THE RELATIONSHIP BETWEEN VISUAL PERCEPTUAL SKILLS, VISUAL MOTOR INTEGRATION SKILLS AND OCULOMOTOR CONTROL, IN LEARNERS ATTENDING A LSEN SCHOOL

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Declaration

I, Laetitia Buurman, hereby declare that this research report is my own work. It is being submitted for the degree of Master of Science at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other university.

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Abstract

Children with specific learning disorders are frequently identified with visual processing difficulties. Receptive client factors such as oculomotor control are seen as foundational skills upon which visual cognitive processing is built, however there is little understanding of these skills and their effect on cognitive interpretation of visual stimuli. This study aimed to investigate the relationship between these concepts.

A quantitative, non-experimental, cross sectional correlation study design was used. Pearsons and Spearman's non-parametric correlation coefficient was used to analyse the interval data and ordinal data respectively. All the scores obtained were not normally distributed. Visual motor integration was significantly correlated with visual perceptual skills. Aspects of oculomotor functioning correlated with visual perceptual skills.

This study concludes that there is a relationship between visual perceptual, visual motor integration skills and oculomotor functioning. It is recommended that the assessment of oculomotor functioning is included during visual perceptual and visual motor integration evaluations.

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Definition of Terms

Visual perception skills: Visual perception entails the ability to receive, interpret, comprehend and describe visual information in the environment by analysing patterns of light that fall onto the retina and assimilating it into images (Warren, 2013).

Visual motor integration skills: According to Beery (2010:10) visual motor integration can be seen as “the degree to which a visual perception and finger-hand movements are well coordinated”.

Oculomotor control: To maintain visual stability and controlling eye movements to create a scan path of the environment to the brain (Hejtmancik and Nickerson, 2015; Warren, 1993)

Standardized assessment: Standardized tests have been made uniform in their procedure of administration and scoring. They are used to determine learners current level of developmental functioning in relation to a person's chronological age (Richardson, 2014).

Specific learning disorder: It is a neurodevelopmental disorder which starts becoming noticeable when a learner is school going age but can often only be diagnosed during adulthood (American Psychiatric Association, 2013). This umbrella term comprises of disorders such as dyslexia (difficulty in reading or writing) and dyscalculia (difficulty with mathematics) (Cain et al., 2004).

Visual discrimination: It enables a person to find similarities, to recognize dissimilarities between objects and to categorize visual stimuli (Schneck, 2010b). It is seen as the basis from which most visual perceptual abilities are developed (Martin, 2006).

Visual spatial relationships: In combination with position in space, form spatial perception. Visual spatial relations are the ability to comprehend the relation between objects. It, in combination with position in space, form spatial perception.

Visual figure ground: Is the ability to distinguish between the foreground and the background of objects. This allows a person to differentiate between important visual information or for visual attention to be placed in a specific area of the environment (Schneck, 2010b).

Form constancy: Is the ability to recognize objects which are similar, but have different sizes, positions or shapes. It further enables a person to recognize letters that are the same but written in different handwritings, typed or in cursive (Schneck, 2010b).

Visual closure: Enables a person to identify a whole object after only seeing part of it. This allows a person to quickly recognize objects and shapes to process visual information rapidly (Schneck, 2010b).

Visual attention: The process of selecting specific visual information to focus on, from all of the available visual information in the environment for further processing (Warren, 1993). When adequate visual attention is not given, then this has an impact on all other visual perceptual skills since one's focus is not on the correct visual stimuli (Schneck, 2010b).

Visual memory: The process of collecting visual information, storing it and being able to retrieve it. Adequate visual memory is vital in enabling academical skills are retained such as reading or writing. It is however dependant on the person's ability to focus on the task at hand (Schneck, 2010b).

Visual imagery: It is the ability to create a mental picture of imagined objects or people. This is seen as a foundational skill for learning specifically reading comprehension and spelling (Schneck, 2010b).

List of Abbreviations

ADHD: Attention Deficit Hyperactivity Disorder

DCD: Developmental Coordination Disorder

DEM: Developmental Eye Movement Test

DT-VMI 5: Developmental Test of Visual-Motor Integration (Beery-Buktenica) - 5th edition

DT-VMI 6: Developmental Test of Visual-Motor Integration (Beery-Buktenica) - 6th edition

MCT: Modified Clinical Technique

LSEN: Learners with Special Educational Needs

RAN: Rapid Automized Naming

SD: Standard Deviation

SEM: Standard error of measurement

SLD: Specific Learning Disorder

TVPS-3: Test of Visual Perceptual Skills-3rd edition

VMI: Visual-Motor Integration

WRAVMA: Wide Range Assessment of Visual Motor Abilities

CHAPTER 1: INTRODUCTION AND BACKGROUND

1.1 Background

Occupational therapists provide intervention for children with a specific learning disorder to facilitate their educational occupational performance in the classroom (Schneck, 2010b; Frolek Clark and Chandler, 2013). The aim of this service is to promote health and well-being by enabling participation in activities of daily living that people want to, need to or are expected to engage in (WFOT, 2012). Occupational therapy has been proven to be effective in improving the educational occupational performance and participation of children (Benedixen and Kreider, 2011; Whalen, 2002; Bayona et al., 2006). It has been noted that it is a cost effective way to improve the immediate and long term productivity of learners with a specific learning disorder (Lammers et al., 2014).

Specific learning disorder is a neurodevelopmental disorder which starts becoming noticeable when a learner is school going age but can often only be diagnosed during adulthood (American Psychiatric Association, 2013). The learning disorder needs to be unexpected thereby indicating that all other neurological structures needs to be intact. According to the DSM-5 specific learning disorder is used as a diagnostic term for all learners who struggle with reading, writing and mathematics.

Children with specific learning disorders are frequently identified with visual processing difficulties (Silver, 2001; Tseng and Chow, 2000; Harris, 2017; Handler and Fierson, 2011). These skills or client factors are vital skills which are used in many activities of daily living (American Occupational Therapy Association, 2014). Occupational performance in the classroom is influenced by visual processing, including perceptual skills and visual motor integration skills (Brown and Link, 2016; Brown, 2012), since these skills are an important basis for academical skills such as mathematics, reading and writing (Pienaar et al., 2014; Sortor and Kulp, 2003; Lotz et al., 2005; Kulp, 1999; Van Hoorn et al., 2010; Ayhan et al., 2015; Bezrukikh and Terebova, 2009).

Visual perception entails the ability to receive, interpret, comprehend and describe visual information in the environment by analysing patterns of light that fall onto the retina and assimilating it into images (Warren, 2013). These images can then be integrated with other sensory input, compared to stored memories, and used in the process of making decisions. Visual perception depends both on the reception and integration of visual information requiring directed attention for selecting relevant stimuli as well as remembered associations to previously seen visual stimuli (Stewart, 2010; Borsting, 2006; Scheiman, 2011; Warren, 2013). The receptive client factors of vision, which include oculomotor control, are seen as foundational skills upon which visual information processing and motor output are dependent (Stewart, 2010; Warren, 2013). Oculomotor control is when visual stability is maintained and eye movements are controlled to create a scan path of the environment to the brain (Hejtmancik and Nickerson, 2015; Warren, 1993).

Visual cognitive processing includes both visual perceptual and visual motor integration skills (Goldstand et al., 2005). The visual cognitive or interpretive component of visual processing includes the organisation, structuring of the visual stimuli received to give meaning to what is seen including judgment of aspects such as the size and configuration of objects. In order to participate in everyday activities, fine, gross and sensory motor responses to perceived and processed visual information, is required. This motor-enhanced visual perception is also called visual-motor integration (May and Marozas, 2007). Beery (2010:10) describes visual motor integration as “the degree to which a visual perception and finger-hand movements are well coordinated”. This also influences academic skills such as writing letters and aligning writing on a page (May and Marozas, 2007).

It is argued by Warren (2013) that receptive client factors are the foundational skills upon which visual cognitive processing is built. When deficits exist in these foundational skills, incorrect or inadequate information about the characteristics of objects and their relationship to each other in the environment is relayed to the central nerve system, where this information is processed. It has been noted that there is little emphasis and understanding of these basic foundation visual-receptive skills, their effect on visual information processing and cognitive interpretation of visual stimuli. On the other hand authors like Coté (2015) suggest that visual processing must be approached within the dynamic systems theory where multiple structures are included in the process, not in a linear manner, but with more complexities. It is suggested that oculomotor abilities do not form the basis of visual perceptual skills, but rather form part of a complex process where foundational skills do not first need to be established before cognitive processing can occur.

In order to determine the importance of addressing foundational as well as higher level cognitive information processing this study will investigate the relationship between oculomotor control, visual perceptual and visual motor integration skills.

1.2 Problem Statement

In the Gauteng province of South Africa learners with a specific learning disorder often attend Learners with Special Needs (LSEN) schools which are schools that provide specialised education for children with barriers to learning. It is the role of occupational therapists to assess and treat these children with the best, evidence based practice to improve performance in education (Department of Basic Education, 2014).

In the LSEN school where the researcher is currently working, most of the learners present with visual perceptual and visual motor integration difficulties. During assessments, it has been observed that many of these learners have difficulties with oculomotor control. Although literature does indicate that oculomotor control may have an association with visual perception and visual motor integration abilities, there is little research on this relationship (Goldstand et al., 2005; Warren, 1993; Kawar, 2002; Stewart, 2010; Warren, 2013). Oculomotor control is not viewed as a primary target for intervention in occupational therapy and as a result, oculomotor deficits often go untreated (Kawar, 2002). There is no clarity on the relationship to and effect of poor oculomotor control on visual perceptual and visual motor integration processing.

1.3 Purpose of the study

It is important to investigate and provide evidence on the aspects which need to be assessed in terms of visual processing in foundation phase learners attending a

LSEN school. This study will consider the relationship between visual perceptual, visual motor integration and oculomotor control in these learners.

1.4 Research question

Is there a relationship between oculomotor control, visual perceptual and visual motor integration skills in foundation phase learners attending a LSEN school?

1.5.1 Aim of the Study

To determine the relationship between visual perceptual skills, visual motor integration skills and oculomotor control in foundation phase learners attending a LSEN school.

1.5.2 Objectives of the Study

Objective 1: To determine the visual perceptual skills of foundation phase learners attending a LSEN school using the Test of Visual Perceptual Skills 3th edition (TVPS 3) (Martin, 2006).

Objective 2: To determine the visual motor integration skills of foundation phase learners attending a LSEN school using the Developmental Test of Visual-Motor Integration - 6th edition (DT-VMI 6) (Beery, 2010).

Objective 3: To determine the oculomotor control of foundation phase learners attending a LSEN school using the Developmental Eye Movement Test (Richman, 2009) and the Eye Movement subsection of the Ayers Clinical Observations (SAISI, 2005).

Objective 4: To determine the relationship between oculomotor control, visual perceptual and visual motor integration skills.

1.5. Justification of the Study

This study aimed to contribute to the Occupational Therapy evidence base of the assessment and treatment of visual processing including visual perceptual and visual motor integration skills. Insight was gained into the visual perceptual, visual motor integration skills and oculomotor control of learners with a specific learning disorder. This supported the call for more research to improve our understanding of the interrelatedness between visual perceptual, visual motor integration and oculomotor control (Buckle, 2019; Goldstand et al., 2005; Kawar, 2002).

It aimed to contribute to and establish the view of the importance of oculomotor control as a foundational skill of visual information processing. It also aimed to assert the assessment and treatment of oculomotor skills and the role it may play in assessment and treatment of visual perceptual and visual motor integration skills. The results for this study will form part of the body of knowledge in the field of occupational therapy. It will guide South African occupational therapists in their assessment and intervention of visual processing, especially for learners in LSEN schools.

1.6 Null Hypothesis

Objective 4: There will not be a significant relationship between oculomotor control, visual perceptual and visual motor integration skills.

1.7 Outline of the study

Chapter 1: Introduction

A basic introduction and background to the study is given. The problem statement is noted as well as the purpose, aims, objectives and justification for the study. Lastly, the outline of the study is provided.

Chapter 2: Literature review

This chapter discusses current research available in in the field of occupational therapy as well as related literature regarding the visual system including visual reception and visual cognitive processing. Oculomotor control is discussed as well as the influence of deficits in oculomotor control. Visual perceptual and visual motor integration skills are discussed. The impact of deficits in these skills are also noted. Models of visual perception in occupational therapy are considered. Lastly the standardized assessment which were used in this study to evaluate these skills, are examined and specific learning disorders are discussed.

Chapter 3: Methodology

This chapter elaborates on the specific research design, the type of study, the research site, the sample selection and the sample size that was included in the study. The instrumentation and outcome measures that was used in this study will be discussed as well as the demographic questionnaire. The research procedure, data analysis and ethical considerations are examined.

Chapter 4: Results

This chapter examine the results of the study and states the demographic information of the participants. It further provides the results of the visual perceptual skills of the participants as assessed by the TVPS-3; the visual motor integration skills of the participants as assessed by the DT-VMI 6; and the oculomotor control of the participants as assessed by the DEM and the Eye Movement subsection of the Ayres Clinical Observations in tables and graphs. This chapter provides the significant correlations between visual perceptual and visual motor integration skills, visual perceptual and oculomotor control as well as visual motor integration and oculomotor control in tables.

Chapter 5: Discussion

This chapter elaborates of the findings in the study. Firstly, the demographic of the participants is discussed and analysed according to the general South African population. The objectives of the study are discussed and related to available literature. Lastly the strengths and limitations of the study will be addressed.

Chapter 6: Conclusion

Lastly the main findings of the study are summarized, clinical recommendations are made, and recommendations are made for future research are made.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Children with a specific learning disorder find it difficult to perform basic skills which are essential for learning such as reading, writing and doing mathematics. Difficulties in these areas negatively impacts other subjects such as science or biology and could therefore hamper a learner's performance in all academical tasks (American Psychiatric Association, 2013). In later life this can lead to not finishing school, unemployment, emotional stress and poorer mental health.

It has been found by numerous studies that children with a specific learning disorder have a greater risk of having deficits in perceptual organization (Di Blasi et al., 2007), visual perceptual, visual motor integration difficulties (Wuang et al., 2008; Memisevic and Sinanovic, 2012) and academical performance (Bezrukikh and Terebova, 2009; Ayhan et al., 2015; Van Hoorn et al., 2010; Sortor and Kulp, 2003; Kulp, 1999; Lotz et al., 2005; Pienaar et al., 2014). Therefore, this chapter reviews literature on the visual system including visual receptive and visual cognitive processing skills. The impact of dysfunction in these aspects on children's educational occupational participation is examined. The theory related to visual perception from an occupational therapy perspective are considered using models of visual perception. Standardized assessments that was used in the evaluation of visual perceptual, visual motor integration and oculomotor skills are examined.

The literature used for the review was sourced from ERIC, EBSCO host, Pubmed, Sxiene Direct, Elsevier and OVID. Some of the iconic research literature on visual perception was developed by Chalfant and Schefflin (1969), Warren (1993, 2013), Coté (2015), Schneck (2010a, 2010b), Richman (2009), Beery (2010) and Martin (2006)

2.2 The visual system

The visual system is responsible for accurately receiving and processing visual information from the environment. It is classified as a special sense which enables the person, more than any other sense, to have a better understanding of their environment (Schneck, 2010b). It has been found that 70% of sensory receptors are assigned to vision (Schneck, 2010a). The visual system is regarded as a dominant system in enabling goal-directed actions since visual perception and motor behaviours are closely linked. Humans, are not passively exposed to visual stimuli in their environments, but seek out valuable sensory information through coordinated motor actions (Jeannerod, 2006; Rucci and Victor, 2015). The brain then monitors, filters, consolidates and integrates environmental information to allow for appropriate adaptive responses (Ayres, 1989). Adaptation is contingent on the capacity to anticipate events and vision allows the perception of a large amount of detail within milliseconds. This data is integrated with other sensory input resulting in reactions, decision making and planning to ensure survival.

Gathering and understanding visual information is not a linear process. It takes place through a circular route where constant input, from structures involved, are analysed and integrated. Firstly, reflected rays of light from an object must reach the eye. These rays of light must then pass through the cornea and lens. Visual receptor cells in the retina is stimulated by light and refraction takes place to form an image on the retina. Electrochemical charges are caused by the light, which creates electrical impulses that flows to the optic nerve (cranial nerve II). Optic nerve fibres from both (left and right) eyes merge to form the optic chiasm. From here the impulse is transferred to the optic tracts which then primarily terminate in the two lateral geniculate nuclei of the thalamus. Impulses with visual information are then sent to the visual cortex in the occipital lobe (Gilman and Newman, 2003; Kandel and Wurtz, 2000; Humphreys and Riddoch, 1994).

In the occipital lobe visual information is sharpened, orientation of lines and colours are established, and images are fine tuned. From here, visual images are sent to the posterior parietal lobe through the dorsal stream, where visual-spatial processing takes place. The dorsal stream is also known as the "vision for action" stream. This stream allows a person to analyse shapes, the orientation and spatial location of objects. Visual information is also sent to the inferior temporal lobe via the ventral stream. The ventral stream is also known as the “vision for perception” stream. This stream allows a person to discriminate and identify visual objects, shapes, pattern, texture and colours (Hebart and Hesselmann, 2012). These two streams interact in an intricate way to inform action planning in three-dimensional space. Lastly visual information is also sent to the prefrontal cortex where decisions can be made based on the information received (Gilman and Newman, 2003; Humphreys and Riddoch, 1994; Kandel and Wurtz, 2000).

The visual system is vital to a person's ability to quickly and effectively process information from the environment. This is not only crucial for survival, but also in the process of learning.

Two vital processes that are integral to receiving and analysing visual information is visual reception and visual cognitive processing (Stewart, 2010; Borsting, 2006; Scheiman, 2011; Warren, 2013). These two processes will be discussed in more detail.

2.2.1 Visual reception

Visual reception refers to the process of obtaining and organizing information from the environment (Schneck, 2010a). Oculomotor control is seen as a visual receptive process. It can be described as motor activity in the eyes which enables a person to gather visual information from the environment by attending to specific visual stimuli (Rucci and Victor, 2015). The motor activity in the eyes turn a static picture in the environment, into a spatiotemporal input signal to the retina (Kowler, 2011).

Through visual search the location of visual stimuli is anticipated, which ensures that visual information can be received and rapidly processed. There are two types of visual searches namely voluntary search and automatic search. Automatic search is controlled by the brainstem and are involuntarily activated by sudden movements in the visual fields. The superior colliculi activates the six oculomotor muscles through cranial nerve III oculomotor, IV trochlear and IV abducens (Kandel and Wurtz, 2000; Moore, 1979; Warren, 2013).

Voluntary search is controlled by cortical processes for the intended purpose of consciously gathering visual information from the environment. The eyes can be controlled to intentionally focus on elements of the visual stimuli which is vital for accurate interpretation of the object or visual environment. In the cerebral cortex, the prefrontal and the premotor area are situated in the frontal lobe and it is primarily responsible for planning accurate, controlled eye movements (Kandel and Wurtz, 2000; Warren, 2013).

The subcomponents of the visual receptive process are: fixation, saccadic eye movement, tracking, acuity, accommodation, binocular fusion, stereopsis, convergence and divergence as well as visual fields (Schneck, 2010a).

The two most vital oculomotor subcomponents are fixation and saccadic eye movements. Fixation can be described as maintaining visual gaze on a static object. Some authors describe the term fixation to be misleading since it has been found that the eyes are never at rest, but movements on a microscopic level can always be observed during fixation. This is known as fixational eye movements (Kowler, 2011; Rucci and Victor, 2015). Saccadic eye movements rely on scanning, or the rapid change of fixation from one point in the visual field to another. It is the quick, synchronized movement of the eyes between objects. This is accomplished by moving the eyes in the direction of an object of interest. Saccades can range in amplitude from small fast movements made while reading to larger slow movements made while gazing around a room (Gilman and Newman, 2003). When enough visual information has been gathered, the eyes move to capture the next letter or object. Boundaries, as seen in the peripheral vision, are used to saccade the eyes to the next position. Key elements are re-examined numerous times to ensure the object is correctly identified and unnecessary visual information is ignored (Reichle et al., 2009).

Tracking occurs when is the eyes fixate on a moving object by ensuring that the high-acuity regions focus on areas of interest in the environment. This enables a person to gather information on a specific dynamic object (Rucci and Victor, 2015). Acuity ensures clarity of vision by allowing intricate features of an object to be identified. This is dependent on optical and neural factors which allows accurate visual information to be sent to the central nervous system. Accommodation enables each individual eye to amend a blurred image to form a clear image. The internal ocular muscle contracts or relaxes to move the lens of the eye. This enables a person to focus on images in a close proximity and shortly after focus on an image further away with clear visibility. Binocular fusion is the process whereby the left and the right eye's visual information is merged to form one image. This allows the brain to combine the images seen by both eyes into a single precept. Stereopsis is when depth perception occurs to form three-dimensional vision. Convergence occurs when both foveae of the eyes are aligned with an object that moves towards or away from the eyes. Visual fields ensure that the complete visual array is recorded (Schneck, 2010b).

Visual reception is an integral part of accurately observing environmental stimuli. The process of oculomotor control and the different subcomponents thereof enables a person to correctly observe static and dynamic images. Involuntary oculomotor movement is important for survival and enables a person to constantly be aware of environmental stimuli. Voluntary oculomotor movements ensure that a person is able to actively learn from the environment. Saccadic eye movements and visual fixation are vital components of oculomotor control. These components provide vital information on oculomotor functioning and therefore must be evaluated specifically.

2.2.2.1 Oculomotor deficits

A school aged child should be able to move their eyes smoothly, well-co-ordinated and controlled in any direction (Schneck, 2010b). It has been noted that children who struggle with visual reception often experience visual fatigue (Schneck, 2010a). Many studies have found that oculomotor control influences perceptual judgement and that there are close links between saccades and perception (Schütz, 2011; Rolfs, 2009; Martinez-Conde, 2013).

When assessing visual perception the importance of screening for oculomotor control was emphasised by Goldstand et al. (2005). In their study they found that 60% of mainstream seventh grade participants failed visual screening using the Modified Clinical Technique (MCT), which includes oculomotor control as a subsection. It was also found that nonproficient readers scored significantly less in the MCT than proficient readers, which indicated that their visual system could be influencing the occupational performance outcomes associated with visual perception such as the ability to read (Goldstand et al., 2005). A possible association between learners with neurodevelopmental disorders such as motor dyspraxia, ADHD and oculomotor dysfunction has been found (Gaymard et al., 2017; Mahone et al., 2009). It is recommended that further investigation of learners with the aforementioned diagnoses undergo in-depth assessment of physical abilities.

