BACKGROUND TO THE STUDY

Prematurity is the world's most overlooked public health problem. Children born prematurely with low birth weight are at a higher risk of becoming visually impairmed compared to children born at full term (Arpino,Compagnone, Montanaro, Cassitore , De Luca , Cerulli , Di Girolama & Cuatolo, 2010). The World Health Organisation (WHO; 2014) reports that 15 million children are born prematurely every year, this equates to 1 in 10 babies world-wide. Out of this number 84 000 are born in South Africa, amounting to 8 in 100 births. South Africa ranks 24 out of 184 countries for children born prematurely (WHO; 2014). Perinatal care has increased the survival rates of very preterm children, although evidence has shown large brain development alterations that take place and remain present throughout childhood and adolescent stage of preterm children (De Kievet, Zoeitbier, van Elburg, Vermeulen & Oosterlaan, 2012). The preterm children tend to exhibit serious behavioural and attention problems at school age (Mulder, Pitchford, Haggerand & Marlow, 2009).

In a study conducted by Kerr-Wilson Mackay, Smith & Pell (2012), it is suggested that visual perceptive abilities is one of the neurocognitive factors attributing to poorer academic performance for children born very preterm compared to their full term born peers. The study further suggests that preterm children exhibit reading problems and academic underachievement associated with visual sensory and perceptive dysfunction, children born preterm with low birth weight are more likely to exhibit learning disabilities in mathematics, reading, writing, and spelling than, full term children due to poor visual perceptual functioning (Zhang, Mahoney & Pinto-Martin, 2013).

Visual perceptual processes form the basis of learning and should this not be developed optimally it results in poor academic performance (Cooke, Foulder-

Hughes, Newsham & Clarke, 2004). Visual perception dysfunction refers to the instance when visual information is perceived or processed incorrectly and cannot be matched or integrated with other senses (Molloy, Wilson-Ching, Anderson, Roberts & Doyle; 2013).

In terms of cognitive and educational outcomes, researchers have found that adolescents born prematurely with extremely low birth weights tend to demonstrate lower scores on Intelligent Quotient (IQ) and achievement tests, higher rates of grade retention, higher rates of enrolment in special education and tutoring classes, and lower rates of graduation from high school (Hack, Flannery, Schluchter, Cartar, Borawski & Klein; 2002)

A study on adolescents born with low birth weight has documented poorer intellectual and educational outcomes. However, two studies from Europe did report that young adults with very low birth weights have levels of educational achievement comparable with normal birth weight populations (Bjerager, Steensberg & Greisen 1995; Perez-Roche, Altemir, Giménez, Prieto, González, Peña-Segura, Castillo, & Pueyo, 2016). This study brings to light the effects of prematurity and low birth weight on children's development by advancing understanding of the long-term cognitive, academic, social-emotional, and behavioural outcomes for these children.

It has been shown that children born prematurely with low or extremely low birth weights demonstrate higher rates of both major and minor developmental disabilities, exhibit higher levels of enrolment in special education programs. These children obtain lower scores on tests of IQ, language skills, visual-motor and visual-spatial skills, academic achievement, and executive functioning, have higher rates of attention problems, are more likely to repeat a grade, are less likely to graduate from high school, and have higher rates of internalizing and externalizing problems. (Molloy et al, 2013). However, it is important to put these findings in perspective, even though premature, low birth weight infants do demonstrate poorer outcomes compared with normal full-term infants, a large number of very low birth weight (VLBW) and at least one-third to one-half of extremely low birth weight (ELBW) children function within normal limits from infancy throughout adolescence

(Klebanov, Brooks-Gunn & McCormick, 1994; Molloy et al, 2013). It should also be noted that neonatal medical conditions such as intrauterine drug exposure (Singer, Arendt, Minnes, Farkas, Salvatore, Kirchner & Kliegman, 2002), perinatal brain injury (Hack & Taylor, 2000) and respiratory problems (Resnick, Gomatam, Carter, Ariet, Roth, Kilgore, Buciarrelli, Mahan, Curran, & Eitzma,1998; Ricci, Romeo, Gallini, Groppo, Cesarini, Pisoni,Serrao, Pappaci, Contaldo, Perrino, Brogna, Bianco, Baranello, Sacco, Quintiliani, Ometto, Cilauro, Mosca, Romagnoli, Romeo, Cowan, Cioni, Ramenghi, Mercuri, 2011) have been found to be associated with deficits in IQ.

Premature and low birth weight children also demonstrate deficits in visual-motor and visual-spatial skills, which is a visual perceptual skill. Several studies have found that premature children perform significantly worse than full-term controls on the Beery Test of Visual Motor Integration, which requires children to copy line drawings (van den Hout, Stiers, Haers, van der Schouw, Eken, Vandenbussche, van Nieuwenhuizen & de Vries, 2000). These children also exhibit lower scores than full-term controls on tasks such as, spatial relations, shape rotation, and line slopes (Luoma, Herrgard & Martikainen, 1998; Omizzolo, Thompson, Scratch, Stargatt, Lee, Cheong, Roberts, Doyle & Anderson, 2013). It has been suggested that these visual-motor and visual-spatial deficits may be the result of small brain lesions in the cerebellum, parietal cortex, or basal ganglia caused by medical conditions such as poor oxygen intake, intraventricular haemorrhage, and seizures, as well as physiological stress in the extrauterine environment (Perlman, 2001). Premature and low birth weight children also tend to demonstrate more generalized learning problems rather than specific learning disabilities (such as only a reading problem). This supports the theory that preterm children's learning problems are caused by a global processing deficit rather than difficulties with isolated skills (Wolke, 1998)

Once children reach school, greater demands are placed on them such as logical reasoning and processing of higher-level visual, spatial, and verbal information. A study by Grunau, Whitfield & Davis (2002) has also found an association between early processing of visual-motor and visual-spatial information, which requires cross-modal information processing, and later learning disabilities.

This study aims to assess the effect of gestational and low birth weight on visual perceptual skills of children in Grade 4-6 at Pulamadibogo primary school. It is important to assess for visual problems such as perceptual vision problems as they influence learning. The current situation in South African government schools thus far has not made these interventions for children entering and already in the school system. Children with visual problems are usually identified by teachers late in their academic years, often not addressing the visual perceptual skills of these learner. Private schools on the other hand have made visual screening as part of their admission process, their focus being visual acuity and not visual perceptual skills. This section of optometric testing is not practiced in most public and private eye care facilities.

1.2 RESEARCH PROBLEM

Prematurity and low birth weight has become a global issue (WHO, 2012). Poor visual perceptual skills may lead to learning disabilities and poor academic achievement. This became a concern to the researcher as awareness of prematurity and birth weight on visual perceptual ability has not been documented in Limpopo Province of South Africa. The effect of prematurity and low birth weight on visual perceptual skills in Grade 4-6 learners at Pulamadibogo Primary School in Limpopo is unknown.

1.3 LITERATURE REVIEW

Prematurity is the leading cause of perinatal morbidity and mortality in developed countries (WHO,2012). Infants are born preterm at less than 37 weeks' gestational age due to the following factors; spontaneous labour with intact membranes, preterm premature rupture of the membranes (PPROM), and labour induction or caesarean delivery for maternal or foetal indications (WHO, 2014). Risk factors for spontaneous preterm births include a previous preterm birth, African race, periodontal disease, and low maternal body-mass index. A short cervical length and a raised cervical-vaginal foetal fibronectin concentration are the strongest predictors of spontaneous preterm birth (WHO, 2014).

In a study done by researchers from University of Iowa (American Academy of Pediatrics, 2014) magnetic resonance imaging and cognitive tests were performed on preterm children ages 7-13 years born at 34-36 weeks' gestation. The tests used to assess cognitive skills were the Wechsler Scale for Intelligence Scale for Children, Benton Judgement of Line Orientation (to assess visual perception), Grooved Pegboard (for assessing fine motor skills and co-ordination) and Children's Memory Scale. The results were compared to those of 64 children who were born at full-term. Preterm children showed to have difficulty with visuospatial reasoning, visual memory and slower processing speed to perform simple tasks. These difficulties could be due to a less curved and in-folded hippocampi of premature children than term infants, and that these shape differences are associated with white matter pathology and postnatal corticosteroid exposure (Thompson, Adamson, Roberts, Faggian, Wood, Warfield & Inder, 2013). Structurally, the brains of the preterm children had less total cerebral white matter which is critical for communication between nerve cells, and smaller thalami, the area of the brain which is most important for sensory and motor signalling. The brain doubles in size in the last 8 weeks of gestation (Kinney; 2006). Being born early disturbs the normal maturation processes of the brain resulting in reduced brain volume, white and grey matter alterations, decreased size of the hippocampus, cerebellum and corpus callosum (Ball, Boardman, Rueckert, Aljabar, Arichi, Merchant, Gousias, Edwards & Counsell, 2012). These areas of the brain are important for overall executive functioning, memory, language and motor skills, which all play an integral role in the learning process (Constable, Ment, Vohr, Kesler, Fulbright, Lacadie, Delancy, Katz, Schneider, Schafer, Makuch & Reiss, 2008).

1.3.1 Visual perception development and prematurity

Visual perception refers to how individuals perceive the world. It is the foundation of learning. If the visual perceptual skills of a child are not optimal, this may lead to learning disabilities. Premature children may be at risk of acquiring these learning disabilities as they are born before the visual system is developed thoroughly and have exhibited a larger proportion of visual impairments which may compound the problem (Edmond & Fooroozan; 2006)

Molloy et al (2013) study compared the visual memory and learning ability was in preterm children and full-term control adolescents by use of the Rey Visual Design Learning Task (RVDLT), this test assesses immediate visual memory, visual learning, delayed visual memory and visual recognition. The researchers also administered the Test for Visual Perceptual Skills-3rd edition (TVPS-3) which is used to assess for all the visual perceptual subtypes mentioned. Results of the study indicated that the preterm children and those with low birth weight performed below average when compared to their full-term peers. The preterm and low birth weight children showed more impairment in immediate memory, visual learning, delayed visual memory, visual recognition and learning.

Many studies have been conducted to see if there is a correlation between visual perceptual skills and birth weight. In a study done by Davis, Burns, Wilkerson & Steichen (2005) 92 pre-school aged children who were born with very low birth weight (M=1020 g, SD=258) with no major disabilities and appropriate for gestational age at birth participated in the study.

Another study that looked at functional Magnetic Resonance Imaging (MRI) on visual-perceptual function, found that very preterm born adolescents did not demonstrate performance deficits on a visual-perceptual learning task inside the MRI scanner but showed different patterns of brain activation compared to term born controls. It is therefore possible that preterm and very low birth weight children develop compensatory connections to improve visual processing which puts them on par with their full term born equals (Narberhaus, Lawrence, Allin, Walshe, McGuire, Rifkin, Murray, Nosarti, 2009). The literature and studies show that prematurity may or may not affect visual processing skills, based on several factors.

Visual perception is broken down into subtypes namely; visual discrimination, visual sequential processing, visual figure ground, visual closure, form constancy and visual memory (Molloy et al, 2013). For a learner to perform optimally academically all these subtypes must be functioning normally. In the developing child, there is a systematic increase in the ability to perceptually analyze and discriminate objects. For children between 5 and 11 years of age, a response to a whole figure rather than the details of a figure is the most immediate form of a perceptual response. The ability to perceive fragments of objects is difficult for young children and improves with maturity (Birch & Lefford, 1967; Tanabe, Tamakoshi, Kikuchi, & Murotsuki, 2014). Figure-ground perception improves from 3 to 5 years with stabilized growth at 6 to 7 years. Form constancy development shows dramatic improvement from ages 6 to 7 years, with development leveling off at 8 to 9 years. Position in space development is complete at 7 to 9 years, and spatial relationships improve through approximately 10 years of age (Williams; 1983). If visual perceptual development is identified by age levels, then the maturation of specific visual perceptual skills appears to be well developed by 9 years of age.

However, there are few follow-up studies on adolescents and young adults (Luu, Ment, Allan, Schneider & Vohr, 2011) and knowledge about long-term cognitive outcomes after preterm birth is therefore still limited

1.4 AIM OF THE RESEARCH

The aim of the study was to determine the effect of premature birth and low birth weight on visual perceptual performance in children doing Grade 4-6 at Pulamadibogo Primary School.

1.4.1 Research Objectives

To investigate the effects of prematurity and low birth weight on visual perceptual skills on a geographically defined population of school-age children.

1.5 RESEARCH QUESTION

What are the effects of prematurity and low birth weight on visual perceptual skills amongst children in Grade 4 to 6 at Pulamadibogo Primary School in Mankweng?

1.6 SIGNIFICANCE OF THE STUDY

Visual perceptual skills are important for daily activities that an individual must undertake. The study will provide insight on the effect the gestational age and birth weight may have on visual perceptual skills during school-going age. The study will serve to raise awareness about visual perceptual screening for school-going children, the impact these skills have on learning, and possible intervention strategies for children with visual perceptual skill dysfunction. Screening of visual perceptual skills is not commonly practiced in public and private health care facilities. The researcher would like to highlight this as a public health intervention strategy.

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1.5 RESEARCH QUESTION

What are the effects of prematurity and low birth weight on visual perceptual skills amongst children in Grade 4 to 6 at Pulamadibogo Primary School in Mankweng?

1.6 SIGNIFICANCE OF THE STUDY

Visual perceptual skills are important for daily activities that an individual must undertake. The study will provide insight on the effect the gestational age and birth weight may have on visual perceptual skills during school-going age. The study will serve to raise awareness about visual perceptual screening for school-going children, the impact these skills have on learning, and possible intervention strategies for children with visual perceptual skill dysfunction. Screening of visual perceptual skills is not commonly practiced in public and private health care facilities. The researcher would like to highlight this as a public health intervention strategy.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter presents the research approaches, procedures and techniques used in the study. It describes the research methodology with regards to the study population, sampling process and data analysis. Quantitative research method was used in this study.

3.2 STUDY DESIGN

3.2.1 Quantitative research design

To critically evaluate the effect of prematurity and low birth weight on visual perceptual skills, the researcher employed a quantitative study design. The research design is a plan, structure and strategy used to investigate to obtain answers to the research question or problem as defined by Kumar (2011) or a blueprint of how a researcher intends to conduct a research study (de Vos, 2005). The results of the subtests of the TVPS-3 test were quantified and compared to age norms. (see Annexure D)

3.3 POPULATION AND SAMPLING PROCEDURES

3.3.1 Population

Population in a research study is defined as all possible participants who comply with the sampling criteria for inclusion in the research study (Burns & Groove, 2005). The school is situated in Mankweng, which is a township 30km east of Polokwane, in the Capricorn district in Limpopo province in South Africa. In this study, the population was children attending Pulamadibogo primary school in Grade 4, 5 and 6 in 2016. Arrangements with the learners' teachers for each grade were made so as not to disrupt their academic schedule. Road to Health charts were scrutinized and sorted by the researcher prior to visual acuity assessment. Visual acuity assessment was performed during school times at the school in a suitable room, this test did not take longer than 10 minutes per learner.

3.3.2 Sampling method

Sampling is the process whereby a sample is selected that is representative of the study participants (Burns & Grove, 2005). The random stratified sampling method was used to select participants in the research study. The population was subdivided into smaller groups of shared attributes namely, gender and birth weight. The study made use of the Road to Health charts (RTCHT) of children in Grade 4-6 born between the years 2003-2007 attending the school. This chart contains the gestational age and birth weight of the child. Learners who were born before 37 weeks' gestational age (preterm) or with a birth weight below 2500g were considered as the study sample. Study participants were then classified according to their respective gestational age and their birth weights, namely extremely low birth weight (ELBW), very low birth weight(VLBW) and low birth weight (LBW). Learners born after 37 weeks (normal term) or with birth weight over and including 2500g were considered as the control group.

3.3.3 Sample size

According to Morgan & Krejcie (1970) scale table a sample size of 97 was reached, which was calculated from a population of 130. This method has been recommended for finite population samples in health research and for effective representation of a population in descriptive case control study designs. The sample size was calculated using the formula below.

$$S = \frac{X^2 NP\,(1-P)}{d^2\,(N-1) + X^2 P\,(1-P)}$$

Where:

S = *Required Sample size*

X = *Z value (e.g. 1.96 for 95% confidence level)*

N = *Population Size*

P = *Population proportion (expressed as decimal) (assumed to be 0.5 (50%)*
d = *Degree of accuracy (5%), expressed as a proportion (.05); It is margin of error*

The intended sample size was 97 primary school learners. Parents and guardians were given consent forms to complete and return to the school for each potential participant (see Annexure B). The final number of participants for this study was 80. This was due to consent or clinical record cards not being obtained from the parents of 17 learners.

3.3.4 Inclusion criteria

The researcher performed visual acuity testing at distance and at near with use of a Snellen Acuity chart to assess the visual status of children. Those children whose visual acuity falls below 6/9 will not be included in the study unless they were corrected by spectacles or contact lenses, as poor vision may hinder them from providing reliable results. Children who did not display or have diagnosed attention problems or hearing loss were included in this study.

Participants were between the ages of 9-13, born before 36 weeks and 6 days' gestational age or with a birth weight below 2500g. Control group children were aged between the ages of 9-13, born after 37 weeks and 6 days' gestational age and birth weight over 2500g. All children must have achieved a visual acuity between 6/6- 6/9 Logmar (corrected and uncorrected). Children had to possess a Road to health chart and signed consent form by their guardians/parents to participate in the study.

3.3.5 Exclusion Criteria

Children with hearing loss, poor visual acuity, uncorrected (below 6/9 (0.20) Logmar) or, known developmental disorders such as cerebral palsy or mental retardation. Children who did not possess a Road to health chart and who did not have a signed consent from their parent/guardian were excluded.

3.4 DATA COLLECTION TOOL

A data collection tool was created for the study which included the participants demographics, visual acuity (monocular visual acuity assessed for each eye at 6m and 40cm). A score of 6/9-6/6 (0.20-0.00) Logmar is normal. (Wild, 1985). Visual perceptual skills were assessed by means of the Test of Visual Perceptual Skills 3rd edition (TVPS-3) test which tests for all aspects of visual perception. The Test of Visual Perceptual skills- 3rd edition (TVPS-3) is a test that helps determine a child's visual perceptual strengths and weaknesses. It is a screening tool designed for use by occupational therapists, psychologists, education diagnosticians and developmental optometrists. Results were recorded on a TVPS-3 score sheet and quantified accordingly. The tests were performed in the school computer lab under normal well-lit illumination and each child took approximately 40 minutes to complete the six subtests from the TVPS-3 were administered which are visual discrimination, visual-spatial skills, form constancy, visual figure-ground, visual memory and visual closure.

3.4.1 TVPS-3 Subtest Scaled Scores

Scaled scores for the TVPS-3 subtests range in value from 1-19 and based on a population distribution with a mean of 10 and a standard deviation of 3. A scaled score of 10 indicates that performance is at the mean for a certain age-group, a scaled score of 13 indicates that the child’s performance was one standard deviation above the age-related mean (and that the child did better than 84% of the same-aged children in the normative population). Scaled scores are used for subtests (which have a limited range of raw score values) and do not extend below 1 or above 19- these are the most extreme scale scores, obtained by less than 0,01% of the population. Namely, the scaled scores for more than 99,99% of the cases in a normal distribution fall between 1 and 19. Raw scores are shown on the far-left column and scaled scores are shown on the interior column (Martin, 2006) Scaled scores for each subtest are found in Appendix E and are classified by age.

3.5 DATA ANALYSIS PROCEDURES

Data analysis was performed using the Statistical Package for Social Sciences (SPSS) Software 23.0 version. The program was utilized to perform numerical functions once all the data had been collected and coded.

Descriptive statistics were utilised to describe findings, namely the means, standard deviations were performed. Analysis included numerical summaries, frequencies, correlations and graphs (presentation).

3.5.1 Internal and External validity

Internal validity refers to the extent which the outcomes of an experiment can be due to the manipulated, independent variables and not uncontrolled environmental factors External validity refers to the extent to which the results of a study can be generalised to other settings and people (Brink, van der Walt & van Rensburg, 2012). Validity also refers to the extent to which a test measures the construct it claims to measure (Anastasi, Urbina, 1997), to ensure that appropriate conclusions can be made from a test. The sample size was small, but because the data-collection instrument (Test of Visual Perceptual skills-3) is precise this was not an issue of concern for the researcher. The less precise the tool, the larger the sample needed (Brink et al, 2012). To maintain validity the same test edition was administered to all children.

3.5.2 Reliability

Overall reliability speaks of the precision, consistency and stability of the test over time and across examiners. To ensure reliability, the researcher performed all the tests in an adequate environment for optimal testing. Visual acuity was assessed using a Snellen chart placed at 6m and a near chart at 40cm with optimal room illumination. For the visual perceptual skills testing, namely the TVPS-3 test, participants were seated comfortably in a quiet room at a desk with the examiner with optimal lighting. The researcher conducted the study with 2 qualified assistants, who are optometrists who have been trained on the administering of the TVPS-3 test, to rule out any variables that may compromise the reliability of the result. (Brink et al, 2012).

The TVPS-3 has a high level of homogeneity, it provides consistent measurement from one testing to the next, and it can be consistently scored by different examiners. The TVPS-3 has a high level of reliability, and users of the TVPS-3 can have a high degree of confidence in the test’s results. (Brown, Elliott, Bourne, Sutton, Wigg, Morgan, Glass, & Lalor, 2011).

3.5.3 Bias

Bias refers to any action which prevents unprejudiced consideration of a research question (Brink et al, 2012) Selection bias will be prevented by means of simple random sampling procedure of participants who fit both case and control criteria.

CHAPTER 4

DATA PRESENTATION AND ANALYSIS

4.1 INTRODUCTION

This chapter presents and analyses data based on the research aim and objectives. Visual perception was assessed by means of the Test of Visual Perceptual Skills- 3rd edition (TVPS-3). The self-administered test gathered data pertaining to the participants' personal information obtained from the Road to Health clinic card and TVPS-3 test. The objective of the data analysis was to investigate whether there were differences in the visual perceptual skills in school-aged children born preterm with low birth weight and full-term with use of the TVPS-3 test. Results were analysed separately for each child to draw a comparison in participants' visual perceptual skills.

4.2 DATA COLLECTION AND ANALYSIS

Data was captured on the TVPS-3 record card for each learner and grouped into two categories, namely school-aged children born preterm and school-aged children born full term. The researcher used the Statistical Package of Social Sciences version 23 software to analyse the respective data.