When determining oculomotor functioning the subcomponents of the visual receptive process needs to be taken into account. An interaction between the convergence and saccade systems has been found and difficulty in one of these areas could negatively influence the other (Alvarez and Kim, 2013). Convergence insufficiency has been associated with frequent loss of place causing a rereading of text. It has also been shown that for individuals with convergence insufficiency and strabismus alternate eyes are used in visual pursuits across the midline speed and accuracy of saccades (Van Leeuwen et al., 2001). Early detection and treatment of oculomotor control deficits can result in a better prognosis for normal development. This can also decrease the impact of learning problems, poor academical performance, and behaviour problems (Ho et al., 2015).

When considering visual reception, the role of the occupational therapist is not to do a comprehensive visual assessment but rather screen for impairments including oculomotor control (Cate and Richards, 2000; Schneck, 2010b). The screening completed by occupational therapy practitioners determines whether these impairments are present and the effect they have on the child's occupational participation (Warren, 2013). Visual screening can enable the therapists to establish the cause for visual perceptual and visual motor integration deficits and determine whether a comprehensive assessment by an optometrist or behavioural optometrist is warranted. Since oculomotor control is a specialized system it requires a complex intervention with specific activities and exercises to improve the systems functioning (Kawar, 2002). Therefore, referral for assessment of visual reception abilities in order to diagnose visual impairments is required and must then be taken into consideration during evaluation of visual perception. Occupational therapists can refer to and work in conjunction with developmental optometrists to improve oculomotor functioning (Scheiman, 2011).

2.2.2 Cognitive processing

The second process which occurs when gathering visual information from the environment is the cognitive processing which is also referred to as visual perception. Through this process visual information is organised, structured and interpreted, giving the visual stimuli meaning which allows understanding of what is seen (Stewart, 2010; Scheiman, 2011). Thus, visual perception is influenced by a person's cognitive ability and conversely influences a person's cognitive development (Lotz et al., 2005; McKenna et al., 2006; Holmqvist, 2012).

It has been noted by many authors that it is of upmost importance to have a basic understanding of the functioning of the visual system in order to fully comprehend visual perception (Groffman, 2006; Handler and Fierson, 2011; Rookes and Willson, 2000; Zoltan, 1996). This ensures that visual perception is approached in a holistic manner and not in isolation as a separate concept.

Visual perception can be divided into two main subsections namely motor-reduced and motor-enhanced (Schneck, 2010b; Hammill, 2014; Brown, 2012).

2.2.3.1 Motor reduced visual perception

Motor reduced visual perception involves little or no motor actions (Hammill, 2014). It is a complex neurophysiological process which functions in a systematic manner and is dependent on the effective functioning of the relevant neurological structures involved (Martin, 2006). This process depends both on the reception and integration of visual information requiring directed attention for selecting relevant stimuli as well as remembered associations of previously seen visual stimuli. An example of this is matching where a child is shown an image of a shape like a square and asked to indicate which shape it matches from a variety of options given on a page (Brown, 2012). Visual perceptual skills are vital for effective participation in everyday occupations such as self-care tasks and leisure activities (Brown et al., 2012;

Zoltan, 1996; Cicerone et al., 2000; Watson et al., 2004; McKenna et al., 2006; Holmqvist, 2012).

In order to evaluation of all aspects of visual cognitive functioning, different subcategories were developed. These subcategories were firstly developed by Chalfant and Schefflin in 1969 based on a literature review of the significant research available in that time period. These categories are visual discrimination, visual spatial relationships, position in space, visual memory, visual figure ground, form constancy and visual closure (Chalfant and Scheffelin, 1969). More recent literature has also included visual attention and visual memory (Schneck, 2010b; Schneck, 2010a; Martin, 2006). This subdivision of visual perception ensures that certain aspects an individual might struggle with can be determined and addressed specifically. Visual perceptual skills can however never be treated in isolation since all visual perceptual skills are inseparably linked (Martin, 2006). Visual perceptual skills develop and are refined over the first 11-12 years of life and should be consolidated by this age.

Visual discrimination enables a person to find similarities, to recognize dissimilarities between objects and to categorize visual stimuli (Schneck, 2010b). It is seen as the basis from which most visual perceptual abilities are developed (Martin, 2006). Poor visual discrimination can cause difficulty in decoding during reading, poor quality writing and reversals (Schneck, 2010b). Visual discrimination should be consolidated by the age of 12 years.

Visual spatial relationships in combination with position in space, form spatial perception. Visual spatial relations are the ability to comprehend the relation between objects. It allows one to understand directional language such as up, down, back, front, middle or left and right. Position is space enables a person to recognize objects in relation to oneself and other objects (Schneck, 2010b). Position in space is usually consolidated by the ages of 7-8 years. The spatial relations component is usually well developed by the age of 10 years.

Visual figure ground is the ability to distinguish between the forefront and the background of objects. This allows a person to differentiate between important visual information or for visual attention to be placed in a specific area of the environment (Schneck, 2010b). Figure ground shows rapid improvement between the ages of 3-5 years and should be consolidated by 9-10 years.

Form constancy is the ability to recognize objects which are similar, but have different sizes, positions or shapes. It further enables a person to recognize letters that are the same but written in different handwritings, typed or in cursive (Schneck, 2010b). Form constancy shows rapid improvement between the ages of 6-7 and is usually consolidated by 8-9 years.

Visual closure enables a person to identify a whole object after only seeing part of it. This allows a person to quickly recognize objects and shapes to process visual information rapidly (Schneck, 2010b).

Visual attention is the process of selecting specific visual information to focus on, from all of the available visual information in the environment for further processing (Warren, 1993). When adequate visual attention is not given, then this has an impact on all other visual perceptual skills since one's focus is not on the correct visual stimuli (Schneck, 2010b). Eye movements play an integral role in visual attention as the eyes needs to be directed towards the correct visual stimuli and to relay the message to the visual cortex.

Visual memory is the process of collecting visual information, storing it and being able to retrieve it. It can mainly be divided into long- and short-term memory with long-term memory being responsible for storing events for an extended period of time ago and short-term memory storing events for a shorter period of time, approximately 30 seconds. Adequate visual memory is vital in enabling academical skills are retained such as reading or writing. It is however dependant on the person's ability to focus on the task at hand (Schneck, 2010b).

Visual imagery is a key aspect of visual cognition. It is the ability to create a mental picture of imagined objects or people. This is seen as a foundational skill for learning specifically reading comprehension and spelling (Schneck, 2010b).

All of these subcategories of motor reduced visual perception should be analysed during an assessment. This ensures that cognitive processing is viewed holistically, and information of all aspects are gathered.

2.2.3.2 Motor enhanced visual perception

Motor-enhanced visual perception occurs when motor output results from the processing of visual perceptual information in tasks. It is reliant the smooth and coordinated work patterns of a person's hands and eyes (Beery, 2010). An example of a motor enhanced activity is asking a child to copy a shape like a circle from a two-dimensional picture onto a page with a pencil (Brown, 2012).

In the brain the parietal cortex has been found to be the most involved in the visual motor integration. The left posterior parietal cortex is mainly responsible for planning and integrating movements with visual information to facilitate actions like reaching and grasping, while the right posterior parietal cortex copies the actions of the others. The parietal lobe is strategically located between the occipital lobe, which main function is vision, and the frontal lobe, which is mainly responsible for making decisions and enabling action (Lacobioni, 2006). It has been found that a significant relationship exists between writing, mathematical performance, visual analysis and motor enhanced visual perception (Carlson et al., 2013; Clark, 2010; Hopkins et al., 2019). Motor enhanced visual perception skills are also a strong predictor of executive functioning skills, especially with regards to self-regulation in the classroom (Kim et al., 2016; Verdine et al., 2014). It is therefore vital to understand a child's motor enhanced visual perception as it influences their educational occupational participation and performance to a great extent.

2.2.3.3 Motor enhanced and motor reduced visual perceptual skills deficits

Deficits in visual perceptual and visual motor integration skills are linked to disorders such as dyslexia (difficulty in reading or writing) and dyscalculia (difficulty with mathematics) and dysgraphia (difficulties with handwriting) (Brown et al., 2012; Hopkins et al., 2019; Clark, 2010; Carlson et al., 2013; Brown and Link, 2016).

A specific learning disorder with associated visual perceptual deficits result in children using more energy to do visual activities and they tend to avoid activities that are dependent on these skills (Schneck, 2010a). They also struggle to complete tasks in the allocated time and are often distractible (Garzia, 1994). When children have motor enhanced visual perceptual difficulties it has been found to produce low self-esteem, decrease in perception of personal abilities, a negative mindset (EngelYeger et al., 2009) and decreased overall academical performance (Hoy et al., 2011; Van Hartingsveldt et al., 2011). These children may never reach their full academical potential without intervention (Hinkley et al., 2011).

It has been found that when a child’s visual perceptual and visual motor integration abilities are not adequately developed, it can negatively influence not only their educational occupational performance, but also activities of daily living, play, leisure and social participation (Schneck, 2010b; Coallier and Rouleou, 2014). However research in occupational therapy on visual perception and visual motor integration in children, focuses mainly on the role these skills play in education as it is one of the main occupations of a child (Lee, 2006; Kawar, 2002) and it has been found that 70% of the time in school is spent on reading and writing (Ritty et al., 1993). Other occupational performance areas such as self-care and leisure has mainly focussed on adults and not children (Brown et al., 2012; Zoltan, 1996; Cicerone et al., 2000; Watson et al., 2004; McKenna et al., 2006; Holmqvist, 2012).

2.3.3 Relationship between motor reduced and motor enhanced visual perceptual skills

For many years contradicting evidence has been found in numerous studies on whether a correlation exists between motor reduced and motor enhanced visual perceptual skills. Some studies suggests that these skills are interrelated and can be used as predictors of one another another (Sigmundsson and Hopkins, 2005; Barnhardt and Deland, 2005; Ayhan et al., 2015; Bezrukikh and Terebova, 2009; Cho et al., 2015; Dankert et al., 2003) while other studies suggest that these skills are separate entities and no relationship exists between the two (Bonifacci, 2004; Colarusso and Hammill, 2003; Henderson et al., 2002).

While Parush et al. (1998) suggest that in typically developing children visual perception and visual-motor integration are separate functions, in children with a learning disorder they found a moderate but significant relationship between these skills. However researchers recommend that these skills should be considered as two separated entities and be approached as such (Parush et al., 1998; Brown, 2012).

This study aims to investigate this relationship between motor reduced and motor enhanced visual perceptual skills, especially when looking at children with a specific learning disorder.

2.4 Models of visual perception in occupational therapy

The way that occupational therapists view visual perceptual and visual motor integration development has been influenced by theory proposed by psychologists such as Bandura (1977),, Gibson (1969), Piaget (1952) and Miller (1998) as well as optometrists such as Getman (1965), Scheiman (2002) and Skeffington (1963). The five basic principles of development that all of their theoretical approaches follow are (Schneck, 2010a):

- The development of visual perceptual and visual motor integration skills is a process.
- Through development, experiences, practice as well as stimulation in the environment, visual perceptual skills can be developed and enhanced.
- Modelling is a process through which children can learn new skills. Modelling can be done by adults and or peers.
- The acquisition of visual perceptual and visual motor integration skills does not necessarily take place in a sequence.
- Participation in everyday occupations are negatively influenced by deficits in visual perceptual and visual motor integration skills.

Based on these theories occupational therapists have developed models to support the assessment and treatment of visual perception related to participation in occupation.

2.4.1 The Hierarchical Model of Visual Perception

The Hierarchical Model of Visual Perception was developed by Warren in 1993. This model presents a hierarchy for visual-perceptual skill development in the central nervous system. According to this model assessment as well as treatment of visual perception is viewed from a bottom-up approach (Sullivan and Knutson, 2000). Based on the theory by Moore (1979), focus is placed on determining where the deficits occur within the visual system and whether the deficits are related to visual-receptive components or visual-cognitive components. Initially the visualreceptive components, including oculomotor control are treated and when these deficits are resolved visual-cognitive skills are assessed and treated.

This model was originally developed for evaluation and treatment of visualperceptual difficulties in adults who has suffered traumatic brain injuries. It can however be effective in evaluating and treating visual-perceptual difficulties in children since visual perceptual development has been organized into a hierarchal system. The different levels are dependent on age appropriate development within a hierarchy of influence. Each process within this hierarchy interacts with and is subservient to the one above. There are foundational skills which support the following function. The subsequent process cannot develop properly without the integration of the lower level process which precedes it (Warren, 2013).

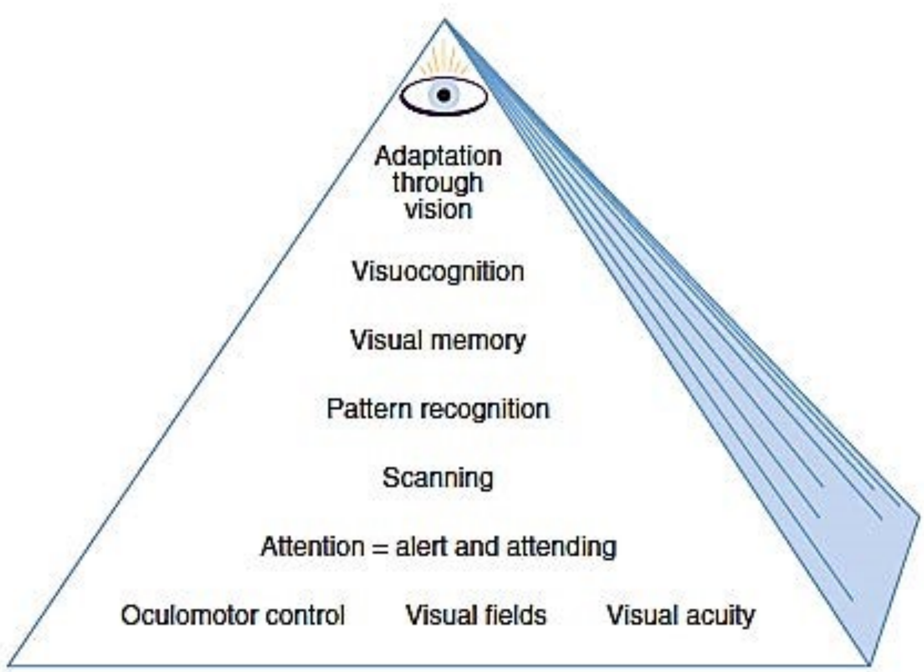

Figure 2.1 Hierarchy of visual perceptual development in the central nervous system. (Warren M: A hierarchical model for evaluation and treatment of visual perceptual dysfunction in adult acquired brain injury, part I, American Journal Occupational Therapy 47[1]:55, 1993.)

As shown in Figure 2.1 visual memory, pattern recognition, visual scanning and visual attention or visual-cognitive. Poor visual attention means the visual search process will not be initiated and a great deal of visual information will be missed. When visual information is attended to in a random or unorganised way, the visual information that is gathered could be inaccurate (Warren, 2013). The process of visual perception is dependent on synergy of all of these systems. These components cannot function individually even though they can be assessed individually, they must always be viewed as a whole. Therefore, according to this model the integration of all these processes in the unified hierarchical system, enables adaption to the environment through effective visual perception (Warren, 2013).

Receptive client factors of vision and oculomotor control are seen as foundational skills upon which visual information processing is dependent (Stewart, 2010). When deficits exist in these foundational skills, incorrect or inadequate information about the characteristics of objects and their relationship to each other in the environment is relayed to the central nerve system, where this information is processed. Efficient and coordinated oculomotor control movements need to be intact in order for adequate development of visual perceptual and visual motor integration skills.

The lowest level of visual-cognitive components represents visual attention, which is vital in the process of visual scanning, and it is the ability to concentrate on a visual stimulus. It can be observed by noting vigilance. It is the process of selecting a subset from all of the available visual information for further processing. The ability to attend to an object determines the amount and the accuracy of the visual information that will be gathered and processed. Poor visual attention means the visual search process will not be initiated and a great deal of visual information will be missed. When visual information is attended to in a random or unorganised way, the visual information that is gathered could be inaccurate (Warren, 2013).

The higher levels of the Hierarchical Model of Visual Perception include pattern recognition or the ability to observe all the noteworthy characteristics of an object. This is dependent on the ability to accurately identify all aspects of the visual stimuli. Visual memory is also included and refers to the process of encoding, storage and retrieval of visual information. It can be seen as the ability to revisualise and recall objects without visual cues. This process is dependent on the ability to identify patterns which form an image. Visual cognition is further enabled by visual memory since it is vital to have the ability to retain a visual image while it is being analysed. Visocognitive skills are an integral part of various activities of daily living which play a vital role in adaptation and skill development in childhood (Martin, 2006; Ho et al., 2015).

Criticism of the Hierarchical Model of Visual Perception is that it only includes vision during assessment, it does not take other senses into consideration. It is widely recognized that the process of analysing the environment occurs as a result of the integration of all the senses (Ayres, 1989; Zoltan, 1996). Therefore another theoretical approach has been proposed which includes a more holistic view of the individual (Schneck, 2010a). Authors like Harth (1976) have questioned the hierarchal simple systems theory underlying the hierarchal visual perceptual development and have argued a more dynamic approach where sensory input are processed on multiple levels at various times which suggests a more interlinked approach to visual perception.

2.4.2 The Dynamic Systems Theory Model of Visual Perception

The dynamic system theory has been widely used not only in occupational science and occupational therapy literature but a variety of social science fields of study (Aldrich, 2008). According to this approach processes or behaviour are viewed as non-linear, complex and inter-related with no predetermined order. A vital concept in dynamic systems theory is the existence of fractals which are subsystems with corresponding functions across different levels. This term was originally used in mathematics but is currently used in a variety of fields like art and law. Analytically fractals are usually indifferentiable and can be seen as having unfolding symmetry at different levels. These different fractals interact with one another across multiple points in time in a bi-directional manner. The concept is supported that a person creates new neurological pathways through what is learned from visual stimuli in the environment and conversely the person can influence the environment through the newly acquired knowledge. Systems which seems to cause small scale changes also have an influence on systems which appears to make larger scale changes and vice versa (Guastello and Liebovitch, 2009).

The profound complexities and unpredictable human behaviour are aimed to be organized through the use of the dynamic systems theory framework. All the known related variables are included in the dynamic systems theory but as a result of the extensive complexities, no accurate prediction can be made and therefore only widespread patterns can be generated (Aldrich, 2008; Thelen, 2005).

A dynamic systems model of visual perception was developed by Coté (2015). According to this model, visual perception is a complex system that has multiple levels of processing at various points in time. It is too complex to explain through the use of reductionistic reasoning. It is argued that reductionist reasoning cannot be applied in situations when clients scores are high in visual perceptual tests, but their academical performance and functioning in the classroom is poor. Another example where more complex reasoning is required is when a person has hampering visual receptive deficits, but they perform well in visual perceptual tasks (Coté, 2015).

This model moves away from organizing visual perception into sequential steps such as a visual stimulus is received by the visual organs and is then transferred to higher neurological systems that process the visual stimuli to make sense out of it. This model views visual perception as the interaction between environmental light signals, multiple neurological structures and the persons unique perceptions at various points in time (Gilbert and Li, 2013; Coté, 2015). It is further recognised that not all people register the same visual stimulation in their environment since where they direct their attention, previous experiences and the specific person's ability to organize themselves within a goal directed action. Coté (2015) uses the term external possibilities rather than visual stimulation in the environment to describe this phenomenon. According to this model there is no behaviour, neurological system or cognitive component that is irrelevant in the process of generating visual perception and therefore it is extremely difficult to predict an outcome.

Aspects of visual perception that are highlighted during assessment and treatment includes goals, attention and knowledge, retinal image, language and culture, motivation and emotions, tactile and proprioception, early visual processes as well as posture and movement. This model brings in all aspects affecting visual perception including movement and sensation.

Figure 2.2 is a visual representation of the model which was developed in an attempt to highlight some of the main, known processes involved in visual perception. Coté (2015) notes that a diagram is reductionistic but is of the opinion that some aspects of visual perception needs to be highlighted to improve understanding of the process.

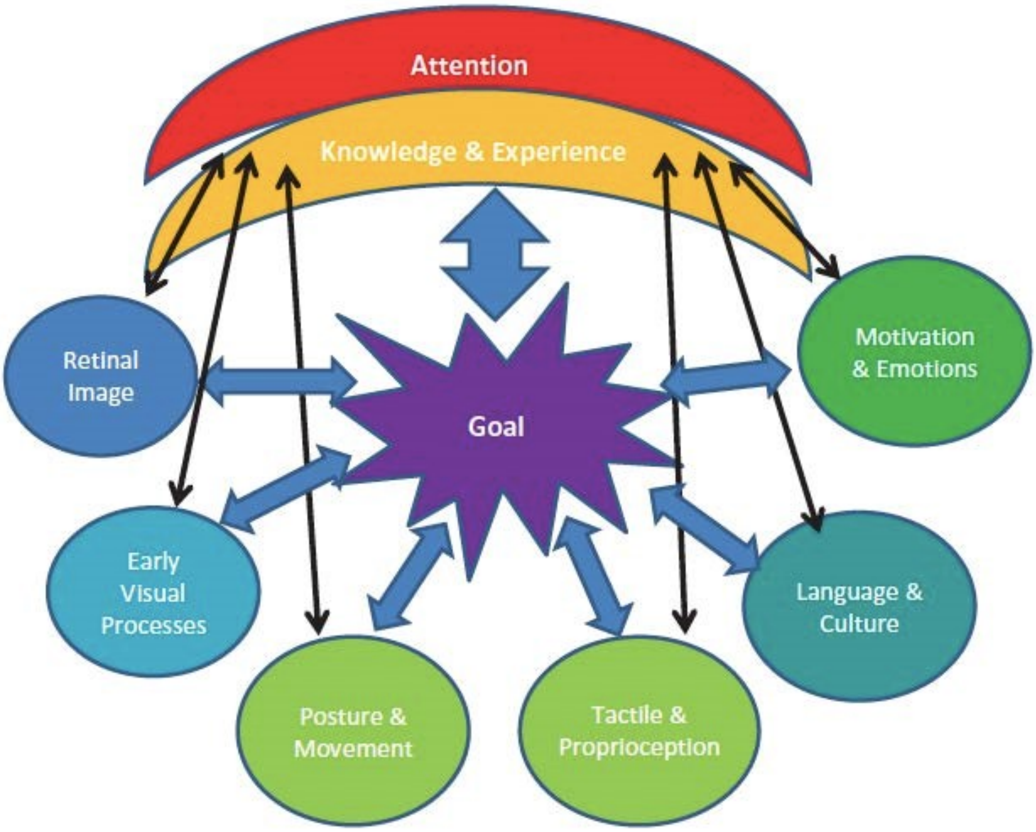

Figure 2.2 Proposed Dynamic Systems Theory Model for Visual Perception with multiple sensory and cognitive components. Arrows indicate the complex and interrelatedness of all known components involved the process of visual perception (Coté, C: A Dynamic Systems Theory Model of Visual Perceptual Development, Journal of Occupational Therapy, Schools, & Early Intervention 8(2), 157-169, 2015).