4.3 RESEARCH RESULTS

4.3.1 Demographics

The sample comprised of 80 participants (40 school-aged children born preterm and 40 school-aged children born full term) from Pulamadibogo primary school. As seen in Table 4.1 and figure F.1 females formed much of the study population, both in preterm and full- term births. There were 55 females (68,8%) in total as compared to 25 males (31,2%). There were 30 full-term females which accounts to 87,5% of the sample, whereas there were 25 preterm females, accounting for 81,2% of the sample.

Table 4.1: Gender of school-aged children born preterm and school-age children born full-term

		Gender		Total
		Male	Female	
Birth	Preterm births	15	25	40
		18.8%	81.2%	100.0%
	Full matured	10	30	40
		12.5%	87.5%	100.0%
Total		25	55	80
		31.2%	68.8%	100.0%

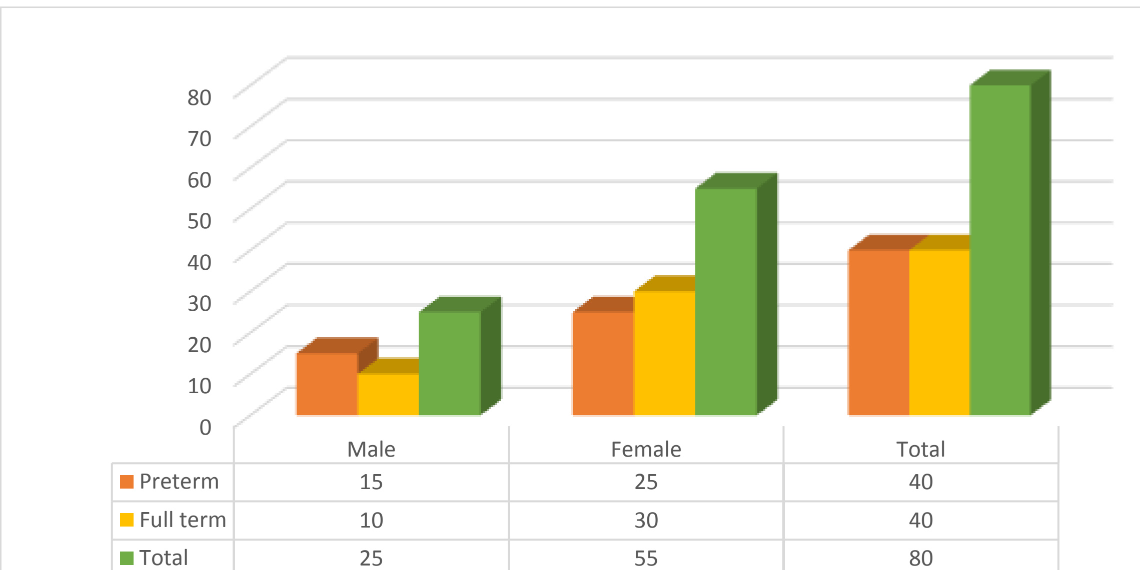

Figure 4.1: Graph of gender composition of school-age children born preterm and full-term born school-age children

4.3.2 Grade composition

Most participants were in Grade 6(N=20) for preterm births and the least in grade 4 (N=5). There was equal grade distribution in full term born children in grade 4 (N=15) and grade 5 (N=15) as shown in Figure 4.2.

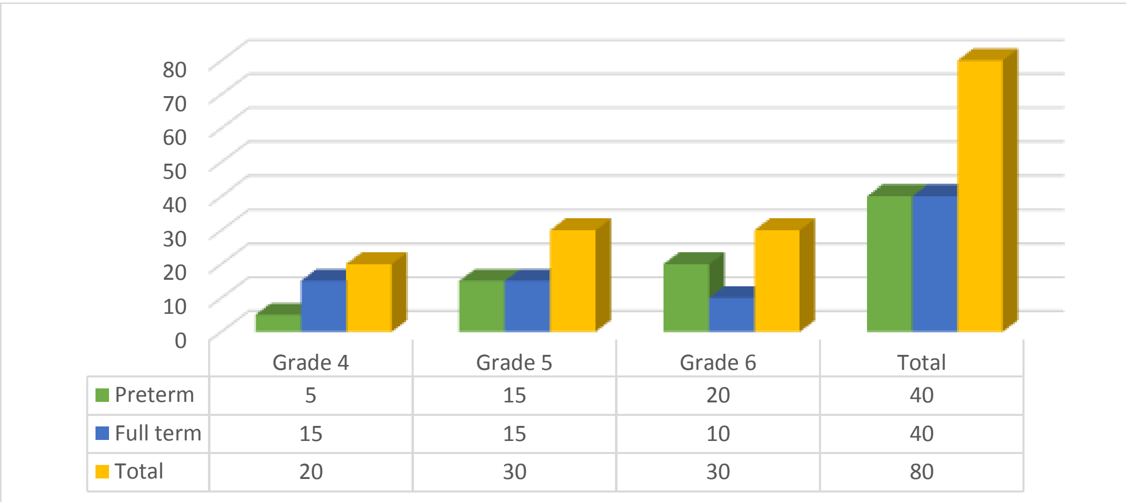

Figure 4.2: Grade composition of preterm born school-age children and full term born school- age learners

4.3.3 Birth weight classification

Preterm born school-age children were classified based on their birth weight (Table 4.2) and gestational age (table 4.3), below are the findings. No children in the study were born extremely low birth weight (N=0).

Table 4.2: Birth weight classification of preterm birth children results

Birth weight	**Number of children**
Low birth weight (1500g-2499g)	22
Very low birth weight (1000g-1499g)	18
Extremely low birth weight (<1000g)	0

Table 4.3: Gestational age classification of preterm birth children

Gestational age	Number of children
Extremely preterm (<28 weeks)	5
Moderate preterm (29-33 weeks)	14
Late preterm (34-37 weeks)	21

4.3.4 Attention Problems

None of the study participants had been with diagnosed attention problems in preterm and full-term birth participants (100%) as depicted in Table 4.4. Students with attention problems would not be able to complete the test efficiently as it requires that the learner pays close attention to presentation of test plates, specific tests of visual memory also required to be timed, this may turn out to be a difficult task for a student with inattention (Martin, 2006).

Table 4.4: Students with known attention problems

		Student has known (diagnosed) attention problems?		
		No	Yes	Total
Birth	Preterm births	40 100.0%	0 0.0%	40 100.0%
	Full-matured	40 100.0%	0 0.0%	40 100.0%

4.3.5 Visual Problems

Two preterm birth learners (2.5%) had refractive errors with spectacle correction out of a total of 40 learners, whereas one full-term birth learner (1,2%) had a refractive error with spectacle correction out of a total of 40 learners as seen in table 4.5 and figure 4.2.

Table 4.5: Visual problems (diagnosed refractive errors)

		Visual		
		Yes	No	Total
Birth	Preterm birth	2 2.5%	38 97.5%	40 100.0%
	Full-term birth	1 1.2%	39 98.8%	40 100.0%

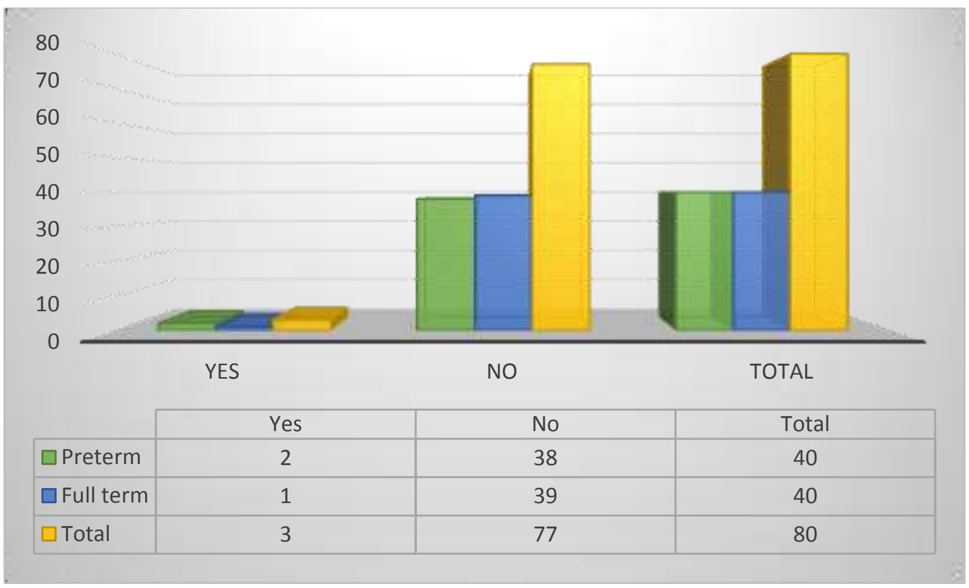

Figure 4.3: Learners with refractive errors in preterm born school-age children and full-term birth

Descriptive statistics were performed for demographics of all learners (Table 4.6). The minimum age for participants in the study was 9, and the maximum 13, minimum birth weight was calculated as 1000g (preterm) and maximum 4500g (full-term). Gestational age was noted to be minimum 27 weeks (preterm) and 40 weeks (full-term)

Table 4.6: Descriptive statistics for demographics

	N	Minimum	Maximum	Mean	Std. Deviation
Age	80	9	13	10.58	.868
Weight	80	1.0	4.5	2.569	.7851
Weeks	80	27	40	36.01	4.373
Valid N (listwise)	80				

4.4 VISUAL PROCESSING SKILLS

In this study TVPS-3 indices and overall standard scores were reported as standard scores based on population distribution having a mean of 100 and a standard deviation of 15). The standard deviations are traditionally reported for a range of ±3 standard deviations from the mean, and do not extend below 55 or above 145, representing the most extreme scores obtained by less than 0.02% of the population (Martin, 2006). Overall processing consists of all scaled score subtests together, while basic processing consists of four subtests (visual discrimination, visual memory, visual sequential memory and form constancy).

Results for participants born premature showed high aggregation for visual perceptual processing in areas of overall processing (which consists of all subscales together), basic processing, sequential skills and complex processing. The greatest difference between mean scores for the two groups occurred in sequential skills with a mean difference of 7.225. The least difference in mean scores occurred in basic processing category with a mean difference of 0,325 between the two groups.

Percentile ranks corresponding to scaled and standard scores are evaluated based on the tables provided in the TVPS-3 test. When looking at the overall percentile performance of the two groups, preterm children performed better. Percentile for children born preterm ranged from 12,400 to 32,475 with a mean of 20,419. Based on percentile tables this performance is of low average to average (see Table 2.6) for TVPS-3 Percentile and Classification System, Chapter 2). The full-term counterparts achieved a percentile score range of 11,750 to 21,925 with a mean of 16,600. They also achieved low average to average performance, See Table 4.7.