Firstly, the goal is the main focus of this model. It refers to a self-directed activity that has a purpose for the individual. Traditionally tasks that require visual perceptual skills have been divided into subsections such as figure-ground or visual closure. This model views those specific skills simply as those required for different types of meaningful tasks (Coté, 2015).

Attention and knowledge are seen as interconnected as attention ensures a focus of cognitive recourses to gain knowledge conversely knowledge leads to attention on specific actions. Retinal imagery is the next important factor. It is seen as complex and dynamic where it is viewed not only as a visual reception component or a response to light stimuli but includes the focus on relevant features. Currently it is unclear when external visual possibilities become a recognizable image (Coté, 2015).

The early visual process involves neurological structures and processes that are close to the retina and support the concept that visual perception is a multidirectional process where structures such as the lateral geniculate nucleus not only relays visual information but also interprets what is seen. Language and culture influence where visual attention is directed. This is especially important when young children learn through language where to direct their visual attention. Motivation and emotions impact learning and the goals that are selected which informs visual attention (Coté, 2015).

Touch, proprioception and vision are displayed as separate entities in the complex integrated system. Touch enables a sense of the spatial properties of objects which informs vision. The somatosensory cortex makes use of proprioceptive input from eye muscles to direct gaze (Harbourne et al., 2014). Posture and movement encompass body, neck, head and eye movements. These structures interact with one another in a complex, dynamic manner where adaptions need to be made constantly to the posture to ensure that gaze can be directed effectively. This model allows assessment of visual perception using actual tasks the child performs in their context which may be impacting a child's performance by observing their individualised solutions to tasks that require visual perceptual skills. In terms of assessment and intervention this model proposes that vision and oculomotor skills interact and both should be considered, incorporating as many components as possible, in therapeutic activities (Coté, 2015).

2.6 Assessment of visual perception, visual motor integration and oculomotor function.

2.6.1 Visual perception

There are a number of standardised tests which are used to assess visual perception that are used in occupational therapy. Research by Piernik-Yoder and Beck (2012) indicated that 54% of paediatric therapist and 43% of school-based therapists were using standardised tests of visual perception. The Developmental

Test of Visual Perception (DTVP) and the Test of Visual perceptual Skills (TVPS) were most commonly used. A survey of 123 South African paediatric occupational therapist reported that 52% use the TVPS-3 as an assessment tool (Janse van Rensburg et al., 2018).

In a recent review of the TVPS-3, the Motor Free Test of Visual Perception and the Developmental Test of Visual Perception by Wohlfert and Bosworth (2018) it was found that these tests were significantly correlated and it was concluded that these tests can be used interchangeably in practice. The TVPS -3 was used for this study as this is a motor reduced test and does not require written or drawn output.

2.6.1.1 Test of Visual Perceptual Skills 3th edition (TVPS)

In a recent South African study conducted in Gauteng with 92 children ages 6-9 year old, Harris (2017) found that the TVPS-3 was suitable to use with urban South African foundation phase learners. The results of the study further indicate that the TVPS-3 is effective in discriminating between children with and without a specific learning disorder. It was found that the test had poor sensitivity in this population due the heterogeneous nature of specific learning disorders since not all learners with these difficulties present with visual perceptual difficulties, but the reliability of the test was adequate. Visser et al. (2017) however found in a cross-sectional study that sixty-eight 5-year-old English speaking children residing in Bloemfontein scored lower in comparison to their American counterparts in all the subtest of the TVPS-3 except for visual memory. The authors cautioned against using only the TVPS-3 to determine visual perceptual skills of preschool learners in South Africa. Critiques have argued that the TVPS-3 is a two-dimensional test which provides multi-choice options which could result in a child randomly selecting the correct answer and lacks in problem solving skills. However some of the problem solving skills in other tests are not motor reduced and therefore cannot be included in the TVPS-3 (Gupta et al., 2019).

Since this current study included school aged children in an urban area, Gauteng in South Africa, the TVPS-3 was selected as the most appropriate test to use in this population to measure visual perceptual skills.

2.6.1.1.1. Validity

Content validity is built into the test though the specific items included that were included and layout requirements which was met. Criterion-related validity is when the test results are compared with other similar tests. The TVPS-3 was correlated with DT VMI-5 and found to be moderately strong scoring 0.67. Construct-validity were analysed when proof of correlation of the test with developmental milestones were found (Martin, 2006).

2.6.1.1.2 Reliability

Reliability is indicative of how consistently a test battery measures abilities such as visual perception. Internal consistency was determined though Cronbach’s coefficient alpha a well as split-half reliability coefficients. . Cronbach's alpha is used to measure how closely related a set of items are (De Vos et al., 2011). The coefficients alphas ranged from 0.75 to 0.88 for the subtests and 0.96 for the entire test. Spearman’s Brown coefficient ranged from 0.76 to 0.88 for the subtests and 0.96 for the entire test. Spearman's Brown coefficient is a measure of test reliability and it takes the split half correlation as input and converts it to an estimate of the full length test (De Vos et al., 2011). Test-retest procedure ranged from 0.34 to 0.81 for the subtests and 0.97 for the entire test. The inter-scorer reliability was reported as having a high level of reliability across of the subtests for all ages (Martin, 2006).

2.6.2 Visual Motor Integration

There are fewer standardized tests available to assess motor enhanced visual perceptual abilities. The test which is most commonly used by occupational therapists is the Beery-Buktenica Developmental Test of Visual-Motor Integration which is now in its 6^{th} edition (Piernik-Yoder and Beck, 2012). Another test which is also generally used is the Wide Range Assessment of Visual Motor Abilities (WRAVMA) (Adams and Sheslow, 1995). Normative data have been gathered on more than 2600 children. No studies on the suitability of using this test on the South African population could be found.

The DT-VMI 6 is widely considered to be the most researched and most valid test the measure motor enhanced visual perceptual abilities. (Coallier and Rouleau, 2014; Brown et al., 2007; Burtner et al., 2002). More than 13 000 children have been included in the development of the test since 1967 (Beery, 2010). A survey of 123 South African paediatric occupational therapist reported that 83,7% use the DTVMI 6 as an assessment tool (Janse van Rensburg et al., 2018). Therefore, the DTVMI 6 was chosen as the most suitable instrument to measure motor enhanced visual perceptual abilities of South African school aged children in this current study.

2.6.2.1 Beery-Buktenica: Developmental Test of Visual-Motor Integration - 6th Edition (DT-VMI 6)

In a recent South African study conducted in Gauteng with 92 children ages 6-9 year old, Harris (2017) found that the DT-VMI 6 was suitable to use with urban South African foundation phase learners. The results of the study further indicate that DTVMI 6 was effective in discriminating between children with and without a specific learning disorder. It was found that the test had poor sensitivity in this population due the heterogeneous nature of specific learning disorder since not all learners with these difficulties present with visual motor integration difficulties, but the reliability of the test was adequate. Visser et al. (2017) also concluded that the DT- VMI 6 was suitable to use in the South African population.

The test is standardized for individuals between the ages of 2-100 years. It has been found that the test is essentially culture-free since it uses geometrical forms to test visual motor integration and visual perceptual abilities instead of letters or numeric forms (Beery, 2010).

2.6.2.1.1 Validity

The VMI Beery measures very high in terms of validity, between 0.80 and 0.95. Content validity determines whether the test in measuring the abilities it was designed to measure. The content validity of the VMI Beery as well as its supplementary tests have been measured through the use of the Rasch-Wright and other item analysis methods. It was found to be strongly supported (Beery, 2010).

Concurrent validity is when the results of a test is measured with other similar tests. The VMI Beery was correlated with the copying subtest of the Developmental Test of Visual Perception (DTVP-2) and the drawing subtest of the Wide Range

Assessment of Visual Motor Abilities (WRAVMA). Correlation was moderately high obtaining a 52 raw score correlation for in the WRAVMA and a 75 raw score correlation for the DTVP-2 (Beery, 2010). The Beery VMI supplementary test were further correlated with the Position in space and Eye-hand Coordination subtests of the DTVP-2. Correlation was moderately high obtaining a raw score correlation of 62 for the visual perception supplementary test and 65 for the motor coordination supplementary test (Beery, 2010).

In terms of predictive validity letter identification and reading readiness were related to the VMI Beery and supplementary scores. A moderate correlation was found between VMI and letter identification (.52) and reading readiness (.57) (Snow, 1998).

2.6.2.1.2 Reliability

Content sampling was evaluated through Rash-Wright analysis. High content reliability was found. The Person reliability with the overall group item separation was 1.00 and the overall group person separation was 0.96. Internal consistency was done by using Spearman-Brown correlation and by analysing the relationship between the odd and even items for 750 children. A mean score of odd-even split half coefficient with regards to age groups were 0.95. The odd -even split half correlation for one-year age groups were 0.88. The Cronbach's Alpha was found to be 0.96. Test-retest coefficient (0.88) and the inter-score reliability (0.93). Reliability coefficients and standard error of measurement were reported as sufficient for use as a screening tool. The interscorer reliability were found to be 0.93 for the VMI Beery test, 0.98 for the visual perceptual supplementary test and 0.94 for the motor coordination supplementary test (Beery, 2010).

2.6.3 Oculomotor function

Oculomotor function can be assessed in occupational therapy using both standardized tests and observation (Schneck, 2010b). Standardized assessments which are commonly used to assess oculomotor functioning are the Developmental Eye Movement Test (Richman, 2009) and the King-Dervick (K-D) test (Lieberman et al., 1983). It has been found that these tests measure similar constructs and can be used interchangeably (Portnoy and Gilaie-Dotan, 2020). Most of the research on the King-Dervick test has focussed on its effectiveness to screen for concussions whereas the Developmental Eye Movement Test has mainly focussed on determining oculomotor functioning of children (Heick et al., 2018). It was therefore decided to use the DEM as a standardized assessment during this study.

Observational instruments has been found to be valuable in determining oculomotor control (Schneck, 2010b) and therefore it was decided that both these assessment methods will be used during this study. The Ayres Clinical Observations is an assessment tool which it widely used by South African paediatric occupational therapist. In a recent study by Janse van Rensburg et al. (2018), it was reported that 98,35% of 123 South African paediatric occupational therapists use it during assessments. The Eye Movement subsection of the Ayres Clinical Observations will form part of the assessment of oculomotor control in the current study.

2.6.3.1 Developmental Eye Movement Test

The Developmental Eye Movement Test (Richman, 2009) is a standardized test which measures saccadic eye movements. The test battery consists of a pre-test where it is determined whether learners can read numbers correctly to ensure that numeric abilities are not hindering the measurement of saccadic eye movement abilities. The test consists of a series of numbers which must be read either vertically or horizontally depending on the specific subtest.

During subtest A and B learners has to read numbers in a vertical direction. This test assesses faster vertical saccades and Rapid Automized Naming (RAN) to determine the speed at which a learner can read and phonologically name numbers. It is suggested that slow naming is a reflection of reflect a dysfunction in sustained attention, visuospatial attention, and basic phonological difficulties which indicate problems in reading, especially word recognition (Van der Strappen and Van Reybroeek, 2018) and could be diagnostic for dyslexia (Biscaldi et al., 1998; Lawton and Shelley-Tremblay, 2017). Learners with these deficits often follow the text to be read with their finger (Drieghe et al., 2004).   During subtest C numbers are read in a horizontal direction. This subtest is effective in testing slower horizontal saccadic oculomotor abilities (Heick et al., 2018; Facchin et al., 2011). There is further a high quantity of numbers which is effective in measuring sustained oculomotor performance. After completion of subtest A, B and C the DEM ratio is determined by comparing the time difference between the vertical (subtest A and B) tests with the horizontal (subtest C) test. The core oculomotor function can be isolated by comparing these tests. Abnormally increased scores for horizontal test with normal scores for the vertical test and ratio indicate ocular movement dysfunction while abnormally high scores for horizontal and vertical test with normal scores for the ratio indicate RAN dysfunction. Abnormally increased scores for all values indicate difficulties in RAN and oculomotor dysfunction (Facchin et al., 2011; Reichle et al., 2009). The errors made during the horizontal subtest (C) is also taken into account when the scoring is done. Researchers have proposed three possible explanations for an increase in the amount of errors made, namely the effects of oculomotor dysfunction in terms of overshooting, causing the eyes to land further than the designated target; undershooting resulting in smaller corrective saccades; or frequent loss of place causing a rereading of a number or a different line of numbers (Vitu and McConkie, 2000; Rayner, 2009).

The main aim of the test is to determine whether a school-aged child has reading difficulties. The test is standardised for children between the ages of 6-13 years (Richman, 2009). The use of the DEM has only been reported in one other South African study (Bense, 2016) and no reliability or validity studies for South African children have been reported.

The validity of the DEM has been brought into question by numerous scholars (Webber et al., 2011; Moiroud et al., 2018; Facchin and Maffioletti, 2018; Medland et al., 2010). Many studies have investigated whether this test is accurate in measuring oculomotor functioning (Ayton et al., 2009; Orlansky et al., 2011). Some studies have concluded that the DEM does not correlate well with eye movement parameters (Orlansky et al., 2011) but a relationship between DEM scores and reading abilities was however found (Ayton et al., 2009; Powers et al., 2008; Palomo-Álvarez and Puell, 2009).

Other studies concluded that the DEM scores are accurate in determining oculomotor functioning (Facchin and Maffioletti, 2018; Garzia et al., 1990; Richman, 2009; Tassinari and Deland, 2005). It was found that many factors could influence test results of the DEM such as attention span, numerical abilities, visual perceptual skills and time it takes to verbalize numbers which could be mistaken for RAN and oculomotor difficulties (Facchin et al., 2011). Despite some limitations, the DEM is an accurate indicator of oculomotor functioning in a clinical setting. Moiroud et al. (2018) also found that the DEM was accurate in identifying learners with dyslexia. Normative values are available in 8 different languages and this test is used around the globe (Facchin and Maffioletti, 2018).

The authors of the DEM has noted that children with a specific learning disorder score lower in all the subtests indicating that they struggle with oculomotor control (Richman, 2009). This needs to be kept in mind when the results of the study are analysed.

2.6.3.1.1 Validity

Internal consistency has been done through correlation coefficients of all the components of the DEM test. A raw score and chronological age measure have been done. Regular improvements in raw scores were detected when chronological age increased. The DEM has been compared to the reading subtest of the Wide Range Achievement Test. The results indicated moderate to high negative correlation with all the subtest of the DEM at $p < 0.001$. (Richman, 2009).

2.6.3.1.2 Reliability

Internal consistency in terms of the test-retest procedure was done on two separate occasions at the same time of day, one week apart. The results of both tests yielded a $p < 0.001$, which indicates no significant difference. In terms of inter-examiner method where two different administrator, administer the same test to the same person also yielded a $p < 0.001$, which indicates no significant difference (Richman, 2009).

2.6.3.2 Eye movement subsection of the Ayers Clinical Observations

The Ayers Clinical Observations are based on the work of Dr J Ayres (SAISI, 2005). The Eye Movement subsection of the Ayers Clinical Observations can be used as a screening tool to observe the oculomotor movement ability of the child to establish and maintain visual contact with a target by assessing a child's ability to track a moving object, their convergence, fixation.

2.6.3.2.1 Validity and reliability

The test is an observational test where a standard score is given according to specific criteria (SAISI, 2005). No reliability or validity data are available for this test which is not standardised.

2.7 Specific learning disorders

In the DSM-5 specific learning disorders are categorized under neurodevelopmental disorders which is the umbrella term for several disorders (American Psychiatric Association, 2013). These disorders share impairments in numerous developmental areas such as personal, social, academical and occupational functioning. It is also noted that these disorders frequently co-occur. Subcategories includes Autism Spectrum Disorder, Motor Disorders, Communication Disorders, Intellectual Disabilities, Attention-Deficit Hyperactive Disorder, Specific Learning Disorders and Other Neurodevelopmental Disorders.

There are three main types of specific learning disorders. Dyslexia mainly affects reading abilities and difficulties which are evident is decoding, comprehension and fluency of reading. Difficulties with spelling and speech are at times also observed. Dysgraphia is mainly difficulties with written expression and can be observed in poor written responses, organizing, sequencing ideas, poor grammar and handwriting. Dyscalculia mainly affects mathematical skills and can be noted in poor number sense, decreased ability to estimate quantities, money, time concepts, recall of numerical facts and solving mathematical problems. Difficulties in more than one types mentioned above is common (American Psychiatric Association, 2013). See diagnostic criteria under 3.4 in chapter 3.

Children with a specific learning disorder have frequently been characterized as having a short attention span. This could have an influence on learning, particularly writing and copying skills (Joseph and Konrad, 2009). It is estimated that one-third of people with specific learning disorder are estimated to have attention-deficit hyperactive disorder (Backer and Neuhäuser, 2003; American Psychiatric Association, 2013). Children with a specific learning difficulty, often display difficulties in working memory, executive functioning, processing speed and phonological awareness (Facchin and Maffioletti, 2018). These symptoms can negatively influence the scoring of standardized testing.

Other mental disorders such as anxiety disorder, depressive and bipolar disorders has also been linked to specific learning disorders (American Psychiatric Association, 2013). In a study by Altay and Grörker (2018) it was found that out of 80 participants, diagnosed with a specific learning disorder, there was a comorbidity rate of 92,5%. Of these participants 82,3% were also diagnosed with ADHD, 46,3% with a specific phobia, 26,3% with oppositional defiant disorder, 25% with enuresis and 22,5% with tic disorders. These children were assessed in a Child and Adolescent Psychiatric facility in Turkey and could have a higher number of mental disorders compared to other settings. It is however important to take note of the high probability that a comorbid condition is likely to exist with a specific learning disorder. This could have a negative influence on the learners test scores. A strong link between attention deficit hyperactive disorder and a specific learning disorder has been found (Koolwijk et al., 2014; Pliszka, 2014; DuPaul et al., 2013) and these learners score lower in standardized assessments due to their difficulties in attention span.

Children with a specific learning disorder have often scored poorly in visual perceptual (Gajre et al., 2015; Rourke, 2005) and visual motor integration tests. It has been noted by the author of the TVPS-3, Martin (2006), that participants with a specific learning disorders make more mistakes and takes longer to complete the test. In the administration manual of the test, a study by Hung et al. (1987) was specifically mentioned where young men with learning difficulties scored significantly lower in all the subsections of the test. These learners have also been found to have poor oculomotor control (Hopkins et al., 2019; Hopkins et al., 2017; Raghuram et al., 2018).

The best treatment for this lifelong condition is an individualized educational program and therapy such as occupational or speech therapy (DuPaul et al., 2013;

Lovett and Sparks, 2013) and medication has not been found effective in treating specific learning disorders.

2.8 Summary

This chapter discussed the current research available in occupational therapy as well as related literature regarding visual processing including visual perceptual, visual motor integration skills and oculomotor control. The visual system is regarded as a dominant system in enabling goal-directed actions since visual perception closely linked to motor behaviours. Literature divides the process of gathering and analysing visual information into two processes namely visual reception, visual and cognitive processing.

Oculomotor control is seen as the process of visual reception which has many subcomponents including acuity, accommodation, binocular fusion, stereopsis, convergence and divergence as well as visual fields. Oculomotor movements can be described as motor activity in the eyes when gathering visual information from the environment while visual cognition is the process through which visual information is organised, structured, interpreted and given meaning (Stewart, 2010; Scheiman, 2011). When considering visual reception, the role of the occupational therapist is to screen for impairments and work in conjunction with developmental optometrists to improve oculomotor functioning. This must then be taken into consideration while compiling a therapy program (Scheiman, 2011).

Visual cognitive processing can be divided into two main subsections namely motor reduced and motor-enhanced. Motor reduced visual perception is the process of effectively using visual information from the environment by analysing patterns of light that fall onto the retina and assimilating it into images while motor enhanced including visual motor integration can be seen as “the degree to which a visual perception and finger-hand movements are well coordinated”.

Two models are commonly used in occupational therapy when viewing visual perception. Firstly, The Hierarchical Model of Visual Perception which was developed by Warren in 1993 presents a hierarchy for visual-perceptual skill development in the central nervous system. Secondly, in a dynamic systems model developed by Coté (2015) visual perception is seen as a complex system that has multiple levels of processing at various points in time.

Assessment of visual processing including visual perceptual, visual motor integration skills and oculomotor control includes the use of standardised and nonstandardised tests. The TVPS-3, DT-VMI 6, DEM and The Eye Movement subtest of the Ayres Clinical Observations. These tests were reviewed in terms of validity and reliability. Lastly specific learning disorders were discussed and the three main types were highlighted. The link between different types of neurodevelopmental disorders were examined.

CHAPTER 3: METHODOLOGY

3.1 Introduction

This chapter aims to describe the methodology that was followed during this study. It firstly describes the type of study, the research site and participants, the instrumentation and outcome measures, the research procedure, data analysis and lastly the ethical considerations are discussed.

3.2 Research design

This research design used for this study was a quantitative, non-experimental, cross sectional descriptive correlation study design. According to Kielhofner (2006) correlation research is used when the association between variables are investigated. It is often described as an exploratory study. The variables that was investigated in this study were visual perception, visual motor integration and oculomotor control.

The advantages of descriptive correlation studies are that research is fast, easy and affordable. The exact strength in the relationship between all the variables can be determined. The results of a correlation study are easy to classify through the information gathered from the correlation coefficient (Gaulle, 2020).

The disadvantages of this research design are that even if a relationship is found between variables the relationship found cannot not be assumed to be causal. A correlation between variables does not amount to causation or determine which variable had the most impact. (Gaulle, 2020).

3.3 Research Site

The data collection of the research took place at School of Achievement in Germiston, Ekurhuleni. This school has a primary and secondary school on the same grounds. In the foundation phase, classes consist of 10-16 learners. Since this is a LSEN school, learners receive additional support by receiving therapy during school hours. At the time of the research there were five counsellors, nine speech therapists and nine occupational therapists. Learners receive speech and occupational therapy at least twice a week in groups of three to four learners and regular class interventions. Learners receive counselling as needed. A multidisciplinary approach is followed and there is regular contact with learners' caregivers. Learners with a specific learning disorder are frequently identified with visual perceptual and visual motor integration difficulties (Handler and Fierson, 2011; Cain et al., 2004) and therefore this is a suitable research site for this study.

3.4 Population and sample

The Gauteng Department of Education in South Africa use the DSM-5 criteria to guide placement of learners in a LSEN school to provide specialized support for remediation (Department of Basic Education, 2014). The learners need to meet the following criteria A-D (American Psychiatric Association, 2013). According to criterion A learners needs to show persistent challenges for more than 6 months in one of the following learning areas namely reading accuracy or fluency; spelling accuracy; written expression, competence or fluency; and numerical skills despite targeted evidence-based intervention. The next criteria, section B, relates to standardized testing results that needs to be significantly below chronological age expectation. The next criteria, section C, states that evidence of poor academical performance must be prevalent during early schooling-years however it can be diagnosed later in life. The diagnosis can only be made in the absence of intellectual disability, undiagnosed visual or auditory impairment, a mental health disorder and if absenteeism did not influence poor performance in schooling according to section D. All the learners at the research site, School of Achievement, needs to adhere to the above-mentioned criteria to be placed in the school.