Table 4.7: Visual perceptual skills of preterm born school-age children and full-term school-age children

				95% Confidence Interval for Mean	
		Mean	Std. Deviation	Lower Bound	Upper Bound
Overall standard score	Preterm	80.325	12.3939	76.361	84.289
	Full term	78.725	10.8297	75.262	82.188
Overall percentile	Preterm	15.725	17.0309	10.278	21.172
	Full term	12.500	14.5831	7.836	17.164
Basic standard score	Preterm	77.000	12.9476	72.859	81.141
	Full term	76.650	12.1540	72.763	80.537
Basic percentile	Preterm	12.400	15.1891	7.542	17.258
	Full term	11.750	16.6514	6.425	17.075
Sequence standard score	Preterm	87.100	23.5392	79.572	94.628
	Full term	79.875	24.1121	72.164	87.586
Sequence percentile	Preterm	32.475	28.9394	23.220	41.730
	Full term	21.925	22.9452	14.587	29.263
Complex standard score	Preterm	82.400	17.3646	76.847	87.953
	Full term	81.975	15.3297	77.072	86.878
Complex percentile	Preterm	21.075	25.5065	12.918	29.232
	Full term	20.225	23.3254	12.765	27.685

Independent t-test and non-parametric Mann-Whitney U test was performed, due to the small sample size and that the data could not be assumed to be normally distributed (McKnight, Najab, 2010) as there is no association between the scores of the two groups and to determine whether the difference between the means of the learners born preterm and full-term were significant. Sequential standard scores showed the highest variance of 1.356. Results indicate that the TVPS-3 did discriminate between children born preterm and full-term for all subtests except for sequential memory

Table 4.8: Independent t-test for preterm born school-age learners and full-term born learners

		Levene's Test for Equality of Variances		t-test for equality of means	
		F	Sig.	t	df
Overall standard score	Equal variances assumed	1.230	0.271	0.615	78
	Equal variances not assumed			0.615	76.622
Basic standard score	Equal variances assumed	0.602	0.440	0.125	78
	Equal variances not assumed			0.125	77.690
Sequence standard score	Equal variances assumed	0.125	0.724	1.356	78
	Equal variances not assumed			1.356	77.955
Complex standard score	Equal variances assumed	0.380	0.540	0.116	78
	Equal variances not assumed			0.116	76.819

4.5 SCALED SCORE RESULTS PRETERM AND FULL-TERM BIRTHS

For an adequate picture of performance in subtests, scaled scores were analysed. Raw scores were converted to scaled scores from tables found in the TVPS-3 booklet for chronological age of the children (Annexure E), which show normal expected findings for each age. Children born preterm achieved a higher overall mean scaled score of all visual perceptual skills.

Table 4.9: Scaled score subtest results of preterm born school-age children and full-term born school-age children

Scaled Scores		N	Mean	Std. Deviation
Visual Discrimination	Preterm births	40	5,25	2,478
	Full matured	40	4,78	3,117
	Total	80	5,01	2,808
Visual Memory	Preterm births	40	5,63	4,235
	Full matured	40	5,55	3,434
	Total	80	5,59	3,831
Visual Spatial	Preterm births	40	7,05	3,602
	Full matured	40	6,55	3,836
	Total	80	6,80	3,706
Form Constancy	Preterm births	40	3,98	3,570
	Full matured	40	3,95	2,828
	Total	80	3,96	3,200
Visual Sequential Memory	Preterm births	40	7,75	3,855
	Full matured	40	6,40	3,448
	Total	80	7,08	3,697
Visual Figure Ground	Preterm births	40	5,80	4,351
	Full matured	40	5,23	3,076
	Total	80	5,51	3,755
Visual Closure	Preterm births	40	7,13	3,517
	Full matured	40	7,00	3,836
	Total	80	7,06	3,657

4.6 CORRELATION

Correlation coefficient (r) quantifies the strength of the relationship between two variables. The coefficient takes values between -1.0 to +1.0. The sign indicates the direction of the relationship while the numerical vale depicts the strength. The +ve sign denotes a direct relationship while -ve denotes the inverse relationship. A value of r closer to either +1.0 or -1.0 indicates a strong linear relationship. A value closer to 0 indicates a random scatter of the values.

Table 4.10 shows that there is a weak correlation between the different subtests of the TVPS-3 test. All the correlations amongst the subtests are below 0.5. since the p-value is less than 0.05 (critical point), so there is a significant difference amongst the subtests of the TVPS-3 test. The reason for these significant differences is that the subtests examine different processes of visual perception.

Table 4.10 Correlation between subtests of the TVPS-3 test

Paired variables	Correlation coefficient (r)	Significance (p)
Visual discrimination and visual memory	0.257	0.02
Visual discrimination and spatial relations	0.44	0.00
Visual discrimination and form constancy	0.307	0.006
Visual discrimination and sequential memory	0.386	0.00
Visual discrimination and figure ground	0.277	0.013
Visual discrimination and visual closure	0.404	0.00
Visual memory and spatial relation	0.414	0.00
Visual memory and form constancy	0.419	0.00

Visual memory and sequential memory	0.393	0.00
Visual memory and figure-ground	0.480	0.00
Visual memory and visual closure	0.417	0.00
Spatial relations and form constancy	0.419	0.00
Spatial relation and sequential memory	0.393	0.00
Spatial relation and figure-ground	0.480	0.00
Spatial relation and visual closure	0.417	0.00
Form constancy and sequential memory	0.328	0.003
Form constancy and figure-ground	0.480	0.00
Form constancy and visual closure	0.312	0.05
Sequential memory and figure ground	0.246	0.028
Sequential memory and visual closure	0.310	0.05
Figure ground and visual closure	0.372	0.01

4.7 VISUAL PERCEPTION SUBTEST RESULTS FOR PRETERM BORN AND FULL-TERM BORN CHILDREN

Visual discrimination is the first subtest in the TVPS-3 test. Results indicated that all preterm children (100%) performed between low average to average for this test, whilst (98,8%) full-term born children achieved low average to average results, with 1 full-term born child (1,2%) achieving above percentile.

Table 4.11: Visual discrimination of preterm born school-age and full-term born school age children

		VISUAL DISCRIMINATION		Total
		Low Average-Average	Above percentile	
Birth	Preterm births	40 100.0%	0 0.0%	40 100.0%
	Full-term	39 98.8%	1 1.2%	40 100.0%

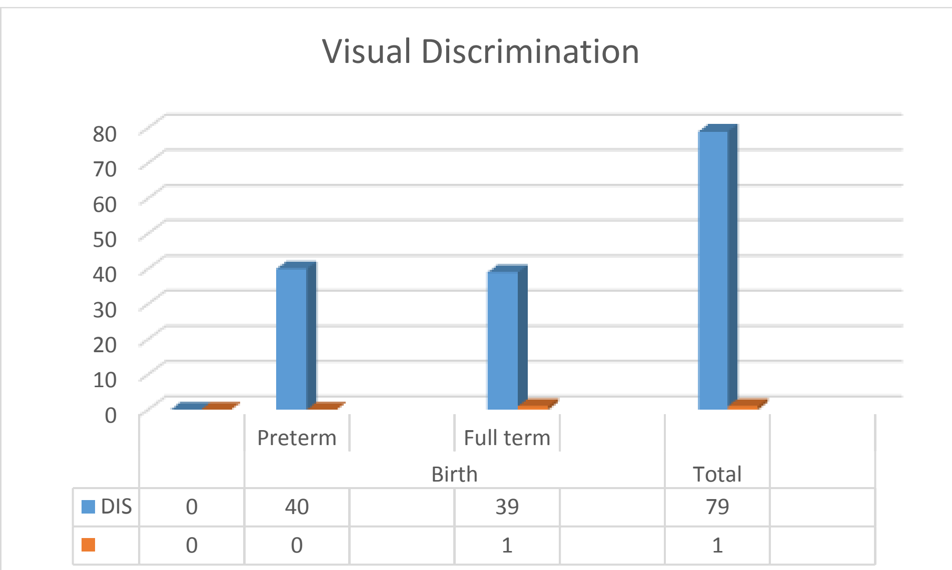

Figure 4.4: Visual discrimination of preterm born school-age and full-term born school-age children

Visual memory is the second subtest in TVPS-3 test. Results indicated that 32 preterm born children achieved low average to average performance (90%), 8 of these children achieving above percentile (10%), as compared to 35 full-term born children who achieved low average to average results (93,8%) and 5 full-term born children who achieved above percentile (6,2%).

Table 4.12: Visual memory of preterm born school-age children and full-term born school-age children

		VISUAL MEMORY		
		Low Average-Average	Above percentile	Total
Birth	Preterm births	32 90.0%	8 10.0%	40 100.0%
	Full-term	35 93.8%	5 6.2%	40 100.0%

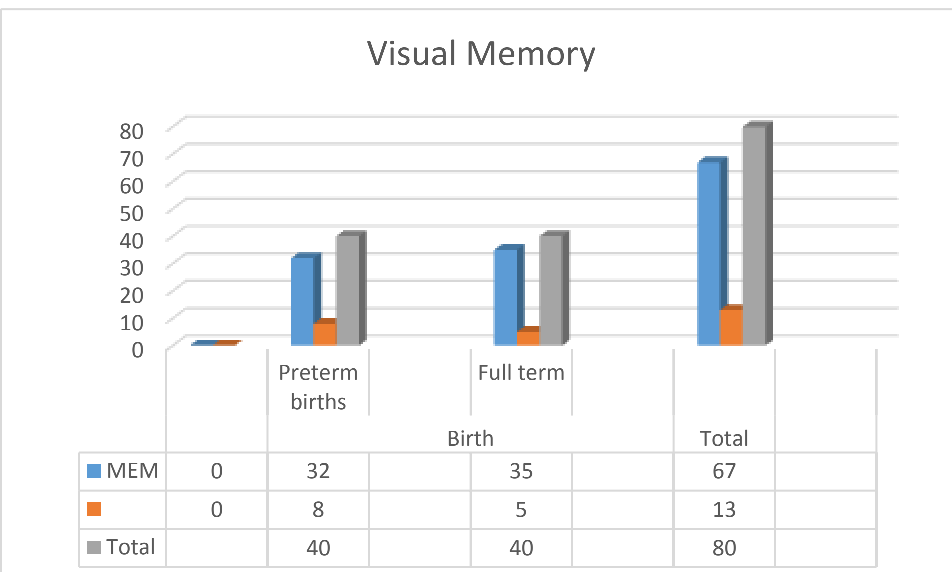

Figure 4.5: Visual memory of preterm born school-age children and full-term born school-age children

Visual spatial skills is the third subtest of the TVPS-3 test. Results indicated that 31 (88,8%) preterm born learners achieved low average to average performance, 9 preterm learners achieved above percentile (11,2%) as compared to 32 (90%) full-term born learners achieving low average to average and 8 (10%) full-term born learners achieved above percentile.

Table 4.13: Visual spatial skills of preterm born school-age children and full-term born school-age children

		VISUAL SPATIAL SKILLS		
		Average	Above percentile	Total
Birth	Preterm births	31 88.8%	9 11.2%	40 100.0%
	Full- term	32 90.0%	8 10.0%	40 100.0%

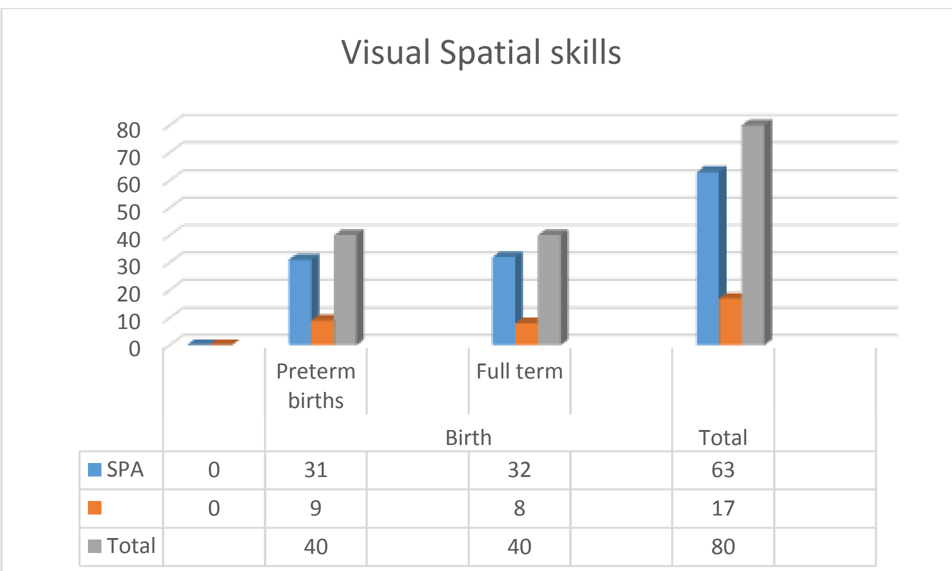

Figure 4.6: Visual spatial skills of preterm born school-age children and full-term born school-age children

Form constancy is the fourth subtest of the TVPS-3 test. Results indicated that all children (preterm and full-term) (100%) achieved low average to average performance, none of the participants in both groups achieved above percentile (0.0%).