At School of Achievement the foundation phase learners all receive occupational therapy and learners in grade 1 and 3 are routinely assessed once a year. Learners in grade 2 are not assessed using the Test of Visual Perceptual Skills 3th edition (TVPS-3) and the Beery-Buktenica Developmental Test of Visual-Motor Integration – 6th Edition (DT-VMI 6), since more time during this year of schooling is spent on therapeutic intervention rather than standardized assessment. These learners do however receive progress reports twice a year. At the time of the research there were 55 learners in grade 3, 49 learners in grade 2 and 34 learners in grade 1.

3.4.1 Sample Selection

Convenient sampling was used to select participants for this study. Convenience sampling method uses participants that are available to the researcher (Kielhofner, 2006). A person who is in the researcher's current environment and who is related to the topic, can be included in the study until the desired amount of data has been collected (De Vos et al., 2011). The researcher is currently working at School of Achievement and therefore these learners were in researcher's direct environment.

Inclusion Criteria

- Learners in a LSEN school, School of Achievement.
- Learners in the foundational phase (grade 1-3).

Exclusion Criteria

- Learners who were assessed less than 6 months ago with the standardized tests used in this study which are the TVPS 3 and DT-VMI 6 since it is stated in both manuals of these standardised assessments that an assessment may only be conducted every 6 months (Martin, 2006; Beery, 2010).
- Learners who have a pre-existing visual impairment that cannot be treated with glasses.

3.4.2 Sample size

At the time of the study 138 learners attended the foundation phase at School of Achievement. Parents/legal guardians of all the learners in the foundation phase, who met the inclusion criteria, were given an information letter and asked to give informed consent for their child to be included in the study. According to Cochranes's formula, based on categorical data, to achieve a 5% margin of error that the true mean of the population is the mean calculated from the sample, a sample of 65 participants is required (Barlett et al., 2001).

3.5 Instrumentation and Outcome Measures

3.5.1 Demographic Questionnaire (Appendix A and B)

A demographic questionnaire was designed by the researcher. It contained personal information such as medical history to ensure the child fits the inclusion and exclusion criteria of the study; whether they repeated any grades, if they had an eye examination by an optometrist, if they need glasses, whether they were using medication to improve concentration and the amount of years each participant has received occupational therapy.

3.5.2. Test of Visual Perceptual Skills 3th edition (TVPS) (Appendix C)

The TVPS-3 is a standardized assessment that measures visual perceptual abilities in order to determine visual perceptual strengths and weaknesses. This test battery consists of 112 black and white geometrical forms and it is divided into seven subtests: Visual discrimination, visual memory, spatial relations, form constancy, sequential memory, figure ground and visual closure. Visual perceptual abilities enable people to process, understand and act upon visual information in their environment. Geometric shapes are used to determine visual perceptual abilities in all of the subtests. The test is presented in a multi-choice format. Depending on the subtest, 4 or 5 options are given from which the learner must choose the correct option by either pointing it out with their finger or naming the number underneath the shape. Each subtest consists of 16 items. The test battery is administered individually and takes approximately 30 minutes to finish depending on the working speed of the learner (Martin, 2006).

Scoring

One point is awarded for each correctly indicated item up until three consecutive mistakes were made. The administration manual as well as the scoring sheet indicates which item is the correct one and how the administrator can mark items indicated on the score sheet. All points awarded before the three consecutive mistakes are added to compose a raw score. Age equivalents and standardized norms are listed in the manual and raw scores can be converted to scaled scores, standard scores, percentiles and T-scores after completion.

3.5.3 Beery-Buktenica: Developmental Test of Visual-Motor Integration - 6th Edition (DT-VMI 6) (Appendix D)

The DT-VMI 6 is a standardized assessment that measures the extent to which a person is able to integrate visual and motor abilities (Beery, 2010). This test battery consists of the visual motor integration test as well as its two supplemental tests namely the visual perception and the motor coordination subtest. The test is a standardized assessment that quantifies visual motor integration abilities. A sequence of geometric forms is presented that must be imitated or copied. The visual motor integration and the motor coordination tests are motor enhanced. The test takes approximately 25 minutes to administer. This test can be administered in groups or on an individual basis (Beery, 2010). For the purpose of this study the test was administered on an individual basis with all the participants. The valid order of administration according to the test manual was used during this study namely firstly the visual motor integration test, then the visual perceptual supplementary test and lastly the motor coordination supplementary test.

Scoring

During the administration of the VMI Beery one point is awarded for each correctly imitated or copied item up until three consecutive mistakes were made. The administration manual provides a clear criterion on what constitutes a correct point and how exactly the administrator should mark the test after completion.

All points awarded before the three consecutive mistakes are added to compose a raw score. The age equivalents and standardized norms are listed in the manual and raw scores can be converted to scaled scores, standard scores, percentiles and T-scores after completion.

3.5.4 Developmental Eye Movement Test DEM (Appendix E)

The test battery consists of a pre-test where it is determined whether learners can read numbers correctly to ensure that numeric abilities are not hindering the measurement of saccadic eye movement. During subtest A and B, learners has to read numbers in a vertical direction. This test mainly serves to determine the speed of vertical saccades and the speed at which a learner can read and phonologically name numbers by assessing RAN. It is suggested that slow naming is a reflection of basic phonological difficulty. Phonological abilities are important in reading, especially word recognition. During subtest C numbers are read in a horizontal direction and test the speed of horizontal saccades. This subtest is effective in testing oculomotor abilities. There is further a high quantity of numbers which is effective in measuring sustained oculomotor performance.

Scoring

The total time in seconds of subtest A and B are added to determine the vertical time score. The horizontal time score is determined through the use of a formula: Test C time x [80/ (80 - omissions + additions]. Errors frequently occur during this test and is also indicated on the score sheet. Errors includes addition, transposition, omission and substitution. Addition is when an extra number has been read which is not indicated on the test. Transpositions are when a number had been read out of sequence. Omission is when a number indicated on the test is not read by the learner. Substitution is when an incorrect number is read instead of the indicated number.

The DEM ratio is determined by dividing the vertical time score with the horizontal time score. All the errors are added to determine the total errors. Age equivalents and standardized norms are listed in the manual. However, a computer program is used to convert raw scores to standard scores, percentiles and Z-scores after completion. The core oculomotor function can be isolated by comparing these tests. The results indicate four different oculomotor functioning. Firstly, a normal oculomotor function where all the scores were within the normal range. Secondly an oculomotor dysfunction which is characterized by an abnormal increase in time of the horizontal section and an average performance in the vertical section. Thirdly it is the inadequately developed automaticity and fluence where learners perform poorly in the vertical section and average in the horizontal section. Lastly it is the mixed type which indicates dysfunction in both the vertical and horizontal sections. The main aim of the test is to determine whether a school-aged child has reading difficulties as a result of phonological or oculomotor difficulties or both (Richman, 2009).

3.3.5 Eye movement subsection of the Ayers Clinical Observations (Appendix F)

The Ayers Clinical Observations are based on the work of Dr J Ayres (SAISI, 2005). The eye movement section of the Ayers Clinical Observations determines the ability of the child to establish and maintain visual contact with a target. It can be used as a screening tool to observe a child's ability to track a moving object and scores for general pursuit, across midline, convergence, quick localization, peripheral fields are recorded.

It takes approximately 3-5 minutes to administer and must be administered individually. A pencil with a rubber or pencil puppet can be used to complete these observations. These clinical observations must be used in conjunction with background information, medical history and other standardized assessment tests. It is only a screening tool to determine whether further investigation is warranted (SAISI, 2005).

Scoring

The scoring of this observational instrument is indicated in the administration manual. The administrator can score a three, which is normal eye movements; a two when the child finds the eye movements slightly difficult; or a one when eye movements are definitely difficult for the child (SAISI, 2005).

3.6 Research Procedure

Once ethical clearance was obtained for the study (Section 3.8, Appendix G) the Gauteng Department of Education was approached, and permission was obtained to conduct the research at School of Achievement (Appendix H). Permission from the headmaster (Appendix I) and the head of the Occupational Therapy Department at School of Achievement (Appendix J) was also obtained to conduct the study at School of Achievement.

Parents/legal guardians of learners who met the inclusion criteria of the study were invited to allow their child to participate in the study. . Information sheets (Appendix K and L), demographic questionnaires (Appendix A and B) and consent forms (Appendix M and N) were sent to these caregivers in either English or Afrikaans (the two languages of instruction used at the school). The learners whose parents/legal guardians gave signed consent for their child to participate in the study, were asked to give witnessed verbal assent on the day testing took place. This was done since all the participants were 12 years and younger at the time of data collection (Appendix O Appendix P). The language in which the child was schooled in and competent to understand what they were consenting to, was used as medium to obtain permission.

The occupational therapists working at School of Achievement were informed about the purpose of the study and they were given the opportunity to assist with data collection. They all agreed to assist with data collection. These therapists routinely assess learner's in grade 1 and grade 3's visual perception skills with TVPS-3 and DT-VMI 6. The results of these standardized assessments formed part of the data collection for this study.

Before the data collection took place all the occupational therapists received an inservice training on the correct, standardized administration of the TVPS-3, the DTVMI 6 and the Eye Movement subsection of the Ayers Clinical Observations. The occupational therapists also received an in-depth training on the administration of the Developmental Eye Movement Test. None of the occupational therapists were familiar with this test so demonstrations of administration were given by the researcher. Although all the standardised assessments have acceptable interrater reliability, to ensure the reliability of the tests scores the researcher made use of randomized checking. Every tenth score sheet for all standardised tests was checked by the researcher to ensure that it was scored correctly.

Each occupational therapist received a list of the learners who they assess and treat, whose parents/legal guardians had given consent for their participation in the study. It was stressed that this list was confidential and only the researcher as well as the assessing occupational therapist had access to the names of the learners who were included in the study.

All the assessments were done in one session and were administered by the learner's treating occupational therapist with whom the learner was familiar. The tests were recorded on a coded score sheet to ensure anonymity of the participant.

After completion of the full assessment, the occupational therapist notified the researcher and handed over the coded score sheet once it had been scored. All of the coded score sheets were kept at a secure location by the researcher.

Grade 2 learners were also included in the study even though they are not routinely assessed by an occupational therapist at the school. The researcher administered all of the tests to the Grade 2 learners in one assessment session. The results were also recorded on a coded score sheet and confidentiality of the participant was ensured throughout the whole process.

Tests were administered in the same order by all therapists. Firstly, the TVPS-3 was administered, then the DT-VMI 6, then the Eye Movement subsection of the Ayres Clinical Observations and lastly the DEM was administered. It was decided to start with the test which takes the longest to administer first, the TVPS-3, to ensure that the test can be completely finished without a possible interruption of the school bell ringing to indicate that the period has ended. Then the test which takes the second longest was administered, the DT-VMI 6. The Eye Movement Subsection of the Ayres Clinical Observations was administered thirdly to give learners a break before the last paper-based assessment, the DEM. The times that the school bell rings were closely monitored by the administrators and learners were reassured before the assessment started, that their teachers gave permission for them to finish their work with the therapists before that they needed to return to class. This was done since the researcher, in consultation with the other therapists working at the school, observed in previous assessments that some learners become anxious when the school bell rings during a standardized assessment. These learners then verbalize that their teacher expects them back at class and they start to rush through the rest of the assessment to get back to class. There are also many distracting sounds in the corridor of the school after the bell rings, which could have a negative impact on the learner’s concentration. Learners were not allowed a break unless it was to go to the bathroom. The average time of administration was approximately 50 minutes, but this depended on the work speed of the learner.

It has been found that standardised tests which are administered in comfortable, familiar, nonthreatening environments are in the best interest of the child (Council, 2001). Especially younger children find it more difficult to build rapport with the examiner. Self-regulation skills are often not fully developed. All the tests were administered in a familiar, nonthreatening environment. The learners were further familiar with the examinee. Illness, fatigue or anxiety could have a negative influence on test scores (Richardson, 2014). This was prevented by consulting with the teacher on whether the learner was healthy and if accurate results could possibly be yielded if testing took place on the specific date.

3.7. Data Analysis

Demographic data is interval and ordinal data; therefore, the method of data analysis was through descriptive statistics including frequencies and percentages. The learner's visual perceptual skills were determined through the TVPS-3. Their visual motor integration skills were determined by the DT-VMI 6 and the oculomotor functioning by using the DEM. The raw scores of all of these standardized tests were converted to scaled scores, standard scores, and z-scores. Analysis of this data on subtests, composite subsections and total scores was done through medians and quartile ranges as well as means and standard deviation as not all the data were normally distributed. Statistica v 13.5 (TIBECO, 2020) was used during the data analysis. The Eye Movement subsection of Ayers Clinical Observations was also used to determine oculomotor functioning. The raw scores of this observational test was analysed by the use of ordinal median and quartile ranges.

Correlations between the subtests and composite standard scores of the TVPS 3, DT-VMI 6 and the DEM were determined. This interval data was analysed through the use of Pearson's correlation coefficient. Correlations between the composite scores as well as each subsection of the TVPS-3, DT-VMI 6 and the Eye Movement subsection of Ayers Clinical Observations were determined. This ordinal data was analysed through Spearman's non- parametric correlation coefficient.

3.8. Ethical Considerations

Ethical clearance for the study was obtained from the Human Research Ethics Committee and the University of the Witwatersrand (M180972) (Appendix G) and permission was obtained from the Gauteng Department of Education (Appendix H)..

Permission from the headmaster (Appendix I) and the head of the Occupational Therapy Department at School of Achievement (Appendix J) was also obtained to conduct the study at School of Achievement.

Children are considered a vulnerable population. Signed informed consent was obtained from the parents/legal guardians of the learners who participated in the study (Appendix M and N). Assent was obtained from the learner before the assessment took place (Appendix O and P). The proceedings of the research study were explained in detail to all participants through the use of a participant information sheet (Appendix K and L).. All consent documents were made available in the two languages schooling takes place in at School of Achievement, namely English and Afrikaans. This was done to ensure that potential study participants had a clear understanding of what participation in the study required of them. The learners and their parents/legal guardians were notified that participation is voluntary and that they could have refused to participate or could have withdrawn their participation at any stage of the research process without any consequence or effect on therapy received by the child. Each individual learner's standardized scores were given to their caregivers through either a full assessment report or a progress report. Each individual learner's standardized scores were given to their caregivers through either a full assessment report or a progress report. Assessment reports or progress reports are sent to parents every 6 months. The results of the current studies standardized assessment was used by each learner’s occupational therapist to guide or adjust their treatment program in order to address each learner's specific deficits. The results of the study were available for the caregivers on request. Learners were treated with respect by all professionals involved during the research process. All data sheets were codes and identifying information was kept separate in a secure location by the researcher to ensure confidentiality.

CHAPTER 4: RESULTS

4.1 Introduction

This chapter aims to report on the data that was gathered during the research project. A hundred participants were recruited and assessed in the study. The data on the results for the participants demographics as well as their visual perceptual, visual motor integration and oculomotor skills is reported. Lastly the relationship between visual perceptual skills, visual motor integration skills as well as oculomotor skills is reported.

4.2 Demographics of the participants

4.2.1 Personal and educational demographics

The sample size of the group were 100 learners who, at the time of the study, attended a LSEN school in the Ekurhuleni district of Gauteng. The learners ageranged between 6 years and 11 years, 11 months. There were 77 males and 23 females who participated in the study.

English was the main language of schooling for 59 of the participants while 41 were predominantly schooled in Afrikaans. All the learners were in the foundation phase with 23 being in grade 1, 37 in grade 2 and 40 in grade 3. At the time of the study 50 of the participants repeated a grade, while 50 of the learners has not repeated a grade (Table 4.1).

Table 4.1: Personal demographics of participants (n=100).

	Total group (N=100)	**Percentage**
Age		
6 years, 11 months	2	2%
7 years, 11 months	11	11%
8 years, 11 months	33	33%
9 years, 11 months	35	35%
10 years, 11 months	16	16%
11 years, 11 months	3	3%
Gender		
Male	77	77%
Female	23	23%
Language		
Afrikaans	41	41%
English	59	59%
Current grade		
1	23	23%
2	37	37%
3	40	40%
Repeated a grade		
Yes	50	50%
No	50	50%

4.2.2 Medical demographics

At the time of the study, 75 participants were using medication while 25 participants did not use medication. Most of the learners, 74, has received an assessment by an optometrist while 26 of the learners did not received an assessment by an optometrist. There were 25 learners who wore glasses and 75 learners who did not wear glasses. (Table 4.2).

Table 4.2: Medical demographics of participants (n=100).

	Total group (N=100)	**Percentage**
Received an assessment from an optometrist	74	74%
Wears glasses		
Yes	25	25%
No	75	75%
Using medication		
Yes	75	75%
No	25	25%

Table 4.3: Specific information on the medication that participant was taking (n=75).

	Total group (N=75)	Percentage
Specific medication		
Medication to improve concentration: Ritalin, Methylphenidate, Concerta, Neucon, Contramyl, Strattera	58	77,33%
Mediation to stabilize mood: Risperdal, Risperdone, Zoxadon	1	1,33%
Combination of medication: Mediation to improve concentration (Ritalin, Methylphenidate, Concerta, Neucon, Contramyl, Strattera) as well as mood stabilizers (Risperdal, Risperdone, Zoxadon)	16	21,33%

Medication to improve concentration were taken by 58 participants at the time of the study. Medication to stabilize mood and improve concentration were taken by 16 of the participants at the time of the study. Medication only used to stabilize mood was taken by 1 participant (Table 4.3).

4.3 Visual perceptual, visual motor integration skills and oculomotor control.

4.3.1 Visual perceptual skills

Visual perceptual abilities were measured by administration of the TVPS-3. This test battery consists of seven sub-tests: Visual discrimination, visual memory, spatial relations, form constancy, sequential memory, figure ground and visual closure as well as three composite subsection scores – basic, sequencing and complex processes. A total score is also calculated (Table 4.4).

Table 4.4: Standard scores for the Test of Visual Perceptual Skills – 3rd edition of participants (n=100)

Standard score of TVPS-3 subtest (n=100)	**Mean**	**Standard deviation**	**Median**	**Lower quartile**	**Upper quartile**
Visual discrimination	83.20	15.99	80.00	70	90
Visual memory	85.35	17.78	90.00	72,5	100
Spatial relations	93.90	21.60	92.50	77,5	105
Form constancy	81.92	16.58	80.00	70	90
Visual sequential memory	85.35	18.30	85.00	70	100
Figure ground	87.30	18.85	85.00	75	100
Visual closure	83.00	18.49	80.00	70	95
Subsection of TVPS-3 scores (n=100)					
Basic scaled score	86.14	13.48	85.50	77	94
Sequence standard score	85.25	18.54	85.00	70	100
Complex standard score	85.35	16.56	83.00	74	95
Sum of scaled scores	85.69	12.80	85.00	76,5	94

Mean & median < 85 indicating a deficit of one standard deviation below the mean

The scores obtained by the participants were not normally distributed and thus the mean and median as well as measures of variance are presented. The sections which had a mean and median score below 85 indicating a deficit of one standard deviation below the mean were visual discrimination, form constancy and visual closure. The z scores for the composite subsection scores and the total score were considered in relation to a normal distribution to establish the deficits with which the participants present. Less than 50% of participants score in the typical range or one standard deviation above the mean indicating a higher incidence of visual perceptual deficits in this sample (Figure 4.1).

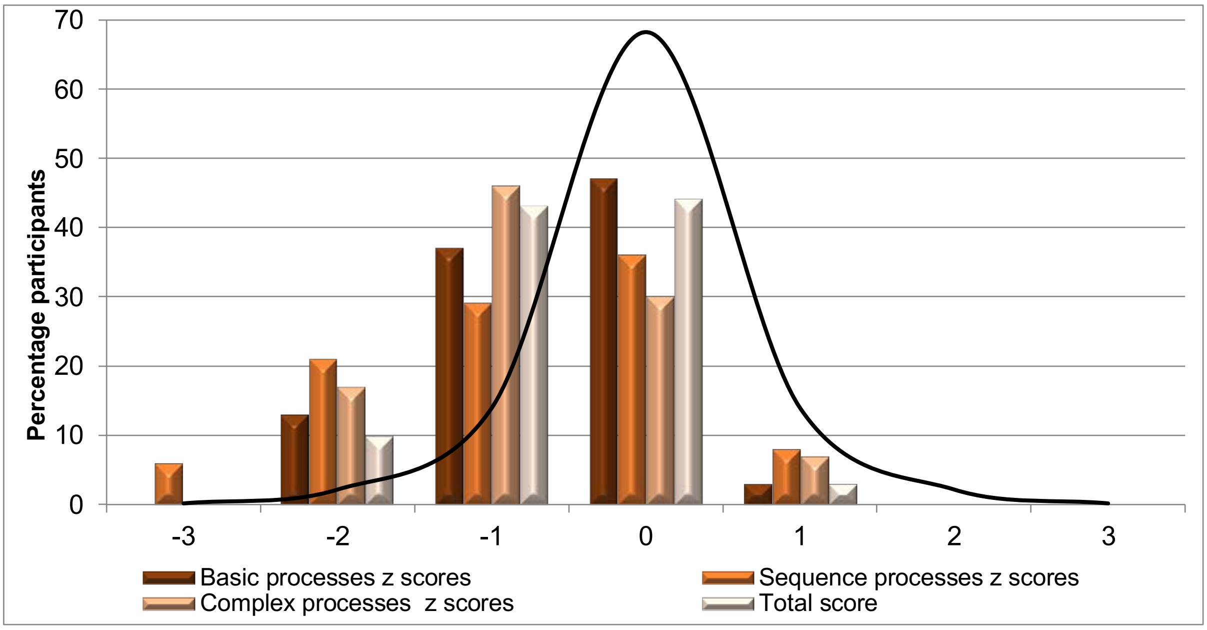

Figure 4.1: z scores for subsections and total scores of the on the Test of Visual Perceptual Skills - 3rd edition compared to a normal distribution (n=100).

In the sequence processes subsection 56% of the participants scored one standard deviation or more below the mean with 6% of participants scoring 3 standard deviations below the mean. In the basic processes 50% of participants scored one standard deviation below the mean or less. In complex processes 63% of participants scored one standard deviation and lower. A small percentage of participants scored one standard deviation above the mean including 3% in basic processes, 8% in sequence processes, 7% in complex processes and 3% in their total score.