Table 4.14: Form constancy of preterm born school-age children and full-term born school-age children

		FORM CONSTANCY		
		Low Average-Average	Above Percentile	Total
Birth	Preterm births	40 100.0%	0 0.0%	40 100.0%
	Full-term	40 100.0%	0 0.0%	40 100.0%

Visual sequential memory is the fifth subtest of the TVPS-3 test. Results indicated that 35 (93,8%) preterm born children achieved low average to average performance as compared to 38 (97,5%) in full-term born children. 5 (6,3%) children in the preterm birth group achieved above percentile as compared to 2 (2,5%) in the full-term birth group who achieved above percentile.

Table 4.15: Visual sequential memory of preterm born school-age children and full-term born school-age children

		VISUAL SEQUENTIAL MEMORY		
		Low Average-Average	Above percentile	Total
Birth	Preterm births	35 93.8%	5 6.3%	40 100.0%
	Full- term	38 97.5%	2 2.5%	40 100.0%

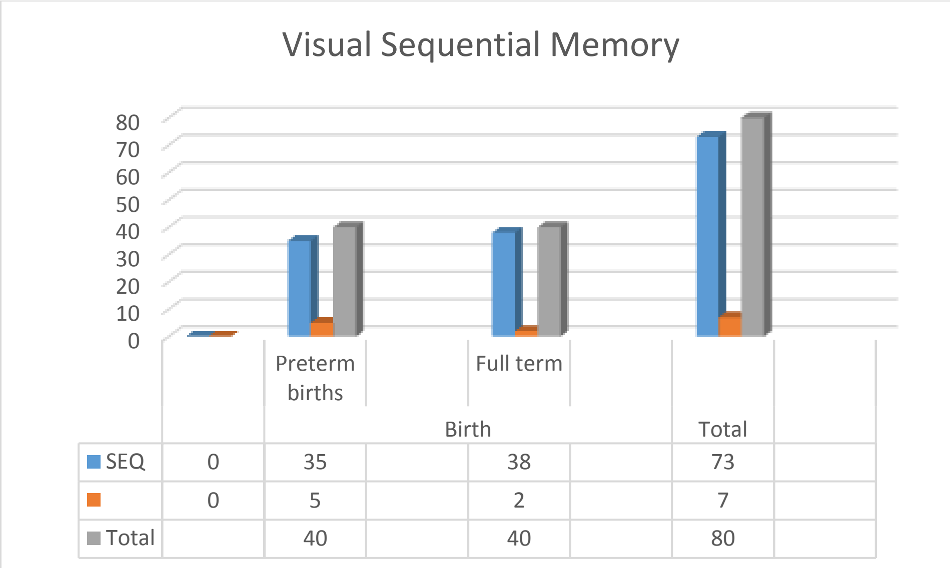

Figure 4.7: Visual sequential memory of preterm born school-age children and full-term born school-age children

Visual figure ground is the sixth subtest of visual perceptual skills. Results indicated that 35 (93,8%) of children born preterm achieved low average to average performance, 38 (97,5%) of children born full-term achieved low average to average results. Whilst 5 (6,3%) children born preterm achieved above percentile as compared to 2 (2,5%) full-term children who achieved above percentile.

Table 4.16: Visual figure-ground of preterm born school-age children and full- term born school-age children

		VISUAL FIGURE-GROUND		
		Low Average-Average	Above percentile	Total
Birth	Preterm births	35 93.8%	5 6.3%	40 100.0%
	Full-term	38 97.5%	2 2.5%	40 100.0%

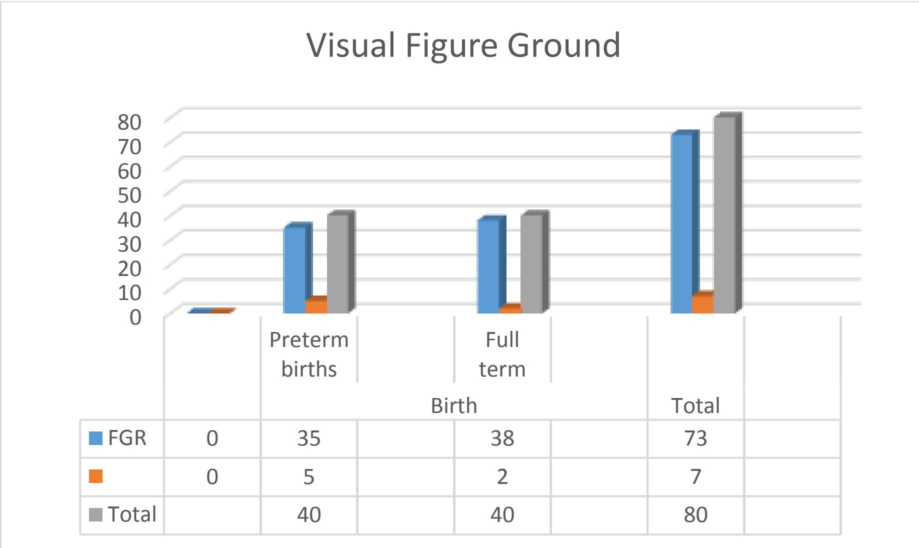

Figure 4.8: Visual figure-ground preterm born school-age children and full-term born school-age children

Visual closure is the seventh and last subtest of the TVPS-3 test. Results indicated that 38 (97,5%) of children born preterm achieved low average to average performance. 37 (96,2%) of full-term born children achieved low average to average results. Whilst 2 (2,5%) children born preterm achieved above percentile, as compared to 3 (3,8%) full-term born children who achieved above percentile results.

Table 4.17: Visual closure preterm born school-age children and full-term born school-age children

		VISUAL CLOSURE		
		Average	Above percentile	Total
Birth	Preterm births	38 97.5%	2 2.5%	40 100.0%
	Full-term	37 96.2%	3 3.8%	40 100.0%

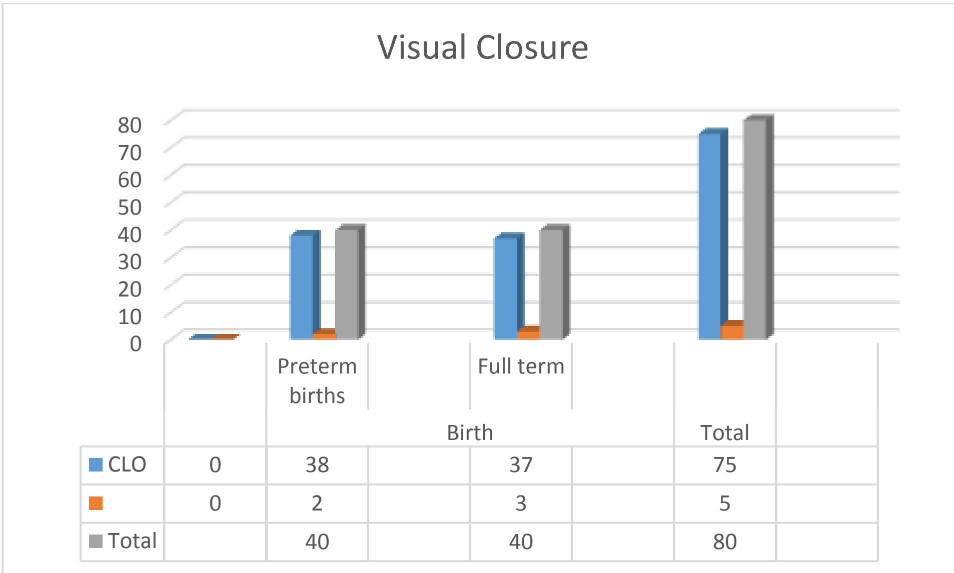

Figure 4.9: Visual closure of preterm born school-age children and full-term born school-age children

CHAPTER 5
DISCUSSION OF RESULTS

5.1 INTRODUCTION

The primary aim of this study was to analyse the visual perceptual skills of learners in grade 4 to 6 at Pulamadibogo primary school in Mankweng, Limpopo. The participants were learners born preterm with low birth weight and learners born full-term with normal birth weight; to ascertain whether there is discrepancy between the two groups. As it has been stated in previous chapters, visual perceptual skills form the basis of learning (Kozeis et al, 2015), namely, reading, spelling and mathematics. Research has shown that children born preterm may exhibit poor visual perceptual skills (Zhang et al, 2013).

This chapter discusses the findings from two sets of data collection tools, the Test TVPS-3 and the patient demographic sheet. The TVPS-3 test was administered by the researcher who is a qualified optometrist. The test was performed at the school at times agreed upon by the principal of the school and the researcher, so as not to disrupt the academic timetable of learners. Issues that were discussed in this section include learner performance for each subtest of the TVPS-3, challenges facing the learner with visual perceptual dysfunctions, awareness of visual perceptual dysfunctions, access to assessment of visual perceptual skills, access to intervention and remedial care.

The integrity of both afferent and efferent visual pathways is required for proper visual processing (Perez-Roche et al, 2016). Initially, the retina receives, captures and transmits a visual stimulus to the primary visual cortex (V1) of occipital area. Injury to V1 reduces visual acuity and colour detection, creating a visual field disturbance. Accurate integration of visual information enables the processing of visual stimuli needed to interpret and organize what is seen. Development of skills, such as visual closure, figure-ground distinction, and visually guided movements, is completed throughout childhood, forming the basis for many other cognitive processes. Loss of visual cognitive abilities is therefore very disruptive for learning. (Perez-Roche et al, 2016)

Preterm birth may result in severe neurological impairment, largely due to perinatal brain injury (Kozeis et al, 2015). Although cerebral palsy is the chief neurological result of prematurity, other neurocognitive deficits may be presented in premature infants, some of them related to sensory processing. Within this spectrum of cognitive deficits, higher visual functions are often affected.

There are at least two possible reasons for expecting poorer visual memory and learning in EP/ELBW children compared with term born peers. Furthermore, EP/ELBW infants are at risk for a range of perinatal complications and treatments. (Ricci, Romeo, Gallini, Groppo, Cesarini, Pisoni,Serrao, Pappaci ,Contaldo ,Perrino ,Brogna , Bianco, Baranello, Sacco , Quintiliani , Ometto , Cilauro , Mosca , Romagnoli , Romeo, Cowan, Cioni, Ramenghi & Mercuri, 2011). Preterm birth may have major consequences to the development of the visual pathway. Both ocular and brain pathology, ranging from local to diffuse, has been implicated in visual deficits in preterm children.