4.3.2 Visual motor integration skills

Visual motor integration skills were measured by administering the DT-VMI 6 (Beery, 2010). This test battery consists of the visual motor integration test as well as its two supplemental tests namely the visual perception and the motor coordination subtest.

The scores obtained by the participants were not normally distributed and thus the mean and median as well as measures of variance are presented. Only the motor co-ordination section had a mean and median score below 85 indicating a deficit of one standard deviation below the mean (Table 4.5).

Table 4.5: Standard scores for the Beery-Buktenica: Developmental Test of Visual-Motor Integration - 6th Edition for participants (n=100).

Standard score of Beery VMI6 subtest (n=100)	Mean	Standard deviation	Median	Lower quartile	Upper quartile
Visual motor integration	92.89	17.21	90.50	81	103
Visual perception	95.01	16.63	95.50	83.5	107
Motor coordination	77.60	14.32	79.00	67	87

Mean & median < 85 indicating a deficit of one standard deviation below the mean

The z scores for the visual motor integration and supplemental visual perceptual and motor coordination tests were considered in relation to a normal distribution to establish the deficits with which the participants present. More than 50% of participants scores in the typical range or one or two standard deviations above the mean for visual motor integration and visual perception. The scores for motor coordination indicated more than 50% of the sample presented with deficits (Figure 4.2). For this supplemental test, 70% of participants scored one standard deviation and below in this section where 8% of participants scored three standard deviations below the mean.

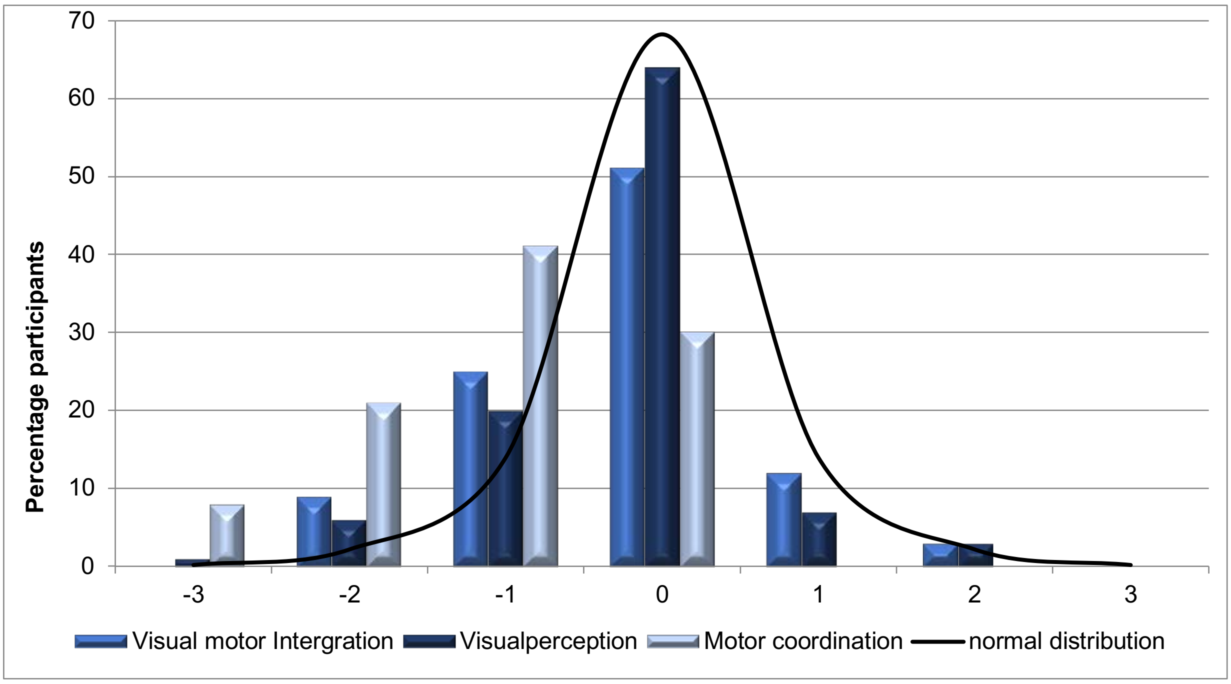

Figure 4.2: z-scores for the Beery-Buktenica: Developmental Test of VisualMotor Integration - 6th Edition compared to a normal distribution (n=100).

In the visual motor integration subsection 34% of participants scored one standard deviation and below. During the visual perceptual subsection 27% of participants scored one standard deviation and less, where 1% of participants scored three standard deviations below the mean for this subsection.

4.3.3 Oculomotor control

4.3.3.1 Developmental Eye Movement test

Oculomotor control, in the form of rapid automatic naming (RAN) and specifically saccadic eye movements was measured by administering the DEM (Richman, 2009). After administration four scores are obtained namely standard vertical score, standard horizontal score, DEM ratio and standard errors.

The scores obtained by the participants were not normally distributed and thus the mean and median as well as measures of variance are presented. The sections which had a mean and median score below 85 indicating a deficit of one standard deviation below the mean were standard vertical score, standard horizontal score, DEM ratio and standard errors (Table 4.6).

Table 4.6: Standard scores for Developmental Eye Movement Test for participants (n=100)

Standard score of DEM subtest (n=100)	Mean	Standard deviation	Median	Lower quartile	Upper quartile
Vertical standard score	62.14	31.77	64.00	42.50	84.50
Horizontal standard score	55.70	40.481	57.50	36.50	83.00
Error scores	80.52	34.57	88.00	62.50	108.00
DEM ratio Standard score	79.20	35.71	86.50	63.50	102.50

Mean & mode < 85 indicating a deficit of one standard deviation below the mean

The z scores for the standard vertical score, standard horizontal score, DEM ratio and standard errors were considered in relation to a normal distribution to establish the deficits with which the participants present. More than 50% of participants score in the typical range or one standard deviation above the norm. This indicated that more than 50% of the sample presented with deficits in oculomotor control (Figure 4.3).

In the vertical subsection of the DEM 76% of participants scored one standard deviation and below. It was also found that 35% of participants scored three standard deviations below the mean indicating problems with faster saccades and phonological RAN deficits. In the horizontal subsection 45% of participants scored three standard deviations below the mean and 76% of participants scored one standard below the mean. This indicates nearly three quarters of the participants present with or are at risk for deficits in slower horizontal saccades and oculomotor dysfunction.

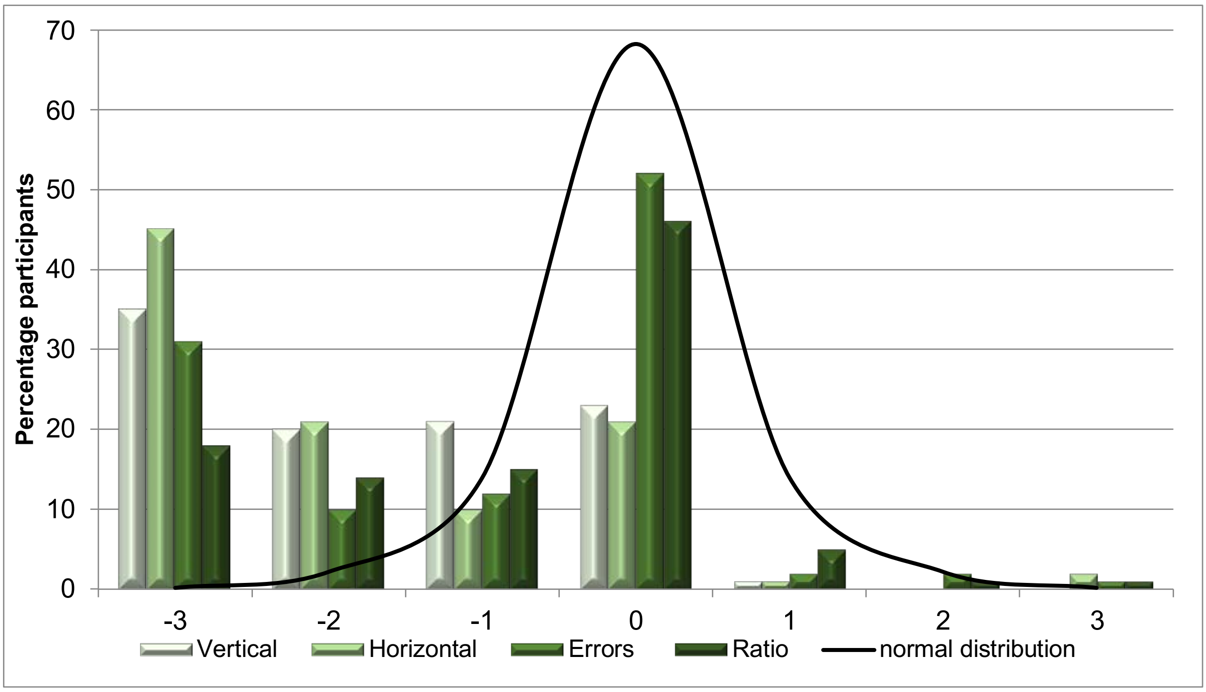

Figure 4.3: z-scores for the Developmental Eye Movement Test. Scores for the participants compared to a normal distribution (n=100)

It was found that 53% of participants were at more than one standard deviation below the mean where 31% made three standard deviations below the mean more errors with missing or repeating numbers confirming saccadic problems. The ratio subtest 47% of participants scored one standard deviation and below where 18% of participants scored three standard deviations and below for this subtest indicating possible mixed dysfunction with oculomotor and phonological RAN deficits.

4.4.3.2 Eye movement subsection of the Ayers Clinical Observations

Oculomotor control, in the form of observed eye movements was measured by administering the Eye Movement subsection of the Ayers Clinical Observations. After administration ordinal scores for general pursuit, across midline, convergence, quick localization, peripheral fields were obtained.

Table 4.7: Ordinal scores for the eye movement subsection of the Ayers Clinical Observations for participants (n=100)

Standard score of the Ayers Clinical Observations (n=100)	**Mean**	**Standard deviation**	**Median**	**Lower quartile**	**Upper quartile**
General pursuit	2.38	0.62	2.00	2.00	3.00
Across midline	2.38	0.66	2.00	2.00	3.00
Convergence	2.46	0.66	3.00	2.00	3.00
Quick localization	2.48	0.66	3.00	2.00	3.00
Peripheral fields	2.49	0.66	3.00	2.00	3.00

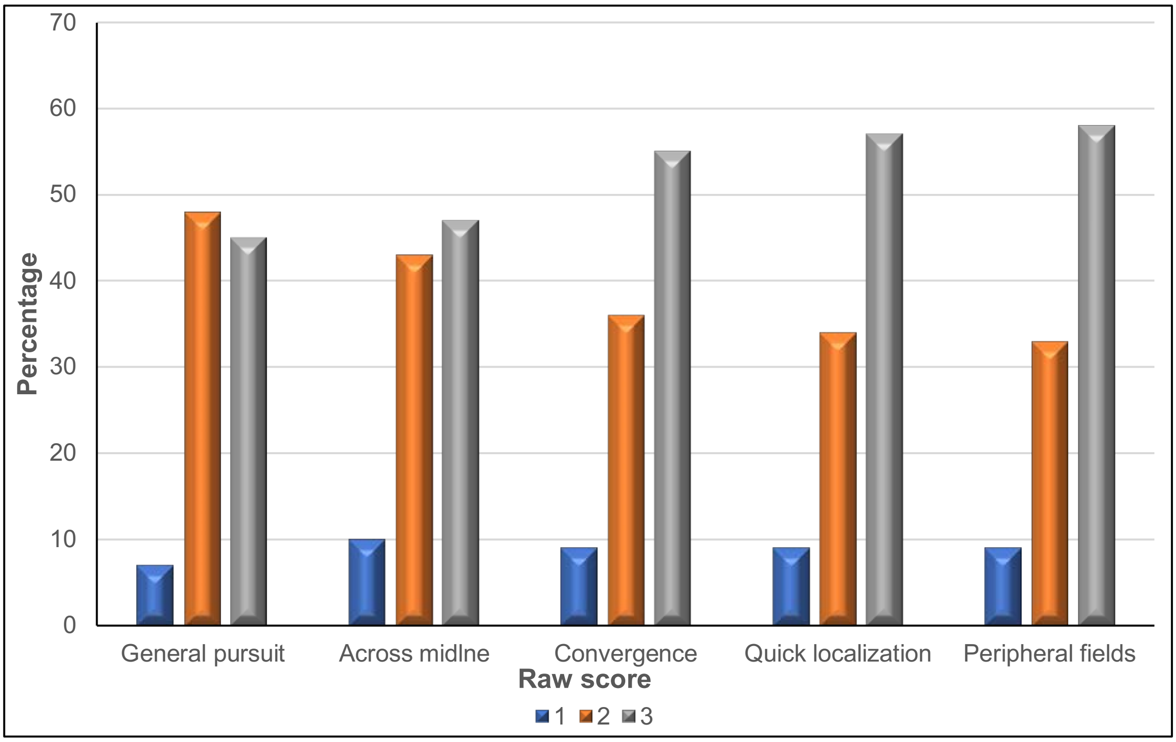

Figure 4.4: Raw scores for the Ayres Clinical Observation participants (n=100).

The observational instrument was scored with either a 1, 2 or 3. Peripheral fields obtained the highest median score with general pursuit and across midline obtaining the lowers scores. The standard deviation was similar for most of the subtests it was 0.66 except for general pursuit which was 0.62. The median for general pursuit and across midline were 2.00. The median for convergence, quick localization and peripheral fields were 3.00. The lower quartile for all the subtests were 2.00 and the upper quartile for all the subtests were 3.00.

4.4 The relationship between oculomotor control, visual perceptual and visual motor integration skills.

A correlation between visual reception skills such as oculomotor control can be seen as a foundational skill upon which visual perceptual skills and visual motor integration skills are dependent has been suggested in the literature (Stewart, 2010). Visual perceptual skills and visual motor integration skills are utilized to interpret visual information from the environment and are an integral part of various activities of daily living and play a vital role in skill development in childhood (Martin, 2006; Ho et al., 2015).

4.4.1 The relationship between visual perceptual scores as assessed and visual motor integration scores.

The visual motor integration subtest of the DT-VMI 6 was significantly correlated with the visual memory, spatial relations, visual sequential memory subtests. It was also significantly correlated with the sequence standard scores and the basic standard scores subsections of the TVPS-3. The visual perceptual subtest of the DT-VMI 6 was significantly correlated with the visual discrimination, visual memory, spatial relations, form constancy and visual sequential subtest of the TVPS-3. It was also significantly correlated with the sequence standard scores and the basic standard scores subsections of the TVPS-3. The visual discrimination subtest of the TVPS-3 was significantly correlated with the visual perceptual test. The motor coordination subtest of the DT-VMI 6 was only significantly correlated with the figure ground subtest of the TVPS-3.

The coefficient of determination (r^2) indicated between 17.6% and 4.4% of the variation in the TVPS -3 subtest scores accounted for the variation in the scores on the on the DT-VMI 6 (Table 4.8).

Table 4.8: The relationship between the subtests of the Test of Visual Perceptual skills-3rd edition and the Developmental Visual Motor Integration Test-6th edition

Subtest of TVPS-3 (n=100)	**Standard Visual Motor Integration**	**Standard Visual Perceptual**	**Standard Motor Coordination**
Visual discrimination	0.09	**0.38***	-0.12
Visual memory	**0.42***	**0.26***	-0.17
Spatial relations	**0.23***	**0.31***	-0.03
Form constancy	0.13	**0.26***	-0.05
Visual sequential memory	**0.25***	**0.38***	0.17
Figure ground	0.07	0.17	**0.21***
Visual closure	0.05	0.11	0.05
Basic composite standard scores	**0.26***	**0.38***	0.14
Sequencing composite standard scores	**0.25***	**0.38***	0.19
Complex composite standard scores	0.07	0.16	0.15
Total score	**0.30***	**0.35***	0.14

∗Significance $p \leq 0.05$

4.4.2 The relationship between the subtests of the Test of Visual Perceptual skills-3rd edition and the Developmental Eye Movement Test

Each subtest of the TVPS-3 was correlated with the four scores obtained through the DEM. The standard vertical score of the DEM had low significant correlations with the greatest number of subtests on the TVPS-3 - spatial relations, form constancy, visual sequential memory and figure ground (Table 4.9).

Table 4.9: The correlations between the subtests of the Test of Visual Perceptual skills-3rd edition and the Developmental Movement Test (N=100)

Subtest of TVPS-3 (n=100)	**Standard vertical score DEM**	**Standard horizontal score DEM**	**Standard DEM ratio**	**Standard errors DEM**
	rho			
Visual discrimination	0.10	0.03	-0.06	-0.11
Visual memory	0.04	-0.06	-0.04	-0.05
Spatial relations	**0.20***	0.07	-0.06	0.05
Form constancy	**0.23***	0.11	-0.01	0.02
Visual sequential memory	**0.31***	**0.27***	0.06	0.14
Figure ground	**0.29***	**0.32***	0.13	**0.25***
Visual closure	0.09	0.09	0.03	0.06

∗Significance $p \leq 0.05$

The coefficient of determination (r^2) indicated between 10.2% and 4% of the variation in the TVPS -3 subtest scores accounted for the variation in the scores on the DEM vertical, horizontal and error subtests with significant correlations

Each composite subsection and the total score of the TVPS-3 was correlated with the four scores obtained through the DEM. Low significant correlations between the standard vertical and horizontal score of the DEM and the sequence standard score subsection as well as the complex standard scores were found. The standard vertical score of the DEM had a low significant correlation to the total score on the TVPS-3 (Table 4.10).

The coefficient of determination (r^2) indicated between 11.6% and 4.4% of the variation in the TVPS -3 composite and total scores accounted for the variation in the scores on the DEM vertical and horizontal subtests with significant correlations.

Table 4.10: The correlation between the subsections of the Test of Visual Perceptual skills-3rd edition and the Developmental Movement Test (n=100)

Subsection of TVPS-3 (n=100)	Standard vertical score DEM	Standard horizontal score DEM	Standard DEM ratio	Standard errors DEM
	rho			
Basic composite standard scores	0.18	0.06	-0.03	0.01
Sequencing composite standard scores	**0.31***	**0.27***	0.06	0.14
Complex composite standard scores	**0.22***	**0.24***	0.10	0.18
Total score	**0.24***	0.17	0.10	0.03

∗Significance $p \leq 0.05$

4.4.2 The relationship between the subtests of the Test of Visual Perceptual skills-3rd edition and the Eye Movement subsections of the Ayres Clinical Observations

Each subtest of the TVPS-3 was correlated with the general pursuit, across midline, convergence, quick localization and peripheral fields subtest scores obtained through the eye movement subsections of the Clinical Observations. (Table 4.11).

The coefficient of determination (r^2) indicated between 12.9% and 4.4% of the variation in the TVPS -3 subtest scores accounted for the variation in the scores on the Eye Movement subsections of the Ayres Clinical observations for significant correlations

Table 4.11: The correlations between the subtests of the Test of Visual Perceptual skills-3rd edition and the eye movement subsections of the Ayres Clinical Observations (N=100)

Subtest of TVPS-3 (n=100)	**General pursuit**	**Across midline**	**Convergence**	**Quick localization**	**Peripheral fields**
	rho				
Visual discrimination	0.18	0.17	0.15	0.12	0.15
Visual memory	0.18	0.12	0.11	0.09	0.09
Spatial relations	0.13	0.09	0.12	0.03	0.03
Form constancy	**0.23***	**0.21***	**0.26***	0.14	0.16
Visual sequential memory	**0.31***	**0.28***	**0.28***	0.16	0.19
Figure ground	**0.29***	**0.31***	**0.36***	**0.28***	**0.30***
Visual closure	0.19	**0.22***	**0.22***	0.14	0.14

*Significance p≤ 0.05

The across midline and convergence subtest scores on the Eye Movement subsections of the Ayres Clinical Observations had low significant correlations with the greatest number of subtests on the TVPS-3 -, form constancy, visual sequential memory, figure ground and visual closure. Low significant correlations between the general pursuit subtest scores on the Eye Movement subsections of the Clinical Observations and three subtests on the TVPS-3 form constancy, visual sequential memory and the figure ground were found. A low significant correlation was also found obtained between the quick localisation and peripheral fields subtest scores on the Eye Movement subsections of the Ayres Clinical Observations and the figure ground subtest on the TVPS-3.

Each composite subsection and the total score of the TVPS-3 was correlated with general pursuit, across midline, convergence, quick localization and peripheral fields subtest scores obtained through the Eye Movement subsections of the Ayres Clinical Observations. Low significant correlations between the general pursuit, across midline, convergence, subtest scores of the Eye Movement subsections of the Ayres Clinical Observations and the basic, standard score subsection sequence standard score subsection as well as the complex and total standard scores were found. The quick localization and peripheral fields subtest scores of the eye movement subsections of the Clinical Observations had a low significant correlation to the complex and total score on the TVPS-3 (Table 4.12).

The coefficient of determination (r^2) indicated between 11.6% and 4% of the variation in the TVPS -3 composite and total scores accounted for the variation in the scores on the Eye Movement subsections of the Ayres Clinical Observations for significant correlations.

Table 4.12: The correlation between the subsections of the Test of Visual Perceptual skills-3rd edition and the eye movement subsections of the Ayres Clinical Observations (n=100)

Subsection of TVPS-3 (n=100)	**General pursuit**	**Across midline**	**Convergence**	**Quick localization**	**Peripheral fields**
	rho				
Basic composite standard scores	**0.24***	**0.20***	**0.21***	0.11	0.13
Sequencing composite standard scores	**0.32***	**0.30***	**0.28***	0.16	0.19
Complex composite standard scores	**0.28***	**0.31***	**0.34***	**0.24***	**0.25***
Total score	**0.31***	**0.29***	**0.30***	0.19	**0.21***

*Significance p≤ 0.05

4.4.3 The relationship between the subtests of the Developmental Test of Visual Motor Integration-6th edition and the Developmental Eye Movement Test

Each subtest of the VMI-6 was correlated with the four scores obtained through the DEM. Low significant correlation were found between standard errors of the DEM and the visual motor integration subtest as well as the motor coordination supplemental test (Table 4.13). The coefficient of determination (r^2) indicated between 7.2% and 5.7% of the variation in the DT-VMI 6 accounted for the variation in the error scores on the DEM for significant correlations.