Results from this study show that children born premature and those with low birth weight performed good compared to those born full term. Similar findings were reported in studies by Bjerager et al (1995) and Perez-Roche et al (2016) who reported that young adults with very low birth weights have levels of educational achievement comparable with normal birth weight populations.

None of the children (100%) in this study had known diagnosed attention problems (see Table 4.3) which is a factor in the administration of the test. Children with attention deficit hyperactivity disorder may not be able to focus during the test and this condition may lead to poor results and under-estimation of the child's true visual perceptual abilities (Harris et al, 2013). Children with uncorrected refractive disorders, may not be able to comfortably perform the test if they cannot see well (Martin, 2006). In this study, 3 learners had refractive problems, 2 (2,5%) were a set of twin's preterm sample, 1 (1,2%) a learner born full-term. All had spectacle correction, so they could complete the test with ease.

Studies have shown a negative correlation between low birth weight and visual perceptual skills, participants who were born preterm were further classified into birth weight classification. It was found that in the present study, there were no children with extremely low birth weight (<1000g), the sample consisted of 22 children of low birth weight (1500g-2499g) and 18 children who were very low birth weight (1000g-1499g) (table 4.2). The reason for preterm birth was not noted in most of the files, but those that were written noted pre-eclampsia, multiple birth and intra-uterine growth restriction (IUGR), see table 2.1. All children in this study were African, this race factor has also been included as a predisposing factor for preterm birth (Woythaler, McCormick, Mao & Smith, 2015).

5.2 VISUAL PERCEPTION SUBTEST RESULTS

Participants had to achieve a total of 10 out of 19 to pass each of the 6 subtests and achieve a percentile ranking score of between 25-99% to pass the test (see Table 2.6). Overall learners (preterm and full term) achieved an overall average percentile of 18,51 which is regarded as "low average". Percentile was calculated based on the group norm of 18,51 for learners participating in this study for subtest performance investigation.

Subtest results of the two groups varied. Visual discrimination was the first subtest of the TVPS-3 to be administered. Visual discrimination is the first subtest in the TVPS-3 test. Results indicated that all preterm children (100%) performed between low average to average for this test, whilst (98,8%) full-term born children achieved low average to average results, with 1 full-term born child (1,2%) achieving above percentile. Children born full-term achieved better results for visual discrimination

Results for the second subtest, visual memory indicated that 32 preterm born children achieved low average to average performance (90%), 8 of these children achieving above percentile (10%), as compared to 35 full-term born children who achieved low average to average results (93,8%) and 5 full-term born children who achieved above percentile (6,2%). Children born preterm performed better in this test. This result is contrary to findings from studies conducted by Molloy et al (2013); Thompson et al (2013) and Ommizolo et al (2015) where it was found that children who were born extremely preterm (<28 weeks) and extremely low birth weight (<1000g) were found to have poor visual memory. In this study, there were only 5 children who were born extremely preterm and none with extremely low birth weight. Most of the preterm participants in this study were late preterm. Studies have found that children born very preterm and with the lowest birth weights are at increased risk for poor visual outcome (Aylward; 2002).

Visual spatial skills being the third subtest of the TVPS-3, Results indicated that 31 (88,8%) preterm born learners achieved low average to average performance, 9 preterm learners achieved above percentile (11,2%) as compared to 32 (90%) full-term born learners achieving low average to average and 8 (10%) full-term born learners achieved above percentile. Geldof et al (2011), McGrath and Sullivan (2002) found that children with birth weights below 1000g, performed poor in this subtest. This study did not have children with birth weight below 1000g.

All the children born preterm and full-term (100%) achieved low average to average performance, none of the participants in both groups achieved above percentile (0.0%). There were no differences between the subgroups for this visual perceptual skill. In a study by Perez-Roche et al 2016 and Molloy et al 2016, it was found that form constancy is affected in prematurity and low birth weight.

Visual sequential memory, being the fifth subtest of the TVPS-3, Results indicated that 35 (93,8%) preterm born children achieved low average to average performance as compared to 38 (97,5%) in full-term born children. 5 (6,3%) children in the preterm birth group achieved above percentile as compared to 2 (2,5%) in the full-term birth group who achieved above percentile. Children born preterm achieved better results for visual sequential memory.

Visual figure ground is the sixth subtest of the TVPS-3. Results indicated that 35 (93,8%) of children born preterm achieved low average to average performance, 38 (97,5%) of children born full term achieved low average to average results. Whilst 5 (6,3%) children born preterm achieved above percentile as compared to 2 (2,5%) full-term children who achieved above percentile. Children born preterm achieved better results for visual figure ground. This is contrary to study done by Perez-Roche et al (2016) who found that children born preterm performed poorly in visual figure-ground as compared to their full-term counterparts.

Visual closure is the last subtest of the TVPS-3. Results indicated that 38 (97,5%) of children born preterm achieved low average to average performance. 37 (96,2%) of full-term born children achieved low average to average results. Whilst 2 (2,5%) children born preterm achieved above percentile, as compared to 3 (3,8%) full-term born children who achieved above percentile results. Children born full-term performed better for visual closure. This correlates with studies conducted by Perez-Roche et al (2016) and Molloy et al (2016), indicate that visual closure is affected in prematurity and low birth weight.

5.3 VISUAL PERCEPTUAL PROCESSING

The findings of this study, as part of assessing the visual perceptual skills of 80 learners; 40 born preterm with low birth weight and 40 born full-term. Findings from the study indicated that all learners achieved low average to average results (see table 2.6,). Learners born preterm performed significantly better than their full-term counterparts, in visual memory (see table 4.11 and figure 4.5), visual spatial skills (see table 4.12 and figure 4.6), visual sequential memory (see table 4.14 and figure 4.7) and visual figure ground (see table 4.15 and figure 4.8). Children born full-term performed better than preterm born children in visual discrimination (see table 4.10 and figure 4.4) and visual closure (see table 4.17 and figure 4.9).

These results are in contrast with studies by (De Kievet et al, 2012 ; Molloy et al , 2017; American Academy of Pediatrics, 2014) where children born preterm failed all tests of visual perception. It is important to note that there are studies which indicate that although ELBW and VLBW children show this pattern of poor prognosis in academic achievement, more than 50% of these children also exhibit no learning delays, exhibit normal IQ's and have levels of educational achievement comparable to their full-term counterparts if these children did not experience any perinatal injury or complications at birth (Kozeis et al, 2015).

The findings of this study indicate that preterm children exhibited a higher overall mean percentile score of 20,419 and full-term children achieved an overall mean percentile score of 16,600. These findings may be due to these children not having experienced perinatal injury, exposure to anaesthesia for surgical intervention, other complications at birth. Preterm learners may have caught up with full term counter-parts due to early visual exposure (Kozeis et al, 2015). In a study done by Harris et al (2013) to determine the incidence and risk of learning disabilities in late preterm infants, findings indicated that these children are not at an increased risk for learning disabilities, there were no clinically significant findings between the two groups (

preterm and full-term), they explain this finding to be linked to the fact that the children born preterm in this study were not at risk for any major morbidity factors such as hyperbilirubinemia, infection or dehydration may not be at risk for adverse neurodevelopmental outcomes (Harris et al, 2013).

In a study of neurodevelopmental outcomes of former late preterm infants, Ricci et al (2011) found that these children had lower developmental index scores on Bayley Scales of Infant Development at 12 to 18 months, but by the age of 5 years exhibited normal IQ. A similar study by Gurka et al, (2010) found that late preterm infants did not have an elevated risk of poor cognitive development when compared to children born full-term at the age of 15 years.

The findings in this study are striking and encouraging, a possible explanation for the positive findings for the preterm participants may be the time factor, reflecting that advancements in neonatal medicine may have resulted in not only increased survival, decreased morbidity and better long-term outcomes for children born preterm. Access to public funded prenatal care for expectant women in the Mankweng and Capricorn district serves as an advantage that could have resulted in the positive outcome of results for children born preterm. Maternal health was not investigated, the mothers of the children born full-term may have had health conditions, alcohol/drug abuse issues or higher maternal age which may have resulted in lower percentile scores in this population. This could be a correlative factor that explains the causal effects of children born preterm in this study performing better than children born full-term.

The results of the study indicate that the sample assessed for visual perceptual skills, preterm birth and full-term birth children at Pulamadibogo school achieved between low average to average performance. Preterm birth children however performed better than full term birth children in visual perceptual skills. This could be supported by the fact that out of all the preterm children selected, none experienced any adverse side effects upon birth, such as pathology of the brain, or like other studies indicate that children born preterm do go through a “catch-up” phase (Lundequist, Bohm, Lagercrantz, Forssberg, Smedler; 2015).

5.4 LIMITATIONS OF THE STUDY

Limitation of this study is the relatively small number of participants, due to parental consent and compliance issues, incomplete Road to Health Charts, which means that the study has limited power to detect minor group and gender differences and must therefore interpret non-significant results with caution. Based on the limited sample size, differences in very low birth weight subgroups based on cut-off values for birth weight and gestational age were not investigated. For data collection tools which are precise, sample size does not have to be large (Brink et al, 2012). Though a much larger sample size would be statistically advantageous to better confirm the research results.

5.5 RECOMMENDATIONS

The importance of visual perceptual skills is not being highlighted in the public health care system and in public schools. Many school-based interventions, focus primarily on auditory or verbal dysfunctions, which is not essential for the learner with visual perceptual dysfunctions. These dysfunctions are not easy to detect. Based on the results found, the researcher recommends the following interventions;

- Gestational age, birth weight and cause for preterm birth must be well recorded on Road to Health Charts of children born in the public health care system so that children at risk can be identified, and a data bank of these children must be formulated, for follow-up purposes.
- Developmental surveillance, namely, screening of visual perceptual skills must be conducted at public health care clinics and hospitals, by skilled professionals for preterm and full-term birth children, before a child enters their formal education, as they are in a critical position to identify delays in development
- Children found to be lacking in visual perceptual skills, must be monitored and treated throughout their academic years in a multi-disciplinary set-up
- The results also call for a prospective cohort study to be able to define risk factors for future school failure

- A test for visual perceptual skills to be adapted for children living in South Africa, norms for this test must be formulated for the South African context.
- Knowing the cause of prematurity could assist health policy makers on intervention strategies in the prevention of preterm birth
- These contrasting findings highlight the need for further research and improved maternal and foetal health screening.

5.6 SIGNIFICANCE OF THE STUDY

This study aims to contribute to policy makers to ensure that optometrists in the public health care system receive training on how to perform and interpret results found of the TVPS-3 test, and to work with other healthcare professionals on intervention and management methods to improve visual perceptual skills dysfunction in identified children.

5.7 CONCLUDING REMARKS

This study of visual perceptual assessment of children born preterm with low birth weight and children born full-term, indicated that children born preterm performed better in overall visual processing skills and achieved better results in 4 out of the 7 subtests of the TVPS-3 test. This finding shows that there are other factors which may influence visual perceptual skills and cognitive skills of the learner, and prematurity may not be the only pre-disposing factor of cognitive development. Health surveillance systems need to be put in place; to identify children who are at risk. The results from this study indicates that there is a need for improved medical recording in public health care systems, as children were excluded from the study as their RTHCT's did not have gestational age, cause of preterm birth and birth weight reported, this made it difficult to identify children at risk. This study indicates the need for visual perceptual skills screening to be performed on all children entering the school system, and for remedial programs to be put in place in the public health care system as there were a large number of children in both the preterm and full-term who achieved a "low average" overall visual processing result (which is a percentile of between 9-24%), this was a concern for the researcher, and could mean that these children could experience learning difficulties as they progress to higher grades and demands become greater on them.

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ANNEXURE A: PARTICIPANT DEMOGRAPHIC SHEET

<table>
<tr><td>Code Number Participant: (Case)</td><td>Code number Participant: (Control)</td></tr>
<tr><td>Age:</td><td>Age:</td></tr>
<tr><td>Gender:</td><td>Gender:</td></tr>
<tr><td>Language:</td><td>Language:</td></tr>
<tr><td>Refractive Disorder:

Unaided VA (D) R___ L____OU_____

(N) R___ L____OU____

Corrected: Yes____ No_____</td><td>Refractive disorder:

Unaided VA (D) R___ L____OU_____

(N) R___ L____OU____

Corrected: Yes____ No_____</td></tr>
<tr><td>Known Attention Problems

Yes___ No___</td><td>Known Attention Problems

Yes___ No___</td></tr>
<tr><td colspan="2">Gestational Age:</td></tr>
<tr><td colspan="2">Birth weight________

ELBW_____ VLBW______ LBW______</td></tr>
</table>

ANNEXURE B: LETTER REQUESTING PERMISSION FROM LIMPOPO DEPARTMENT OF EDUCATION

The Cluster Manager

Limpopo Department of Education

Polokwane

0700

Dear Provincial Office Manager

I am writing this letter to request your permission to conduct research at the Pulamadibogo Primary school in Mankweng for a study entitled **Effect of Prematurity amongst School-age Children in Grade 4-6 at Pulamadibogo School in Mankweng, Limpopo.** Visual perception is the process of receiving and processing information from our environment. This skill is important for the process of learning**.** I have been granted ethical clearance from the research ethics committee of the University of Limpopo, this research will be conducted as part of degree in Masters of Public health. The study has been approved by University of Limpopo research Ethics Committee and as part of that approved process; I am required to obtain gatekeeper permission from sites where I will be recruiting the participants.

The aim of this study is to to determine the association of premature birth on visual perceptual performance in children doing Grade 4-6 at Pulamadibogo Primary School.

The project will consist of not more than thirty minutes per vision screening per child and visual perceptual assessment done at the school. The researcher humbly requests your office to grant permission to conduct this study as outlined above.

The researcher will be very appreciative if this requisition may be given a positive response.

Yours faithfully

LK Mmusi-Landela (Researcher)

ANNEXURE C: CONSENT LETTER FROM PARENT/GUARDIAN OF LEARNER

To: Parent/Guardian of Learner in Pulamadibogo School

Dear Parent/ Guardian

I am writing this letter to request your permission to conduct visual perceptual tests on your child at the Pulamadibogo Primary school in Mankweng for a study entitled **Effect of Prematurity amongst School-age Children in Grade 4-6 at Pulamadibogo School in Mankweng, Limpopo.** Visual perception is the process of receiving and processing information from our environment. This skill is important for the process of learning**.** This test will not harm your child in any way and only requires for them to sit for a maximum period of 30 minutes while the test is being conducted at the school. Your child will be given a booklet to look through with an examiner and asked answer the questions to the best of their ability. Your child may refuse to partake at any point should they not want to continue with the test.

I have been granted ethical clearance from the research ethics committee of the University of Limpopo, this research will be conducted as part of degree in Masters of Public health. The study has been approved by University of Limpopo research Ethics Committee.

The researcher humbly requests your consent with this regard. Should you approve of your child partaking in this study, may you kindly include their clinic card with this consent form, the details will be copied and sent back home. Care will be taken to ensure that the card is kept safe while in my care.

The researcher will be very appreciative if this requisition may be given a positive response.

Yours faithfully

LK Mmusi-Landela (Researcher)

Learners name______________________ Grade____________________________

YES, my child may partake in the study NO my child may not partake in the study

Parent/ Guardian Signature______________________________

ANNEXURE D: TVPS-3 RECORD CARD

TEST OF VISUAL PERCEPTUAL SKILLS
3RD EDITION

Name: ______________________ Gender: ______ Grade: ____________

School: ______________________ Examiner: ____________

Reason for Testing: ______________________

Date of Test	year	month	day
Date of Birth	year	month	day
Chronological Age	year	month	day*

*Do not round months up by one if days exceed 15

Student has known (diagnosed) attention problems? ☐ Y ☐ N

Student has known (diagnosed) visual problems? ☐ Y ☐ N

Subtests	Subtest Scores			Index Scores			
	Raw Score	Scaled Score	Percentile Rank	Overall	Basic Processes	Sequencing	Complex Processes
1. Visual Discrimination (DIS)							
2. Visual Memory (MEM)							
3. Spatial Relations (SPA)							
4. Form Constancy (CON)							
5. Sequential Memory (SEQ)							
6. Figure Ground (FGR)							
7. Visual Closure (CLO)							
			Sum of Scaled Scores				
			Standard Scores				
			Percentile Rank				
				Overall	Basic	Sequencing	Complex

%ile Rank	Scaled Score	DIS	MEM	SPA	CON	SEQ	FGR	CLO	OVERALL	BASIC	SEQUEN.	COMPLEX	Standard Score	% ile Rank
>99	19												145	>99
>99	18												140	>99
99	17												135	99
98	16												130	98
95	15												125	95
91	14												120	91
84	13												115	84
75	12												110	75
63	11												105	63
50	10												100	50
37	9												95	37
25	8												90	25
16	7												85	16
9	6												80	9
5	5												75	5
2	4												70	2
1	3												65	1
<1	2												60	<1
<1	1												55	<1

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TVPS-3 subtests do not have basals.

A ceiling is established for each subtest when a student has answered all 16 items or misses 3 items in a row. Then proceed to the next subtest.

Record the student's answers in the Response column. Each correct answer is scored "1"; errors are scored "0". Tally the scores for each subtest in the spaces provided. **Do not score the examples.**

Upon completion of the *TVPS-3*, transfer the subtest raw scores to the front page of this protocol. Use the norms tables in Appendix B to derive subtest scaled scores, index standard scores, the overall standard score and percentile ranks.

Scaled and standard scores can be graphed on the front page of this protocol. The shaded area represents one standard deviation above and below the mean.

SUBTEST 1: Discrimination

Item #	Correct Answer	Response	Score
DIS Ex A	*(3)*		
DIS Ex B	*(5)*		
DIS 1	(3)		
DIS 2	(2)		
DIS 3	(3)		
DIS 4	(2)		
DIS 5	(1)		
DIS 6	(1)		
DIS 7	(5)		
DIS 8	(2)		
DIS 9	(4)		
DIS 10	(4)		
DIS 11	(5)		
DIS 12	(4)		
DIS 13	(2)		
DIS 14	(5)		
DIS 15	(3)		
DIS 16	(1)		
		Total Subtest 1	

Do not turn to the next plate until you've read the directions for the next subtest.

SUBTEST 2: Memory

Reminder: Present the target item for 5 seconds. Response is not timed.

Item #	Correct Answer	Response	Score
MEM Ex C	*(3)*		
MEM Ex D	*(2)*		
MEM 17	(3)		
MEM 18	(1)		
MEM 19	(2)		
MEM 20	(2)		
MEM 21	(3)		
MEM 22	(2)		
MEM 23	(4)		
MEM 24	(1)		
MEM 25	(2)		
MEM 26	(1)		
MEM 27	(3)		
MEM 28	(4)		
MEM 29	(2)		
MEM 30	(4)		
MEM 31	(3)		
MEM 32	(1)		
		Total Subtest 2	

Do not turn to the next plate until you've read the directions for the next subtest.

SUBTEST 3: Spatial Relations

Item #	Correct Answer	Response	Score
SPA Ex E	*(2)*		
SPA Ex F	*(4)*		
SPA 33	(1)		
SPA 34	(2)		
SPA 35	(5)		
SPA 36	(3)		
SPA 37	(3)		
SPA 38	(5)		
SPA 39	(1)		
SPA 40	(2)		
SPA 41	(2)		
SPA 42	(1)		
SPA 43	(4)		
SPA 44	(3)		
SPA 45	(4)		
SPA 46	(5)		
SPA 47	(2)		
SPA 48	(4)		
		Total Subtest 3	

Do not turn to the next plate until you've read the directions for the next subtest.

Refer to the TVPS-3 manual for complete instructions.

SUBTEST 4: Form Constancy

Item #	Correct Answer	Response	Score
CON Ex G	*(3)*		
CON Ex H	*(5)*		
CON 49	(2)		
CON 50	(1)		
CON 51	(4)		
CON 52	(4)		
CON 53	(5)		
CON 54	(3)		
CON 55	(5)		
CON 56	(4)		
CON 57	(1)		
CON 58	(5)		
CON 59	(3)		
CON 60	(2)		
CON 61	(3)		
CON 62	(1)		
CON 63	(2)		
CON 64	(2)		
		Total Subtest 4	

Do not turn to the next plate until you've read the directions for the next subtest.

SUBTEST 5: Sequential Memory

Reminder: Present the target item for 5 seconds. Response is not timed.

Item #	Correct Answer	Response	Score
SEQ Ex I	*(2)*		
SEQ Ex J	*(3)*		
SEQ 65	(1)		
SEQ 66	(4)		
SEQ 67	(1)		
SEQ 68	(4)		
SEQ 69	(3)		
SEQ 70	(1)		
SEQ 71	(4)		
SEQ 72	(2)		
SEQ 73	(2)		
SEQ 74	(3)		
SEQ 75	(1)		
SEQ 76	(3)		
SEQ 77	(2)		
SEQ 78	(3)		
SEQ 79	(2)		
SEQ 80	(4)		
		Total Subtest 5	

Do not turn to the next plate until you've read the directions for the next subtest.

SUBTEST 6: Figure Ground

Item #	Correct Answer	Response	Score
FGR Ex K	*(2)*		
FGR Ex L	*(1)*		
FGR 81	(3)		
FGR 82	(2)		
FGR 83	(4)		
FGR 84	(1)		
FGR 85	(4)		
FGR 86	(1)		
FGR 87	(4)		
FGR 88	(3)		
FGR 89	(2)		
FGR 90	(3)		
FGR 91	(1)		
FGR 92	(2)		
FGR 93	(4)		
FGR 94	(3)		
FGR 95	(1)		
FGR 96	(2)		
		Total Subtest 6	

Do not turn to the next plate until you've read the directions for the next subtest.

SUBTEST 7: Visual Closure

Item #	Correct Answer	Response	Score
CLO Ex M	*(4)*		
CLO Ex N	*(2)*		
CLO 97	(2)		
CLO 98	(3)		
CLO 99	(1)		
CLO 100	(4)		
CLO 101	(2)		
CLO 102	(2)		
CLO 103	(3)		
CLO 104	(4)		
CLO 105	(1)		
CLO 106	(4)		
CLO 107	(3)		
CLO 108	(1)		
CLO 109	(4)		
CLO 110	(3)		
CLO 111	(1)		
CLO 112	(2)		
		Total Subtest 7	

Do not turn to the next plate until you've read the directions for the next subtest.

STOP – End of Test

Student's Medical / Family History:

Previous Test Information:

Comments About TVPS-3 Test Performance:

Recommendations:

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ANNEXURE E: TVPS-3 CONVERSION TABLES

Appendix B.1—Raw Score to Scaled Score Conversion
Ages 9-0 to 9-5

Scaled scores are shown in the interior of this chart.