Table 4.13: The correlation between the subtests of the Developmental Test of Visual Motor integration-6th edition and the Developmental Eye Movement Test (n=100)

Standard score of Beery VMI-6 subtest (n=100)	**Standard vertical score DEM**	**Standard horizontal score DEM**	**Standard DEM ratio**	**Standard errors DEM**
	rho			
Visual motor integration	-0.09	-0.13	-0.02	**0.27**
Visual perception	0.04	-0.02	-0.08	0.20
Motor coordination	0.05	0.02	0.03	**0.24**

∗Significance p≤ 0.05

4.4.4 The relationship between the subtests of the Developmental Test of Visual Motor integration-6th edition and the Eye Movement subsections of the Ayres Clinical observations

Each subtest of the DT-VMI 6 was correlated with the general pursuit, across midline, convergence, quick localization and peripheral fields subtest scores obtained through the Eye Movement subsections of the Ayres Clinical Observations. Low significant correlation was found between the general pursuit and across midline of the Eye Movement subsections of the Ayres Clinical Observations and the visual perception as well as the motor coordination supplemental tests (Table 4.14).

The coefficient of determination (r^2) indicated between 5.2% and 3.6% of the variation in the DT-VMI -6 accounted for the variation in the scores on the Eye Movement subsections of the Ayres Clinical observations for significant correlations.

Table 4.14: The correlation between the subtests of the Developmental Test of Visual Motor Integration-6th edition and the Eye Movement subsections of the Ayres Clinical observations (n=100)

Standard score of Beery VMI6 subtest (n=100)	**General pursuit**	**Across midline**	**Convergence**	**Quick localization**	**Peripheral fields**
	rho				
Visual motor integration	0.05	0.02	0.06	0.02	0.00
Visual perception	**0.23***	0.19	0.10	0.04	0.04
Motor coordination	**0.22***	**0.21***	0.16	0.14	0.14

∗Significance $p \leq 0.05$

4.4.5 The relationship between the Eye Movement subsections of the Ayres Clinical observations and the Developmental Movement Test

The observational subtests of the Eye Movement subsection of the Ayres Clinical Observations were correlated with the four scores obtained through the DEM. Low significant correlation between the standard vertical score of the DEM and the general pursuit, across midline, convergence, quick localization and peripheral fields subtest. Significant correlation between the standard horizontal score of the DEM and the general pursuit, across midline and convergence subtests were found (Table 4.15).

The coefficient of determination (r^2) indicated between 12.2% and 4.4% of the variation in the DEM vertical and horizontal subtests accounted for the variation in the scores on the Eye Movement subsections of the Ayres Clinical observations for significant correlations.

Table 4.15 The relationship between the Eye Movement subsections of the Ayres Clinical Observations and the Developmental Eye Movement Test (n=100)

Clinical observations (n=100)	**Standard vertical score DEM**	**Standard horizontal score DEM**	**Standard DEM ratio**	**Standard errors DEM**
	rho			
General pursuit	**0.31***	**0.21***	0.01	0.09
Across midline	**0.31***	**0.25***	0.06	0.13
Convergence	**0.35***	**0.26***	0.06	0.13
Quick localization	**0.29***	0.18	0.02	0.05
Peripheral fields	**0.28***	0.19	0.04	0.06

*Significance p≤ 0.05

4.5 Summary

This chapter firstly reported on the demographics of the participants. There were 100 participants included in this study who were all in the foundation phase of an LSEN school in the Ekurhuleni district of Gauteng. It was reported whether the participants used medication, what gender they are, which language they receive schooling in, whether they have been assessed by an optometrist and whether they have repeated a grade.

The visual perceptual, visual motor integration and the oculomotor control scores were not normally distributed. This indicates a higher incidence of visual perceptual, visual motor integration and oculomotor control deficits in this sample.

The visual motor integration was significantly correlated with the visual memory, spatial relations, visual sequential memory subtests. It was also significantly correlated with the sequence standard scores and the basic standard scores subsections of the TVPS-3. The standard vertical score of the DEM had low significant correlations with the greatest number of subtests on the TVPS-3 - spatial relations, form constancy, visual sequential memory and figure ground. Low significant correlations between the standard vertical and horizontal score of the DEM and the sequence standard score subsection as well as the complex standard scores were found. The standard vertical score of the DEM had a low significant correlation to the total score on the TVPS-3.

Low significant correlation was found between standard errors of the DEM and the visual motor integration subtest as well as the motor coordination supplemental test. Low significant correlation was found between the general pursuit and across midline of the Eye Movement subsections of the Ayres Clinical Observations and the visual perception as well as the motor coordination supplemental tests. Low significant correlation between the standard vertical score of the DEM and the general pursuit, across midline, convergence, quick localization and peripheral fields subtest. Significant correlation between the standard horizontal score of the DEM and the general pursuit, across midline and convergence subtests were found.

CHAPTER 5: DISCUSSION

5.1 Introduction

This chapter will discuss the results of the study and how these relate to other studies. The demographics of the participants will be considered and related to the South African population. The four objectives will be discussed: namely the first three determining the visual perceptual skills, visual motor integration skills as well as the oculomotor control of learners attending a LSEN school and the fourth to determine the relationship between these concepts. The findings of a variety of studies that utilized the TVPS-3, DT-VMI 6 and DEM will also be discussed and compared the findings of the current study. Lastly the strengths and limitations of this study will be discussed.

5.2 Demographics

At the time of the study there were 138 learners who met the inclusion and exclusion criteria, 110 males and 28 females, enrolled in the foundation phase of School of Achievement. A sample of 100 learners participated in this study. Participants from different racial backgrounds namely White, Black, Indian, Asian and Coloured participated however the predominant race was White. This is not representative of the South African population as according to Stats SA (2019) 80,7% of the population are Black Africans; 8,8% are Coloured people; 2,6% are Indian and Asian people and 7,9% are White.

Learners have to pay a nominal fee to attend the school except if their income per household is below a certain amount, then their school fees are waivered. The school is situated in a middle-class income group area however learners reside in a variety of areas and are transported to the school. The school admits learners from all socio-economic backgrounds and therefore the participants is representative of the South African population.

Of the 100 participants 23% were female, while 77% were male (Table 4.1).. The fact that more males than females were included in the study is consistent with the profile of children with a specific learning disorder where it has been found that the prevalence is greater in males. In America during the 2017 to 2018 school year 17 percent of male students received special educational support compared to 9 percent of female students (NCES, 2019). This is a world-wide trend with many authors form a variety of ethnic and racial groups coming to the same conclusion (Hawke et al., 2007; Wheldall and Limbrick, 2010; Rutter et al., 2004; Skårbrevik, 2002; Olson, 2009; Abdalah, 2018). In a large scale study by Quinn and Wagner (2015) it was found that out of 491 103 learners in mainstream schools boys were 2,4 times more likely to have a reading impairment. It was found that boys reading impairments were also more severe than girls.

Of the 100 participants 50% has repeated a grade (Table 4.1). Many studies have shown that learners with specific learning disorders are more likely to repeat a grade (American Psychiatric Association, 2013; Cain et al., 2004; DuPaul et al., 2013; Kormos, 2017), since academical skills such as reading and writing are challenging for these learners. In South Africa learners who are identified to struggle with academical tasks are often given extra support in their mainstream class before being placed in a LSEN school. This results in learners often repeating a grade before attending a LSEN school. However, no statistics are available to the researcher to determine the exact reasons why so many learners have repeated a grade or to determine if this is a trend in all LSEN schools

The majority of the learners, 75%, were using medication during the study. Most of the learners who were using medication, 77,33%, to address difficulties with concentration. Some of the learners were using medication, 21,33%, to address both concentration and to stabilize mood (Table 4.3). Medication has not been found effective in treating specific learning disorders. The best treatment for this lifelong condition is an individualized educational program and therapy such as occupational or speech therapy (DuPaul et al., 2013; Lovett and Sparks, 2013). The fact that so many of the learners were using medication could be ascribed to the strong link between attention deficit hyperactive disorder and a specific learning disorder has been found (Koolwijk et al., 2014; Pliszka, 2014; DuPaul et al., 2013). Medication which improves concentration has therefore been prescribed for learners with a specific learning disorder with co-morbid ADHD. Learners who were taking medication to stabilize mood could be as a result of co-morbidities or emotional difficulties associated with a specific learning disorder..

The majority of participants, 74%, indicated that they have gone for a visual assessment by an optometrist (Table 4.2). Of these learners, 25% were prescribed glasses to rectify visual acuity difficulties. The prevalence of refractor errors have been found to vary among race and geographical locations (Goh et al., 2005; Sharma et al., 2012). In America it was found that 33% of children aged 6-17 wears glasses or contact lenses (U.S. Department of Health and Human Services, 2017). Visual acuity difficulties could be the cause of reading difficulties. It is recommended that all learners who have reading difficulties should go for an eye examination by an optometrist to ensure that visual acuity difficulties are not the main cause for their reading difficulties (Olitsky and Nelson, 2003; Wallace et al., 2017; Muzaliha et al., 2012).

The participants in the study fall into a group of learners who attend School of Achievement in Gauteng, South Africa. These learners need to fulfil specific criteria to attend this school as stipulated by the Gauteng Department of Education which is guided by the DSM-5 criteria for children with a specific learning disorder. This includes standardized testing results that are significantly below chronological age expectation, and this can include tests for visual perceptual deficits and visual motor integration deficits. These deficits may be characteristic of specific learning disorders but not all learners diagnosed with specific learning disorders will present with significant problems for these components (O'Brien et al., 1988). The visual perceptual, visual motor integration and oculomotor skills of foundation phase participants attending a LSEN school are discussed below.

5.3 Visual perceptual skills

The first objective of the study was to determine the visual perceptual skills of foundation phase learners attending a LSEN school using the Test of Visual Perceptual Skills 3th edition (TVPS 3). Overall the results of the TVPS-3 indicated that the majority of participants scored significantly below their chronological age group in all of the subsections. In the sequence processes overall 56% of the participants scored one standard deviation or more below the mean (Table 4.4).

This subsection's score is only derived from the visual sequential memory subtest. This indicates that most of the participants finds it challenging to encode, store and retrieve visual information that has been given in a sequence. This will impact on the learner’s abilities to remember a sequence of words, letters or sentences. It will also decrease the learner’s ability to keep a narrative in the same, original order. This could further result in poor handwriting and letter reversals (Schneck, 2010a).

Harris (2017) also found that the greatest deficits at two standard deviations below the mean were in the sequencing subsection score but her findings did not support the current study since she found 29% of learners had below average scores. Garje (2015) however reported 58% of learners fell into the below average category in their study again confirming the variation of prevalence of sequencing visual perceptual deficits in this population.

In the basic processes’ subsection, 50% of participants scored one standard deviation below the mean(Table 4.4). This subsection consisted of the visual discrimination, visual memory, spatial relations and form constancy subtests. Theses scores indicate that half the participants have difficulty in the ability to identify differences between objects and to orientate manners in which objects relate to one another in the environment. This further indicates that they found it difficult to internalize and recall characteristics of objects and to recognize objects which are similar, but different sizes (Schneck, 2010b). Difficulties in these areas of visual perception could result in letter or number reversals, difficulty in recognizing or recalling letters or words and poor handwriting abilities (Schneck, 2010a). The percentage of participants with difficulties on the basic processes’ subsection was greater than the 32% reported by Harris (2017) for learners attending a LSEN school in Gauteng.

In the complex processes’ subsection, which consists of figure ground and visual closure, 63% of participants scored one standard deviation and lower (Table 4.4). The participant's scores indicate that they found it difficult to differentiate between the foreground and the background of objects and that they struggle to recognize the complete object when only presented with a part of it (Schneck, 2010b). This could result in difficulty to perceive an object in the environment which is not well defined (Schneck, 2010a). Again, Harris (2017) reported a lower percentage of participants, 39%, who scored one standard deviation below the mean in this subsection. Complex processes are dependent on the development of basic processes and therefore it could explain why these scores seems to be similar for the participants in the current study as well as the study of Harris (2017).

Both the current study and that by Harris (2017) indicate the variance of visual perceptual skills in learners with a specific learning disorder with the number of learners in the current study being 20-25% higher those reported by Harris (2017). The findings in the current study are however supported by those of Gajre et al. (2015) who also found below average scores for between 26% and 32% for learners with a specific learning disorder on the TVPS-3.

The participants in the current study presented with deficits in all the subsections of the TVPS-3. When considering the specific subtests, participants performed below their chronological age in the visual discrimination, form constancy and visual closure subtests. This reflects the findings of Harris (2017) who also found that learners with a specific learning disorder scored below their chronological age in these subtests. The findings for visual discrimination and form constancy, were also supported by Garje (2015) who found more than 50% of learners with a specific learning disorder presented with deficits on these subtests. They reported that only a third of learners in their study had below average scores for visual closure.

Buckle (2019) however found that South African learners in a LSEN school who were diagnosed with ADHD obtained the lowest scores in the visual discrimination and visual closure. These learners also scored poorly on the visual spatial relations and visual memory subtests which was not supported by the current study but was supported by Garje et al. (2015) as some participants in their study had ADHD.

The results of the current study concur with the findings of previous studies, that a percentage of learners with a specific learning disorder tend to score below their chronological age in some aspects of the TVPS-3. This study found that the lowest scores were obtained in visual discrimination, form constancy and visual closure. This supports the need to consider the heterogeneous nature of specific learning disorders and subtypes of learning disorders when determining visual perceptual deficits (Rourke, 1985). It is therefore vital to assess these learners with the correct standardized assessments to accurately identify visual perceptual abilities.

5.4 Visual motor integration skills

The second objective of the current study was to determine the visual motor integration skills of foundation phase learners attending a LSEN school using the Developmental Test of Visual-Motor Integration - 6th edition (DT-VMI 6) (Beery, 2010).

On the visual motor integration test 34% of participants scored one standard deviation and below (Table 4.5). Difficulties in visual motor integration has mainly been associated with reduced quality of handwriting (Brown and Link, 2016; Clark, 2010). It could result in a learner struggling to copy letters and forms legibly, difficulty building blocks or Legos and a reduced speed in motor outputs such as cutting activities (Schneck, 2010a). Even though the majority of learners did not score below their chronological age, deficits in VMI was found in a large group of this study. Harris (2017) found that learners in LSEN schools are more likely to fall into the at-risk group, scoring below their chronological age in the VMI subtest of the DT-VMI 6, than learners in mainstream schools. It must therefore be noted that learners with a specific learning disorder could possibly have VMI deficits.

In the motor coordination supplementary test, 70% of participants scored one standard deviation and below (Table 4.5). Of these participants, 8% scored three standard deviations below the mean. This is indicative of significant difficulties in motor coordination. These findings are supported by O’Brien et al. (1988) who found that there are subgroups of learners with a specific learning disorder who have more deficits in motor competence. Some learners with specific learning disorders also present with fine and gross motor deficits which affect the motor output on standardised tests assessing visual motor integration (Portwood, 2013). This confirms the notion that children with neurodevelopmental disorders often have developmental delays in similar developmental areas (American Psychiatric Association, 2013).

Sixty four percent of the participants scored in the average range on the perceptual supplemental test of the DT-VMI 6 which was unexpected in terms of the high prevalence of perceptual deficits found on the TVPS-3 for this sample (Table 4.5) The differences in the visual perceptual skills on the two tests will be discussed under objective four.

Since the participants in this study had lower scores for the motor coordination compared to the visual perception supplemental test on the DT-VMI 6 it can be accepted that for this sample motor coordination was a greater problem and motor dyspraxia may co-occur with a specific learning disorder (Rourke, 1985). This is contrary to findings in studies on typical children in South Africa where DT-VMI 6 scores for motor coordination have been consistently reported as higher than those for visual perception (Van Heerden et al., 2011; Du Plessis and Coetzee, 2013; Dunn et al., 2006; Lotz et al., 2005). The findings of this study also differ from the findings by Buckle (2019) on a homogeneous group of learners with ADHD where it was found that most of the participants scored within the average range for the VMI and motor coordination supplemental test of the DT-VMI 6. The difference noted in the results of this current study could be due to the more heterogeneous nature of the population included. The results of this objective indicate that learners with a specific learning disorder need to undergo a visual motor integration and motor coordination assessment since it is likely for these learners to have a visual motor integration deficit and or deficits in motor components subserving scholastic functions.

5.5 Oculomotor control

The possible association between learners with neurodevelopmental disorders such as motor dyspraxia, ADHD and oculomotor dysfunction has (Gaymard et al., 2017; Mahone et al., 2009) underpinned the importance of objective three which was to determine the oculomotor control of foundation phase learners attending a LSEN school using the Developmental Eye Movement and Eye Movement subsection of the Ayers Clinical Observations.

Of all the standardised assessments, the DEM scores were the lowest. In the vertical subsection of the DEM 76% of participants scored one standard deviation or more below the norm (Table 4.6). It was also found that 35% of participants scored three standard deviations below the mean. This is indicative that participants had difficulty with faster vertical saccades assessed by rapid automatized naming (RAN) (Hopkins et al., 2019). This is indicative of poor phonics, sound-symbol associations and have been found to have poor reading abilities. A deficit in this component has also been associated with specific learning disorders, specifically the dyslexic subtype (Richman, 2009). Raghuram et al. (2018) found the percentage of learners with dysfunction for vertical scores were lower than those for horizontal scores. They however found between 45% - 64% of learners with development dyslexia, not specifically identified with a specific learning disorders, scored below average especially on the vertical subtest of the DEM. Therefore, it seems that lower scores on the vertical subtest of the DEM indicates that a specific learning disorder more specifically dyslexia could be present. These learners will also have difficulty in reading.

In the horizontal subsection 76% of participants scored below average. Of these participants, the high percentage of 45% scored three standard deviations below the mean (Table 4.6). This supports the notion that participants had greater difficulty with slower horizontal saccades and oculomotor function which has previously been reported for children with a specific learning disorder (Palomo-Álvarez and Puell, 2009). Difficulties in this component of the test is associated with more motor dysfunction (Reichle et al., 2009). The median vertical and horizontal standard scores in the current study were higher than the 40 and 48.6 reported by Hussaindeen et al. (2018) in learners with specific learning disorders. This discrepancy can be accounted for by the sample in the latter study, only learners with oculomotor binocular vision anomalies were included and fewer learners presented with RAN automaticity difficulty dysfunction on the vertical test. They found only 18% of their participants had scores in the average range for oculomotor function on the DEM.

In the current study it was found that 53% of participants made errors which was more than one standard deviation below the mean, where 31% made three standard deviations below the mean more errors (Table 4.6). Errors were only associated with the slower saccadic movement in the horizontal eye movement subsection. These errors include addition, transposition, omission and substitution. Addition is when an extra number has been read which is not indicated on the test. Transpositions are when a number had been read out of sequence. Omission is when a number indicated on the test is not read by the learner. Substitution is when an incorrect number is read instead of the indicated number. These errors were all added as no standardized scores are available for each section of errors only a total score.

These errors indicate that learners were often overshooting, causing the eyes to land further than the designated target. They also undershot, resulting in smaller corrective saccades or they frequent lost their place causing a rereading of a number or a different line of numbers (Vitu and McConkie, 2000; Rayner, 2009). This causes learners to read slowly as was evident in the findings of this current study. Transposition errors associated with dyslexia also occurred but the error rate in the current study was lower than the 66% reported by Raghuram et al. (2018) who sampled learners with a specific learning disorder specified as the dyslexia subtype only.

In the ratio score, 47% of participants scored one standard deviation and below where 18% of participants scored three standard deviations and below (Table 4.6). When the ratio score is below average, the participants scored poorly in the vertical and horizontal scores. This is indicative of difficulties with both the slow and fast saccadic movement and could be identified as mixed motor and dyslexic dysfunction (Reichle et al., 2009). The scores of the participants that fell into the normal ratio range could nevertheless have dysfunctional vertical or horizontal scores. They could therefore still present with dyslexic or oculomotor dysfunction respectively.

The second oculomotor assessment used was the Eye Movement section of the Ayers Clinical Observations. This screening assessment determines the ability of the child to establish and maintain visual contact with a target. The results of the indicated that more than 50% of participants scored borderline during the general pursuit and moving their eyes across the midline subtests (Table 4.7).. Smooth eye movements across the midline and being able to pursue an object is necessary for effective saccades (Hopkins et al., 2017) and dysfunction in this area could negatively influence reading abilities.

The results of both the DEM and the Eye Movement Subsection of the Ayres Clinical Observations indicate that most of the learners in this LSEN school struggled with oculomotor control. The findings of the DEM were more specific, indicating that most of the participants had difficulties with both the slow and fast saccadic movement. They could be identified as mixed motor and dyslexic dysfunction. The results of the Eye Movement Subsection of the Ayres Clinical Observations were less specific and only indicated borderline scores, but this still indicate that more investigation of oculomotor function is necessary. It is therefore vital to assess the oculomotor control of learners with a specific learning disorder since it is very likely that deficits in this area might occur which needs to be addressed during intervention.

5.6 Relationship between oculomotor control, visual perceptual skills and visual motor integration skills

The fourth objective of the current study was to determine the relationship between oculomotor control, visual perceptual skills and visual motor integration skills. Firstly, the relationship between visual perceptual skills as measured by the TVPS3 compared to the DT-VMI 6. Then visual motor integration and visual perceptual skills will be discussed. The results of the DEM will be compared to the results of the Eye Movement Subsection of the Ayres Clinical Observations and the relationship between these tests and visual perception will be discussed. Lastly the relationship between visual motor integration and oculomotor control will be addressed.

5.6.1 Relationship between visual perceptual skills as measured by the TVPS-3 and the visual perceptual supplementary test of the DT-VMI 6

When correlating the motor reduced visual perception scores as obtained by the TVPS-3 and the visual perception supplemental test of the DT-VMI 6 five out of the seven subtests of the TVPS-3 had a low significant correlation (Table 4.8). These subtests were visual discrimination, visual memory, spatial relations, form constancy and visual sequential memory. The basic and sequential subsection as well as the total scores also had a low significance correlation to the visual perpetual supplemental test of the DT-VMI 6. This indicates that between 14.4% and 6.7% of the variation in the TVPS-3 accounts for variation in the DT-VMI 6. Therefore, the relationship between these concepts are positive but very low. If one score increases, the other score will also increase (Kielhofner, 2006). This suggests that these tests evaluate components at a similar level but that the components being assessed differ and thus the dysfunction indented by the tests differ.

In assessing the validity of the TVPS-3, Martin (2006) found that there was a moderately strong (0.67) correlation between the supplementary visual perceptual subtest of the DT-VMI 5 and the TVPS-3. Since the TVPS-3 assesses 7 different subcomponents of visual perception which comprises of 112 items compared to only the visual perceptual supplementary test of the DT-VMI 6 which has no subcomponents and only takes approximately 5 minutes to administer, much more detail about the learners' visual perceptual abilities was gathered by the results of the TVPS-3. The lack of a significant correlation of the DT-VMI 6 visual perceptual scores to the visual closure and figure ground subtests may indicate the different skills are being assessed. No other research has provided correlations between these tests making it difficult to compare which components of visual perception may be required for the different tests.

The lack of correlation of the DT-VMI 6 to the complex subsection test on the TVPS 3 indicates the TVPS-3 appears to assess more complex concepts not assessed by this supplemental test of the DT-VMI 6. Thus, the TVPS-3 focusses on visual perceptual skills and provides a more comprehensive assessment of this component while the visual perceptual supplemental test of the DT-VMI 6 is part of the assessment of visual motor integration and should be viewed in this light. The tests cannot be used interchangeably as they assess different but interrelated skills.

5.6.2 Relationship between visual perceptual skills and visual motor integration skills

There was a low significant correlation between three (visual memory, spatial relations and visual sequential memory) subtests and the basic, sequential subsection as well as the total scores on the TVPS-3 and the VMI section of the

DT-VMI 6 (Table 4.9). Between 17.6% to 5.2% of the variation in the TVPS-3 subtest scores accounted for the variation in the scores the VMI section of on the DT-VMI 6. As expected, this indicates that even though there is a motor component to the VMI section, a small component of visual perceptual skills is also required in VMI tasks.

Visual memory and visual sequential memory is important in VMI tasks since these tasks requires a person to encode visual information in the environment, store and retrieve this information (Schneck, 2010b) to later give a motor output on this information. It has been noted that visual memory has consistently been linked to VMI abilities (Schneck, 2010a). The sequential subsection consists only of the visual sequential memory subtest and therefore this subsections score is related to VMI for the same reason.

Dankert et al. (2003) found that visual sequential memory and visual figure ground were consistently significant predictors of visual motor integration skills. In the current study on learners with a specific learning disorder only visual sequential memory accounted for 6.2% of the variation with VMI section of the DT-VMI 6, whereas visual memory predicted 17.6%. This is congruent with the findings of Parush et al. (1998) for learners with developmental coordination disorder (DCD) and poor motor coordination. This indicates that children with a specific learning disorder who has difficulty with visual memory will have lower scores on VMI tests and likely struggle with writing tasks.

Spatial relations is the ability to comprehend the relations between objects (Schneck, 2010b). It is important to understand directional language such as up, down, left or right. The correlation between spatial relations and VMI implies that a person's ability to comprehend relations between objects in the environment influences their ability to produce motor responses about the environment. It has been noted that spatial relations has consistently been linked to VMI abilities (Schneck, 2010a).

The relationship between spatial relations and VMI section of the DT-VMI 6 in the current study was supported by Bezrukikh and Terebova (2009) although they also found a relationship to figure ground in typically developing children. In the current study the figure ground subtest of the TVPS-3 only had a low significant correlation with the motor coordination supplemental test of the DT-VMI 6 (4.4% variance). Figure ground, the ability to distinguish between the foreground and the background of objects (Schneck, 2010b), only influences motor outputs to a minimal extent. This is supported by the findings of Sigmundsson et al. (2003) and Brown (2012) who found that figure ground constructs explained 4.9% of the variance for motor coordination.

When learners with a specific learning disorder have difficulty with VMI, it is likely that they will have low scores for aspects of visual perceptual abilities such as visual memory, spatial relations and visual sequential memory. Improvement in one aspect of the visual perceptual skills as mentioned above, will likely cause improvements in VMI assessment scores. Since there was only a low significance correlation between the different visual perceptual skills and VMI, the assessment of these visual perceptual skills cannot replace the assessment of VMI.

In conclusion this study agrees with the findings of previous studies (Ayhan et al., 2015; Barnhardt and Deland, 2005; Bezrukikh and Terebova, 2009; Cho et al., 2015; Sigmundsson and Hopkins, 2005; Brown, 2012) which found that motor reduced visual perceptual skills are associated with and predict specific types of motor enhanced VMI constructs. This was particularly true for visual memory, visual sequential memory and spatial relations. The fact that not all of the subtests correlated significantly further supports the conclusion of previous studies (Parush et al., 1998; Brown, 2012) that these two concepts are interrelated, but that they are still two separate entities and should be treated as such. Therefore, visual perceptual and visual motor integration skills need to be assessed separately in learners with a specific learning disorder.

5.6.3 Relationship between the scores of the Eye Movement subsections of the Ayers Clinical Observations and the Developmental Eye Movement Test

There was a low significant correlation between the vertical subtest of the DEM and all the subtests of the Ayers Clinical Clinical Observations (Table 4.15). The highest correlation was with convergence but variance on all Eye Movement subsections of the Ayers Clinical Observations indicated between 12.2% and 7.8% is predictable from faster saccades and automaticity assessed by RAN on the DEM. The higher correlations between the vertical and horizontal scores on the DEM and convergence on the Eye Movement subsections of the Ayers Clinical Observations is supported by studies, suggesting an interaction between the convergence and saccade systems (Alvarez and Kim, 2013). Convergence insufficiency has also been associated with frequent loss of place causing a rereading of text and results in lower scores on the DEM.

However, a low significant correlation between the horizontal subtest of the DEM was found only with general pursuit, across midline and convergence on the Eye Movement subsections of the Ayers Clinical Observations (Table 4.15).. These movements are congruent with the slower saccades and oculomotor function movements assessed by the DEM horizontal subtest. Between 7.8% and 4.4% of oculomotor function is predictable from the scores for these subtests of the Eye Movement subsections of the Ayers Clinical Observations. Visual pursuits and saccades are linked in the frontal eye field which is the principal neocortical region involved in the execution of both saccadic and pursuit eye movements with varying response to fixed and moving stimuli (Rosano et al., 2002). It has also been shown that for individuals with convergence insufficiency and strabismus alternate eyes are used in visual pursuits across the midline speed and accuracy of saccades (Van Leeuwen et al., 2001).

Vertical scores on the DEM also correlated with peripheral vison and quick localisation (Table 4.15) since downward saccades on equidistant targets consistently accompanied by vergence and convergence due to activation of the oblique eye muscles allowing stimuli in the periphery to be identified (Alvarez and Kim, 2013). Therefore, the correlations reported in the current study were not unexpected although the low percentage variability in one assessment that accounts for variability in the other indicates that many components of visual processing, phonological and automaticity skills, not only oculomotor function, are being assessed by the DEM.

As expected, no significant correlation was seen between the ratio of errors subtest of the DEM and any of the subtests of the Eye Movement subsections of the Ayers

Clinical Observations (Table 4.15). These components are not part of the clinical observation assessment and provide information which are unique to the DEM. This indicates that even though the Eye Movement subsections of the Ayers Clinical Observations is only the observation of eye movements, it can be used as a screening tool to establish whether a more in-dept assessment of saccades and oculomotor control is required. The fact that so many South African occupational therapists are using the test (Janse van Rensburg et al., 2018) indicate that they see the value of this observational tool but deficits noted need to be followed up with other standardised tests for appropriate therapy and referral for eye movement deficits to occur. It is also important for occupational therapists to understand the relationship of oculomotor function to other visual deficits, to provide a holistic treatment approach in learners with a specific learning disorder.

5.6.4 Relationship between visual perceptual skills and oculomotor control

When the scores on the TVPS-3 and the DEM were considered there was low significant correlation between the spatial relations, form constancy, visual sequential memory and figure ground subtests and sequential, complex subsection and total scores of the TVPS-3 and the vertical subtest of the DEM (Table 4.10). Thus the 11.6% – 4.4% variation in the scores on the sections of TVPS-3 predict variation in scores on the vertical subtest of the DEM which is used to evaluate fast saccades and RAN (Hopkins et al., 2019). A deficit in RAN has been associated with poor phonological awareness and automaticity, processing speed mastering literacy and reading performance (Van der Strappen and Van Reybroeek, 2018) and is diagnostic for dyslexia (Biscaldi et al., 1998).

Low significant correlations were found between the visual sequential memory and figure ground subtests as well as sequential and complex subsection scores on the TVPS-3 and the horizontal subsection of the DEM (Table 4.10). Thus the 7.2% – 5.6% variation in the scores on the sections of TVPS-3 predict variation in scores on the horizontal subtest of the DEM which is used to evaluate fast saccades, eye movements and oculomotor function (Richman, 2009). In this subtest deficits in saccades and tracking quickly across objects, patterns and lines of text result in objects or letters were indicated. Words being missed or disorientation with the lines on the page with movement down to the line below in mid pattern or sentence and missing words were further indicated by the poor scores obtained. Thus, only variance in visual sequential memory and figure ground subtests of the TVPS-3 where fast saccades appear to affect performance were related to the horizontal subtest of the DEM. This can also be observed by the reduced speed and difficulty in following text when reading and following text with a finger while reading (Drieghe et al., 2004)..

The vertical and horizontal subtests of the DEM was found to have a low association with motor-reduced visual perception constructs on the TVPS-3 (Table 4.10). A greater number of subtests and subsection scores on the TVPS-3 are associated with the vertical subtest on the DEM indicating an association with RAN which could be a diagnostic for possible dyslexia. Although fewer subtests and subsection on the TVPS-3 are associated with the DEM a weak link between oculomotor function and visual perception was indicated.

Looking at the Eye Movement Subtest of the Ayres Clinical Observations, a correlation between figure ground and all of the subcomponents of the Eye Movement Subtest of the Ayres Clinical Observations were found (Table 4.12). This is indicative that difficulty in moving the eyes can influence a person's ability to discern between objects in the forefront and the background and that difficulty with eye movements could be linked to dyslexia (Lawton and Shelley-Tremblay, 2017).

A low significant correlation was found between across midline, convergence, general pursuit and two subsections of the TVPS-3 namely visual sequential memory and form constancy. This is indicative that the ability to memorize sequences is firstly dependant on the ability to perceive sequences. It further indicates that smooth and coordinated tracking of moving objects are important is identifying similarities and dissimilarities of objects within changing environments. When a child has a midline jerk, or are unable to track an object, visual information is bound to be missed. Lastly a low significant correlation was found between visual closure, across midline and convergence. This further suggests that smooth and coordinated eye movements, especially across the midline, is important in the ability to perceive visual objects as a whole.

The weak link between visual perceptual skills and oculomotor control were substantiated by the low significant correlation that was found between visual perceptual skills as measured by the DT-VMI 6, the general pursuit, convergence and the across midline subtests of the Eye Movement Ayres Clinical Observations. Learners with a specific learning disorder, who struggle with reading tasks such as displaying poor phonological awareness, slow reading speed, often miss words, difficulty with orientation of lines on the page and difficulty in following text while reading need to undergo visual perceptual as well as oculomotor control assessment.

5.6.5 Relationship between visual motor integration skills and oculomotor control

Looking at the DT-VMI 6 scores a low significant correlation was found in the both the VMI section and the motor coordination supplemental test and the errors of the DEM (Table 4.13). This indicates 7.2% and 5.7% of the variation in the VMI and motor coordination on the DT-VMI 6 predict variation in the error scores on the DEM. The number of errors made on the DEM are scored for the horizontal test, these are related to oculomotor function in the DT-VMI 6. This reflects missed detail when reproducing shapes on the two motor enhanced tests of the DT-VMI 6. This could be linked to figure ground in particular when copying and reproducing figures.

In their study Hopkins et al. (2019) found a significant correlation between VMI section of the DT-VMI 6 and DEM vertical and horizontal scores as well academic performance. The findings of the current study do not echo these findings. This could be since the sample used by Hopkins et al. (2019) were mainstream Australian children whereas the sample of the current study is South African children in a LSEN school.

A weak link between motor coordination supplemental test and oculomotor control was confirmed by the results on the Eye Movement subtests of the Ayres Clinical Observations since a low significant correlation was found between the general pursuit and the across the midline (Table 4.14). However, no link to the VMI section of the DT-VMI 6 and any of the Eye Movement subtests of the Ayres Clinical Observations were found (Table 4.14). This could be attributed to the fact that the Eye Movement subtests of the Ayers Clinical Observations is only a screening tool and lacks in the amount of detailed information that a standardized assessment tool can provide.

5.7 Strengths and limitations of the study

The strengths of the study were firstly the large sample size which were more than the sample of 65 required for the study. This allowed for results on a heterogeneous sample to produce results that could be differentiated for different oculomotor deficits.

Another strength of the study was that the participants were assessed by an occupational therapist who are familiar to the participant. The occupational therapists were competent in the administration of all the assessment instruments before the study was conducted except the DEM. They furthermore received training before the research took place, to establish their competence in all the tests especially the DEM. Therefore, it can be assumed that the correct, standardized method was used to administer all the tests. This was confirmed by the randomized checking of the score sheets that were done. All the assessments that were checked, was done correctly. The participants were also tested in a familiar environment. This ensured that the scores obtained by the instruments were as accurate as possible.

Limitations of the study was that it was not representative of the South African population in terms of race and gender. Even though research has shown that males are more likely to have specific learning disorder than females, only 23% of the participants in this study was females. The study furthermore made use of convenient sampling since the researcher is currently working at the research site. Data were not normally distributed since the learners with specific learning disorders included, were heterogenous and thus parametric statistics could not be used which may have added rigour to the study.

All testing was done in one session which may have affected the participants attention and resulted in test fatigue.

CHAPTER 6: CONCLUSION

6.1 Main findings

The aim of this study was to determine the visual perceptual, visual motor integration and oculomotor control of foundation phase learners attending a LSEN school and to investigate the relationship between these aspects.

The results of the current study concur with the findings of previous studies (Silver, 2001; Tseng and Chow, 2000; Harris, 2017; Handler and Fierson, 2011), that learners with a specific learning disorder tend to score below their chronological age in some aspects of motor reduced and motor enhanced visual perceptual abilities. This study however found that the lowest scores were obtained in visual discrimination, form constancy and visual closure similar to those reported by Gajre et al. (2015) for Indian children whereas other studies found that learners in South African LSEN schools also had lower scores for visual sequential memory, visual memory and the spatial relations subtests (Buckle, 2019; Harris, 2017). This supports the heterogeneous nature of specific learning disorders and subtypes needs to be considered (Rourke, 1985).

Learners had significant difficulties in the motor coordination supplemental test of the DT-VMI 6 indicating significant motor coordination deficits. This supports the findings of O'Brien et al. (1988) that there are subgroups of learners with specific learning disorder who have more deficits in motor competence. Participants in this study appear to represent a more homogeneous group where motor dyspraxia may be more prevalent (Rourke, 1985), co-occurring with the specific learning disorder.

More than 70% of learners scored significantly lower than the mean for their chronological age in the vertical and horizontal subtest of the DEM. This supports the findings of the author of the test (Richman, 2009) who notes that children with a specific learning disorder scores lower in all the subtests of the DEM. The scores that were obtained in the errors as well as the ratio subsection of the DEM were mostly associated with fast saccadic movement in the horizontal eye movement subsection. This is indicative that almost 50% of all the participants could be identified as having oculomotor deficits associated with motor dysfunction rather than mixed motor and dyslexic dysfunction (Reichle et al., 2009). The results of the Eye Movement subtest of the Ayres Clinical Observations indicated that learners struggled with general pursuit and moving their eyes across the midline obtaining the lowers scores. This could have a negative influence on their reading abilities (Hopkins et al., 2017).

With regards to the relationship between visual perceptual and visual motor integration skills, this study agrees with the findings of previous studies (Ayhan et al., 2015; Barnhardt and Deland, 2005; Bezrukikh and Terebova, 2009; Cho et al., 2015; Sigmundsson and Hopkins, 2005) which found that these two concepts are weakly interrelated. The fact that not all of the subtests correlated significantly further supports the conclusion of previous studies (Parush et al., 1998; Brown, 2012) that even though they are interrelated, it is still two separate entities and should be treated as such.

This study has concluded that oculomotor control is weakly associated with and can be seen as a predictor of 12% to 8% motor-reduced visual perception constructs on the TVPS-3. A greater number of subtests and subsection scores on the TVPS-3 are associated with the vertical subtest on the DEM indicating an association with RAN and possible dyslexia. Although not all subtests and subsection on the TVPS-3 are associated with the DEM, the link between oculomotor function and visual perception should be considered in the intervention of visual perceptual difficulties.

Only the number of errors made on the DEM were associated to oculomotor function in the VMI and motor supplementary test of the DT-VMI 6. This reflects missed detail when reproducing shapes on the two motor enhanced tests of the DT-VMI 6. The link between motor coordination supplemental test and oculomotor control was confirmed by the results on the Eye Movement subtests of the Ayres Clinical Observations since a low significant correlation was found between the general pursuit and the across the midline. Thus, a weak relationship between oculomotor control and motor enhanced visual perception seems to be reflected in the motor supplementary subsection of the DT-VMI 6.

The findings of this study concur with Coté (2015), that visual reception function or oculomotor control is an important aspect of visual information processing, but that it is part of a more complex system which does not develop in a linear or hierarchical manner. Even though there is a clear interrelatedness between visual receptive and visual cognitive processing as suggested by Warren (2013), visual receptive skills do not have to be fully developed in order for visual cognitive processes to develop.

6.2 Clinical recommendations

For future practice it is recommended that occupational therapists include the assessment of oculomotor functioning during evaluations. A screening tool like the Eye Movement subtest of the Ayres Clinical Observations can be useful in determining whether further investigation of oculomotor control is warranted. Many South African Occupational Therapists are using the test (Janse van Rensburg et al., 2018) and this study has further substantiated its relevance. Other instruments like the DEM can also be useful to determine the oculomotor functioning of a child with more accuracy and detailed information.

It is further recommended that occupational therapists who work with children in LSEN schools or children who have been diagnosed with a specific learning disorder, must note that their visual perceptual and visual motor integration skills and motor coordination skills could possibly be below the mean for their chronological age. A thorough evaluation of these client factors are warranted to determine to what extent deficits in these skills might be impacting academical performance.

It is recommended that occupational therapists view the development of visual cognitive processing skills in a dynamic, complex manner where a throughout investigation of each individual person's visual receptive and visual cognitive processing within different environments, is necessary to address their unique visual information processing strengths and weaknesses.

6.3 Recommendations for future research

Firstly, future studies can aim to include participants form a variety of schools which are representative of the South African population in a variety of provinces.

Investigation of the visual perceptual, visual motor integration skills and oculomotor control of children in mainstream schools can be conducted and compared to the findings of this study. This will also ensure that data is more normally distributed and that parametric statistics could be used. Future research could further aim to distribute the administration of the tests to more than one session to prevent test fatigue.

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Appendix A Demographic questionnaire (English version)

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Code: ______________________

The relationship between visual perceptual skills, visual motor integration skills and oculomotor control, in learners attending a LSEN school

To be kept separate

Dear Parent/guardian,

Please complete the following demographic questionnaire concerning your child. All information given will be kept strictly confidential.

Personal information	
Name of parent or guardian	
Child	
Name of child	

Code ____________________

The relationship between visual perceptual skills, visual motor integration skills and oculomotor control, in learners attending a LSEN school

QUESTIONNAIRE

1. Has your child ever been assessed by an optometrist or a behavioural optometrist?
   Yes ☐ No. ☐
   If yes, how long ago was the evaluation?

---

2. Does your child wear glasses? Yes ☐ No. ☐
   If yes, since what age?

---

3. Does your child suffer from any visual condition that cannot be treated with glasses?
   Yes ☐ No. ☐
   If yes, please specify?

---

4. How long has your child been receiving occupational therapy at School of Achievement?

---

5. Did your child receive occupational therapy prior to attending therapy at the school?
   Yes ☐ No. ☐

6. How is your child currently performing at school in the areas of his/her writing, mathematics, spelling and reading?

---

7. Has your child ever repeated any grades? Yes ☐ No. ☐
   If yes, which grades has been repeated and what was the reason?

---

8. Is your child currently taking any medication? Yes ☐ No. ☐

If yes, please indicate the type and dosage of medication;

Name_____________________________________Dosage_________________________

Name_____________________________________Dosage_________________________

Name_____________________________________Dosage_________________________

Thank you very much for your participation in this study.

Appendix B Demografiese vraelys (Afrikaanse weergawe)

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Die verhouding tussen visueel-persepsuale vaardighede, visueel-motoriese integrasie en oculomotoriese beheer van leerders in 'n LSEN skool.

Gaan apart gehou word

Geagte ouer/voog,

Sal u asseblief die onderstaande demografiese vraelys aangaandie u kind invul. Al die inligting was u verskaf sal streng vertroulik gehou word.

Persoonlike inligting	
Naam van ouer of voog	
Kontaknommer	
Kind	
Geboortedatum	
Geslag	
Huidige graad	

Die verhouding tussen visueel-persepsuale vaardighede, visueel-motoriese integrasie en oculomotoriese beheer van leerders in 'n LSEN skool.

VRAELYS

1. Is u kind al voorheen deur 'n optometris of 'n gedrags optometris geasseseer?

   Ja ☐ Nee ☐

   Indien ja, hoe lank gelede was die assessering?

   ____

2. Dra u kind 'n bril? Ja ☐ Nee ☐

   Indien ja, sedert watter ouderdom?

   ____

3. Lei u kind aan enige visuele kondisie wat nie deur die dra van 'n bril behandel kan word nie?

   Ja ☐ Nee ☐

   Indien ja, brei asseblief meer uit oor die kondisie?

   ____

4. Vir hoe lank ontvang u kind al arbeidsterapie by Prestasieskool?

   ____

5. Het u kind enige arbeidsterapie ontvang voorday hy/sy in Prestasieskool is?

   Ja ☐ Nee ☐

6. Hoe vorder u kind tans by die skool ten opsigte van spelling, lees-, skryf-, en numeriesevaardighede?

   ____

7. Het u kind al enige grade herhaal? Ja ☐ Nee ☐

   Indien ja, watter grade is herhaal en wat is die moontlike rede hiervoor?

   ____

8. Neem u kind tans enige medikasie? Ja ☐ Nee ☐

   Indien ja, dui asseblief aan watter tipe medikasie en die dosering;

Naam______________________________Dosering____________________

Naam______________________________________Dosering________________________

Naam______________________________________Dosering________________________

Baie dankie vir u deelname aan die studie.

Appendix C Test of Visual Perceptual Skills 3rd Edition

TEST OF VISUAL PERCEPTUAL SKILLS 3RD EDITION

CODE: ______________________

Examiner: ______________________

Reason for Testing: ______________________

Date of Test ______ year ______ month ______ day

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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Appendix D Developmental Test of Visual-Motor Integration 6th Edition

The Beery–Buktenica
Developmental Test of Visual–Motor Integration

Beery™ VMI Sixth Edition

CODE: ____

Examiner: ____

Test Date: ____ year ____ month ____ day

Ages 2 through 100 (FULL FORM)

by Keith E. Beery, Norman A. Buktenica, and Natasha A. Beery

SUMMARY

See the Beery VMI manual (sixth edition) for norms.