Note: If any standard score is not shown it is because the statistical value fell between two raw score values; all scores were rounded to the nearest integer.

Raw Score	DIS	MEM	SPA	CON	SEQ	FG	CLO	Raw Score
1	0	0	0	0	1	0	1	**1**
2	1	0	1	1	2	2	3	**2**
3	3	1	3	3	3	3	5	**3**
4	4	2	4	4	4	4	6	**4**
5	5	3	5	5	5	5	7	**5**
6	6	4	6	6	6	7	8	**6**
7	7	5	6	8	7	8	9	**7**
8	8	7	7	9	8	9	**10**	**8**
9	9	8	8	**10**	9	**10**	11	**9**
10	11	9	9	11	**10**	11	12	**10**
11	12	**10**	**10**	13	11	13	13	**11**
12	13	12	11	14	12	14	14	**12**
13	15	14	12	16	14	16	16	**13**
14	17	16	15	18	16	18	18	**14**
15	19	18	17	19	18	19	19	**15**
16	19	19	18	19	19	19	19	**16**

Appendix B.1—Raw Score to Scaled Score Conversion
Ages 9-6 to 9-11

Scaled scores are shown in the interior of this chart.

Note: If any standard score is not shown it is because the statistical value fell between two raw score values; all scores were rounded to the nearest integer.

Raw Score	DIS	MEM	SPA	CON	SEQ	FG	CLO	Raw Score
1	0	0	0	0	0	0	1	**1**
2	1	0	1	1	1	1	3	**2**
3	2	0	2	2	2	3	4	**3**
4	4	1	3	4	4	4	5	**4**
5	5	3	4	5	5	5	6	**5**
6	6	4	5	6	6	6	7	**6**
7	7	5	6	7	7	7	8	**7**
8	8	6	7	8	8	8	9	**8**
9	9	7	7	9	9	**10**	**10**	**9**
10	**10**	8	8	**10**	**10**	11	11	**10**
11	11	9	9	12	11	12	12	**11**
12	13	11	**10**	14	12	13	14	**12**
13	14	13	11	15	13	15	15	**13**
14	16	15	14	17	16	17	17	**14**
15	18	17	16	18	18	19	18	**15**
16	19	18	18	19	19	19	19	**16**

Appendix B.1—Raw Score to Scaled Score Conversion
Ages 10-0 to 10-11

Scaled scores are shown in the interior of this chart.

Note: If any standard score is not shown it is because the statistical value fell between two raw score values; all scores were rounded to the nearest integer.

Raw Score	DIS	MEM	SPA	CON	SEQ	FG	CLO	Raw Score
1	0	0	0	0	0	0	1	**1**
2	0	0	1	0	1	1	2	**2**
3	1	0	2	1	2	2	4	**3**
4	3	1	3	3	3	3	5	**4**
5	4	2	4	4	4	4	6	**5**
6	5	3	5	5	5	5	7	**6**
7	6	4	5	6	6	6	8	**7**
8	7	6	6	8	7	8	9	**8**
9	8	7	7	9	8	9	9	**9**
10	9	8	8	**10**	9	**10**	**10**	**10**
11	**10**	9	9	11	**10**	11	11	**11**
12	12	**10**	**10**	13	11	12	13	**12**
13	13	12	11	14	13	14	14	**13**
14	15	14	13	16	15	16	16	**14**
15	18	16	15	18	17	18	18	**15**
16	19	18	17	19	19	19	19	**16**

Appendix B.1—Raw Score to Scaled Score Conversion
Ages 11-0 to 11-11

Scaled scores are shown in the interior of this chart.

Note: If any standard score is not shown it is because the statistical value fell between two raw score values; all scores were rounded to the nearest integer.

Raw Score	DIS	MEM	SPA	CON	SEQ	FG	CLO	Raw Score
1	0	0	0	0	0	0	0	**1**
2	0	0	0	0	0	0	1	**2**
3	1	0	1	1	1	2	3	**3**
4	2	0	2	2	3	3	4	**4**
5	3	1	3	3	4	4	5	**5**
6	4	3	4	5	5	5	6	**6**
7	6	4	5	6	5	6	7	**7**
8	6	5	6	7	7	7	8	**8**
9	7	6	6	8	8	8	9	**9**
10	8	7	7	9	8	9	9	**10**
11	9	8	8	**10**	9	**10**	**10**	**11**
12	11	**10**	9	12	11	11	12	**12**
13	12	11	**10**	14	12	13	13	**13**
14	14	13	12	16	14	15	15	**14**
15	16	15	14	17	16	17	17	**15**
16	18	17	16	18	18	19	19	**16**

Appendix B.1—Raw Score to Scaled Score Conversion
Ages 12-0 to 12-11

Scaled scores are shown in the interior of this chart.

Note: If any standard score is not shown it is because the statistical value fell between two raw score values; all scores were rounded to the nearest integer.

Raw Score	DIS	MEM	SPA	CON	SEQ	FG	CLO	Raw Score
1	0	0	0	0	0	0	0	**1**
2	0	0	0	0	0	0	1	**2**
3	0	0	0	0	1	1	2	**3**
4	1	0	1	1	2	2	4	**4**
5	3	1	2	3	3	3	5	**5**
6	4	2	3	4	4	4	6	**6**
7	5	3	4	5	5	5	7	**7**
8	6	4	5	6	6	6	8	**8**
9	7	5	6	8	7	7	8	**9**
10	8	6	6	9	8	8	9	**10**
11	9	8	7	**10**	9	**10**	**10**	**11**
12	**10**	9	8	11	**10**	11	11	**12**
13	12	**10**	**10**	13	11	12	12	**13**
14	13	12	11	15	13	14	14	**14**
15	15	14	13	16	15	17	16	**15**
16	18	17	16	18	18	19	18	**16**

Appendix B.1—Raw Score to Scaled Score Conversion
Ages 13-0 to 13-11

Scaled scores are shown in the interior of this chart.

Note: If any standard score is not shown it is because the statistical value fell between two raw score values; all scores were rounded to the nearest integer.

Raw Score	DIS	MEM	SPA	CON	SEQ	FG	CLO	Raw Score
1	0	0	0	0	0	0	0	**1**
2	0	0	0	0	0	0	1	**2**
3	0	0	0	0	1	0	2	**3**
4	1	0	0	1	2	2	3	**4**
5	2	0	1	2	3	3	4	**5**
6	3	1	2	3	4	4	5	**6**
7	5	2	3	5	5	5	6	**7**
8	5	3	4	6	6	6	7	**8**
9	6	5	5	7	7	7	8	**9**
10	7	6	6	8	7	8	8	**10**
11	8	7	7	9	8	9	9	**11**
12	**10**	8	8	**10**	**10**	**10**	**10**	**12**
13	11	**10**	9	12	11	12	11	**13**
14	12	12	**10**	14	13	13	13	**14**
15	14	14	12	16	15	16	15	**15**
16	17	16	15	18	18	19	17	**16**

Appendix B.4
Percentile Ranks and Other Scores

Standard Scores	Percentile Ranks	NCEs	T-Scores	Scaled Scores	Stanines
< 55	<1	1	<20	1	1
56	<1	1	20	1	1
57	<1	1	21	1	1
58	<1	1	21	2	1
59	<1	1	22	2	1
60	<1	1	23	2	1
61	<1	1	23	2	1
62	1	1	24	2	1
63	1	1	25	3	1
64	1	1	26	3	1
65	1	1	27	3	1
66	1	2	27	3	1
67	1	4	28	3	1
68	2	5	29	4	1
69	2	6	29	4	1
70	2	8	30	4	1
71	3	9	31	4	1
72	3	11	31	4	1
73	4	12	32	5	2
74	4	13	33	5	2
75	5	15	33	5	2
76	5	16	34	5	2
77	6	18	35	5	2
78	7	19	35	6	2
79	8	21	36	6	2
80	9	22	37	6	2
81	10	23	37	6	2
82	11	25	38	6	3
83	13	26	39	7	3
84	14	28	39	7	3
85	16	29	40	7	3
86	18	30	41	7	3
87	19	32	41	7	3
88	21	33	42	8	3
89	23	35	43	8	4
90	25	36	43	8	4
91	27	37	44	8	4
92	30	39	45	8	4
93	32	40	45	9	4
94	34	42	46	9	4
95	37	43	47	9	4
96	39	44	47	9	5
97	42	46	48	9	5
98	45	47	49	10	5
99	47	49	49	10	5
100	50	50	50	10	5
101	53	51	51	10	5
102	55	53	51	10	5
103	58	54	52	11	5
104	61	56	53	11	6
105	63	57	53	11	6
106	66	58	54	11	6
107	68	60	55	11	6
108	70	61	55	12	6
109	73	63	56	12	6
110	75	64	57	12	6
111	77	65	57	12	6
112	79	67	58	12	7
113	81	68	59	13	7
114	83	70	59	13	7
115	84	71	60	13	7
116	86	72	61	13	7
117	87	74	61	13	7
118	88	75	62	14	8
119	90	77	63	14	8
120	91	78	63	14	8
121	92	79	64	14	8
122	93	81	65	14	8
123	94	82	65	15	8
124	95	84	66	15	8
125	95	85	67	15	8
126	96	87	67	15	9
127	96	88	68	15	9
128	97	89	69	16	9
129	97	91	69	16	9
130	98	92	70	16	9
131	98	94	71	16	9
132	98	95	71	16	9
133	99	96	72	17	9
134	99	98	73	17	9
135	99	99	73	17	9
136	99	99	74	17	9
137	99	99	75	17	9
138	99	99	75	18	9
139	>99	99	76	18	9
140	>99	99	77	18	9
141	>99	99	77	18	9
142	>99	99	78	18	9
143	>99	99	79	19	9
144	>99	99	79	19	9
145	>99	99	80	19	9
>145	>99	99	>80	19	9

Appendix B.5
Age Equivalents for TVPS-3 Subtest Raw Scores

Raw Score	DIS Age Equivalent	MEM Age Equivalent	SPA Age Equivalent	FORM Age Equivalent	SEQ Age Equivalent	FG Age Equivalent	CLO Age Equivalent
0	<4-0	<4-0	<4-0	<4-0	<4-0	<4-0	<4-0
1	<4-0	<4-0	<4-0	<4-0	<4-0	<4-0	<4-0
2	<4-0	<4-0	<4-0	<4-0	<4-0	<4-0	<4-0
3	<4-0	<4-0	<4-0	<4-0	<4-0	<4-0	<4-0
4	<4-0	<4-0	4-3	4-0	4-4	4-3	4-3
5	4-0	4-3	4-9	4-9	4-10	5-1	5-2
6	5-1	4-9	5-2	5-6	5-5	5-9	6-1
7	6-0	5-3	5-7	6-5	6-0	6-8	7-0
8	6-11	5-10	6-2	7-4	6-8	7-6	8-0
9	7-10	6-6	6-9	8-4	7-6	8-6	9-0
10	9-0	7-5	7-6	9-10	8-6	9-8	10-2
11	10-4	8-5	8-3	11-7	9-10	11-2	11-5
12	12-1	9-11	9-3	13-10	12-0	13-1	13-1
13	14-9	12-0	10-7	16-7	15-7	16-0	14-0
14	18-9	15-0	12-8	>18-11	>18-11	>18-11	17-6
15	>18-11	>18-11	16-0	>18-11	>18-11	>18-11	>18-11
16	>18-11	>18-11	>18-11	>18-11	>18-11	>18-11	>18-11