	Beery VMI	Visual Perception	Motor Coordination
Raw Scores:	____	____	____
Standard Scores:	____	____	____
Scaled Scores:	____	____	____
Percentiles:	____	____	____
Other Scaling:	____	____	____

Comments and Recommendations:

PROFILE

Standard Score	Beery VMI	Visual Perception	Motor Coordination	Percentile
145	-	-	-	99.7
140	-	-	-	99.2
135	-	-	-	99
130	-	-	-	98
125	-	-	-	95
120	-	-	-	91
115	-	-	-	84
110	-	-	-	75
105	-	-	-	63
100	-	-	-	50
95	-	-	-	37
90	-	-	-	25
85	-	-	-	16
80	-	-	-	9
75	-	-	-	5
70	-	-	-	2
65	-	-	-	1
60	-	-	-	.8
55	-	-	-	.3

Begin testing on page 1. Turn booklet over with bound edge toward the examinee. If subtests are used, always test in this order: VMI → Visual → Motor.

Product Number 46240/46241

Appendix C Developmental Eye Movement Test

DEM Scoresheet

Code

Articulation Pre-Test Y N   Number Knowledge Pre-Test Y N

/ = substitution error   o= omission error

a = addition error   <or> = transposition error

Test A

3	4
7	5
5	2
9	1
8	7
2	5
5	3
7	7
4	4
6	8
1	7
4	4
7	6
6	5
3	2
7	9
9	2
3	3
9	6
2	4

____sec

Test B

6	7
3	9
2	3
9	9
1	2
7	1
4	4
6	7
5	6
2	3
5	2
3	5
7	7
4	4
8	6
4	3
5	7
2	5
1	9
7	8

____sec

Total Time : ____ sec

Adjusted Time = ____ sec

Errors : _____

Test C

2	5	9	4	3
4	5	2	7	8
3	5	7	4	9
8	7	9	5	7
3	7	1	4	5
6	1	4	6	2
9	3	7	2	6
7	2	4	6	3
6	3	2	9	1
7	4	6	5	2
5	3	7	4	8
4	5	2	1	7
7	9	3	9	2
1	4	7	6	3
2	5	7	4	6
3	7	5	9	8

Time: ______ sec

____ substitution (s) errors   ____ ommision (o) errors

____ addition (a) errors   ____ transposition (t) errors

$$\text{Adjusted Time} = \text{Time} \times \frac{80}{(80 - o + a)}$$

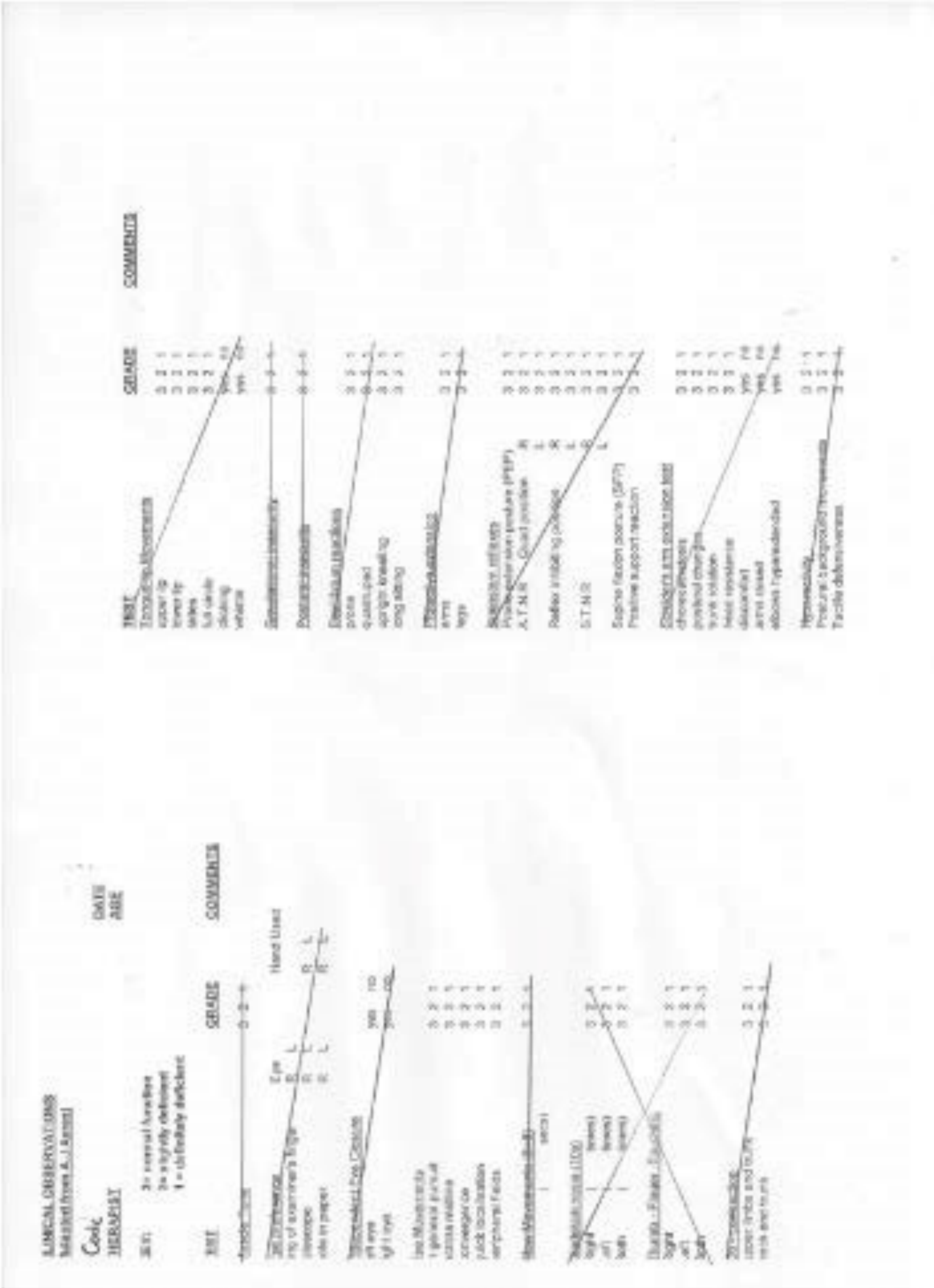
Adjusted Time = ______ sec

Total Errors (s + o + a +t) = ____

$$\text{DEM Ratio} = \frac{\text{Horizontal Adj Time}}{\text{Vertical Adj Time}} = \boxed{\_\_\_\_}$$

DEM1 *(Copyrighted Bernell Corporation 2011)*

Appendix F The Eye Movement Subsection of the Ayres Clinical Observations



Appendix G Ethical Clearance Certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Ms Laetitia Buurman

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M180972

NAME: (Principal Investigator)	Ms Laetitia Buurman
DEPARTMENT:	Occupational Therapy School of Achievement Germiston, Ekurhuleni
PROJECT TITLE:	The relationship between visual perceptual skills, visual motor integration skills and oculomotor control, in learners attending a LSEN school
DATE CONSIDERED:	28/09/2018
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Janine van der Linde
APPROVED BY:	CB Penny Dr C B Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	25/02/2019

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **September** and will therefore be due in the month of **September** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature ____________ Date ____________

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix H Permission to conduct research from the Gauteng Department of Education

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

GDE RESEARCH APPROVAL LETTER

Date:	05 February 2019
Validity of Research Approval:	05 February 2019 – 30 September 2019 2018/389
Name of Researcher:	Buurman L
Address of Researcher:	Westlake Eco Estate
	Unit 225 Westfield Street
	Modderfontein, 1609
Telephone Number:	011 916 1917/ 084 807 7974
Email address:	laetitiabuurman@gmail.com
Research Topic:	The relationship between visual perceptual skills, visual motor integration skills and oculomotor control, in learners attending a LSEN school
Type of qualification	Masters
Number and type of schools:	One LSEN Schools.
District/s/HO	Ekurhuleni South

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

The following conditions apply to GDE research. The researcher may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

05/02/2019

1

Making education a societal priority

Office of the Director: Education Research and Knowledge Management
7th Floor, 17 Simmonds Street, Johannesburg, 2001
Tel: (011) 355 0488
Email: Faith.Tshabalala@gauteng.gov.za
Website: www.education.gpg.gov.za

1. *The District/Head Office Senior Manager/s concerned must be presented with a copy of this letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.*
2. *The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.*
3. *A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.*
4. *A letter / document that outline the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.*
5. *The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, and chairpersons of the SGBs, teachers and learners involved. Persons who offer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.*
6. *Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.*
7. *Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year.*
8. *Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.*
9. *It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.*
10. *The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.*
11. *The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.*
12. *On completion of the study the researcher/s must supply the Director: Knowledge Management & Research with one Hard Cover bound and an electronic copy of the research.*
13. *The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned.*
14. *Should the researcher have been involved with research at a school and/or a district/head office level, the Director concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.*

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards

....

Mr Gumani Mukatuni
Acting CES: Education Research and Knowledge Management

DATE: 05/02/2019

Office of the Director: Education Research and Knowledge Management
7th Floor, 17 Simmonds Street, Johannesburg, 2001
Tel: (011) 355 0488
Email: Faith.Tshabalala@gauteng.gov.za
Website: www.education.gpg.gov.za

Appendix ! Permission to conduct research form the headmaster of School of Achievement

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Department of Occupational Therapy
Wits Education Campus

School of Therapeutic Sciences, Faculty of Health Sciences, 7 York Road, Parktown, 2193, South Africa

Tel: +27 11 717 3701 | Fax: +27 717 3709 | Email: leilane.bogoshi@wits.ac.za | **www.wits.ac.za**

Laetitia Buurman
Westlake EcoEstate
Westfield Street
Unit 225
Modderfontein
1609

The Principal
School of Achievement
Germiston
1459

24 July 2018

Dear Sir,

My name is Laetitia Buurman and I am an occupational therapist currently working at School of Achievement. I am completing my master's degree in occupational therapy at the University of Witwatersrand. In order to complete my degree, I am required to do a research report. The title of the study is: "The relationship between visual perceptual skills, visual motor integration skills and oculomotor control, in learners attending a LSEN school".

The aim of this research project is to determine whether there is a relationship between oculomotor control (eye movements) and visual information processing (which consists mainly of visual perceptual and visual motor integration skills). Occupational therapists routinely assess these skills, but it is unclear what the relationship between visual information processing and eye movement functioning is. If there is more information on the relationship between these aspects, it could influence the way occupational therapists plan intervention for children.

This letter serves as a request to perform my research at your school, School of Achievement, and to use the occupational therapy assessment areas and assessment resources available.

The researcher or the occupational therapist who treats the learner at School of Achievement, will ask the learner to complete the Beery VMI 6th edition and the Test of Visual Perceptual Skills 3rd edition which will involve the recognition of various patterns and shapes. They will also be asked to complete the Developmental Eye Movement Test which involves reading out numbers and the eye movement subsection of the Ayers Clinical Observations where their eye movements will be assessed by asking them to look and follow a pencil tip with their eyes. These tests are routinely used at School of Achievement as part of the occupational therapy assessment. Testing will be done over two sessions on two different days and will take about 25 minutes for the Beery VMI 6th edition and the Test of Visual Perceptual Skills 3rd edition on day 1 and 10 minutes for the eye movement tests on day 2. The assessment will be completed during school hours in the occupational therapy sessions and in the occupational therapy assessment area at School of Achievement. The assessments will not interfere with any participants academical work.

The results will be available to you following the study. If the parent or guardian of the learner provides permission the occupational therapist, who is currently treating the learner, will also be informed of all the results of the assessments. The learner's occupational therapy intervention plan will be adjusted accordingly to ensure that he\she will benefit from therapy.

The parents or guardian will be informed about the study and asked to give written consent for their child to participate in the study. On the day of the assessment the learner will also be asked to give verbal assent that they are willing to participate in the study. There will also be a witness present to confirm that the learner has given verbal assent.

Participation is voluntary, this means that the parents and learner may refuse to participate with no penalty or loss of benefits which they are entitle to within the classroom as well as during their school-based therapy. They may also decide to discontinue participation at any time without penalty loss of benefits to which they are entitled to both within the classroom as well as during school-based therapy.

All the participants personal information such as name, date of birth and results of the assessment will be kept confidential and only known to the researcher and the learner's occupational therapist at School of Achievement. To ensure confidentiality data will be coded with no names attached and this data will be kept in a secure location by the researcher.

If you have any questions you are welcome to contact me, Laetitia Buurman at School of Achievement on 011 916 1917 during school hours or on 084 807 7974.

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg ("Committee"). A principal function of this Committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research.

If you have any concerns or complaints, you can contact the chair and secretariats of the Wits Human Research Ethics Committee (Medical): **Chairperson**: Dr Clement Penny, who may be contacted on telephone number 011 717 2301, or by e-mail on Clement.Penny@wits.ac.za. The telephone numbers for the Committee secretariat are 011 717 2700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za; Rhulani.Mukansi@wits.ac.za. Your permission to allow me to conduct my research at your school will be greatly appreciated.

Yours Sincerely,
Laetitia Buurman
B. Occupational Therapy (UFS)

PERMISSION TO DO RESEARCH FROM THE PRINCIPAL OF SCHOOL OF ACHIEVEMENT

I hereby confirm that I have been informed by the researcher, Laetitia Buurman, about the study project: "The relationship between visual perceptual skills, visual motor integration skills and oculomotor control, in learners attending a LSEN school".

I have also read and understood the information sheet regarding the research project. I understand that the learners' personal details such as their names, date of birth, and results of the assessments will be kept anonymous.

I agree that the occupational therapists at school can assist the researcher and complete the Beery VMI 6th edition and the Test of Visual Perceptual Skills 3rd edition with the children who they are currently seeing for therapy. I agree that all the occupational therapy assessment areas and recourses needed to complete the assessments can be used at School of Achievement.

I agree to allow the learners in my school to participate in the study outlined in the information sheet.

Principal's name: ________________________________

____

____

Principal's signature Date

PERMISSION TO DO RESEARCH FROM THE PRINCIPAL OF SCHOOL OF ACHIEVEMENT

I hereby confirm that I have been informed by the researcher, Laetitia Buurman, about the study project: "The relationship between oculomotor control and visual-information processing skills in learners attending a LSEN school".

I have also read and understood the information sheet regarding the research project. I understand that the learners' personal details such as their names, date of birth, and results of the assessments will be kept anonymous.

I agree that the occupational therapists at school can assist the researcher and complete the Beery VMI 6th edition and the Test of Visual Perceptual Skills 3rd edition with the children who they are currently seeing for therapy. I agree that all the occupational therapy assessment areas and recourses needed to complete the assessments can be used at School of Achievement.

I agree to allow the learners in my school to participate in the study outlined in the information sheet.

Principal's name: Tinus du Preez

Principal's signature

07/02/2019

Date

Appendix H Permission to conduct research from the Head of the Occupational Therapy Department as School of Achievement

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Department of Occupational Therapy
Wits Education Campus

School of Therapeutic Sciences, Faculty of Health Sciences, 7 York Road, Parktown, 2193, South Africa

Tel: +27 11 717 3701 | Fax: +27 717 3709 | Email: leilane.bogoshi@wits.ac.za | **www.wits.ac.za**

Laetitia Buurman
Westlake EcoEstate
Westfield Street
Unit 225
Modderfontein
1609

The Head of Department
Occupational Therapy
School of Achievement
Germiston
1459

24 July 2018

Dear Madam,

My name is Laetitia Buurman and I am an occupational therapist currently working at School of Achievement. I am completing my master's degree in occupational therapy at the University of Witwatersrand. In order to complete my degree, I am required to do a research report. The title of the study is: "The relationship between visual perceptual skills, visual motor integration skills and oculomotor control, in learners attending a LSEN school".

The aim of this research project is to determine whether there is a relationship between oculomotor control (eye movements) and visual information processing (which consists mainly of visual perceptual and visual motor integration skills).

Occupational therapists routinely assess these skills, but it is unclear what the relationship between visual information processing and eye movement functioning is. If there is more information on the relationship between these aspects, it could influence the way occupational therapists plan intervention for children.

This letter serves as a request to perform my research at School of Achievement and to use the occupational therapy assessment areas and assessment resources available.

The researcher or the occupational therapist who treats the learner at School of Achievement, will ask the learner to complete the Beery VMI 6th edition and the Test of Visual Perceptual Skills 3rd edition which will involve the recognition of various patterns and shapes. They will also be asked to complete the Developmental Eye Movement Test which involves reading out numbers and the eye movement subsection of the Ayers Clinical Observations where their eye movements will be assessed by asking them to look and follow a pencil tip with their eyes. These tests are routinely used at School of Achievement as part of the occupational therapy assessment. Testing will be done over two sessions on two different days and will take about 25 minutes for the Beery VMI 6th edition and the Test of Visual Perceptual Skills 3rd edition on day 1 and 10 minutes for the eye movement tests on day 2. The assessment will be completed during school hours in the occupational therapy sessions and in the occupational therapy assessment area at School of Achievement. The assessments will not interfere with any participants academical work.

The results will be available to you following the study. If the parent or guardian of the learner provides permission the occupational therapist, who is currently treating the learner, will also be informed of all the results of the assessments. The learner's occupational therapy intervention plan will be adjusted accordingly to ensure that he\she will benefit from therapy.

The parents or guardian will be informed about the study and asked to give written consent for their child to participate in the study. On the day of the assessment the learner will also be asked to give verbal assent that they are willing to participate in the study. There will also be a witness present to confirm that the learner has given verbal assent.

Participation is voluntary, this means that the parents and learner may refuse to participate with no penalty or loss of benefits which they are entitle to within the classroom as well as during their school-based therapy. They may also decide to discontinue participation at any time without penalty loss of benefits to which they are entitled to both within the classroom as well as during school-based therapy.
All learner's personal information such as name, date of birth and results of the assessment will be kept confidential and only known to the researcher and the learner's occupational therapist at School of Achievement. To ensure confidentiality data will be coded with no names attached and this data will be kept in a secure location by the researcher.

If you have any questions you are welcome to contact me, Laetitia Buurman at School of Achievement on 011 916 1917 during school hours or on 084 807 7974.

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg ("Committee"). A principal function of this Committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research.

If you have any concerns or complaints, you can contact the chair and secretariats of the Wits Human Research Ethics Committee (Medical): **Chairperson**: Dr Clement Penny, who may be contacted on telephone number 011 717 2301, or by e-mail on Clement.Penny@wits.ac.za. The telephone numbers for the Committee secretariat are 011 717 2700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za; Rhulani.Mukansi@wits.ac.za. Your permission to allow me to conduct my research at your school will be greatly appreciated.

Yours Sincerely,
Laetitia Buurman
B. Occupational Therapy (UFS)

PERMISSION TO DO RESEARCH HEAD OF OCCUPATIONAL THERAPY DEPARTMENT AT SCHOOL OF ACHIEVEMENT

I hereby confirm that I have been informed by the researcher, Laetitia Buurman, about the study project: "The relationship between visual perceptual skills, visual motor integration skills and oculomotor control, in learners attending a LSEN school".

I have also read and understood the information sheet regarding the research project.

I understand that the learners' personal details such as their names, date of birth, and results of the assessments will be kept anonymous.

I agree that the occupational therapists at school can assist the researcher and complete the Beery VMI 6th edition and the Test of Visual Perceptual Skills 3rd edition with the children who they are currently seeing for therapy. I agree that all the occupational therapy assessment areas and recourses needed to complete the assessments can be used at School of Achievement.

____

Head of the Occupational Therapy Department at School of Achievement's

____________________________ ____________________________

Head of Department's signature Date

PERMISSION TO DO RESEARCH HEAD OF OCCUPATIONAL THERAPY DEPARTMENT AT SCHOOL OF ACHIEVEMENT

I hereby confirm that I have been informed by the researcher, Laetitia Buurman, about the study project: "The relationship between visual perceptual skills, visual motor integration skills and oculomotor control, in learners attending a LSEN school".

I have also read and understood the information sheet regarding the research project.

I understand that the learners' personal details such as their names, date of birth, and results of the assessments will be kept anonymous.

I agree that the occupational therapists at school can assist the researcher and complete the Beery VMI 6th edition and the Test of Visual Perceptual Skills 3rd edition with the children who they are currently seeing for therapy. I agree that all the occupational therapy assessment areas and recourses needed to complete the assessments can be used at School of Achievement.

Retha van Lingen

Head of the Occupational Therapy Department at School of Achievement's

09/02/2019

Head of Department's signature

Date

Appendix K Parent/Guardian information letter

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Department of Occupational Therapy
Wits Education Campus

School of Therapeutic Sciences, Faculty of Health Sciences, 7 York Road, Parktown, 2193, South Africa

Tel: +27 11 717 3701 | Fax: +27 717 3709 | Email: leilane.bogoshi@wits.ac.za | **www.wits.ac.za**

The relationship between visual perceptual skills, visual motor integration skills and oculomotor control, in learners attending a LSEN school

Dear parent/guardian,

My name is Laetitia Buurman and I am an occupational therapist currently working at School of Achievement. I am completing research for my master's degree in occupational therapy at the University of Witwatersrand.

The aim of this research project is to determine whether there is a relationship between oculomotor control (eye movements) and visual information processing (which consists mainly of visual perceptual and visual motor integration skills). Occupational therapists routinely assess these skills, but it is unclear what the relationship between visual information processing and eye movement functioning is. If there is more information on the relationship between these aspects, it could influence the way occupational therapists treat these aspects. I am inviting your child to be part of the study.

If you give consent for your child to participate in this study you will be asked to complete a demographic questionnaire. I or the occupational therapist who treats your child at School of Achievement, will ask them to complete the Beery VMI 6th edition and the Test of Visual Perceptual Skills 3rd edition which will involve the recognition of various patterns and shapes. They will also be asked to complete the Developmental Eye Movement Test which involves reading out numbers and the eye movement subsection of the Ayers Clinical Observations where their eye movements will be assessed by asking them to look and follow a pencil tip with their eyes. These are tests which are routinely used at School of Achievement as part of the occupational therapy assessment. Testing will be done over two sessions on two different days and will take about 25 minutes for the Beery VMI 6th edition and

the Test of Visual Perceptual Skills 3rd edition on day 1 and 10 minutes for the eye movement tests on day 2.
The assessment will be completed during school hours in the occupational therapy sessions and in the occupational therapy assessment area at School of Achievement. The assessments will not interfere with any participants academical work.

If you agree to allow your child to participate, I will also ask them to give verbal assent that they are willing to take part. There will also be a witness present to confirm that your child has given verbal assent.

Feedback on your child's results will be provided to you and with your permission the occupational therapist, who is currently treating your child, will also be informed of all the results of the assessments. Your child's occupational therapy intervention plan will be adjusted accordingly to ensure that he\she will benefit from therapy.

You or your child can withdraw from the research project at any time without having to provide a reason. If you decide to withdraw for the study or choose not to participate the occupational therapy treatment your child receives at School of Achievement will not be influenced in any way.

Your child's personal information such as name, date of birth and results of the assessment will be kept confidential and only known to the researcher and your child's occupational therapist at School of Achievement. To ensure confidentiality data will be coded with no names attached and this data will be kept in a secure location by the researcher.

If you have any questions you are welcome to contact me Laetitia Buurman at School of Achievement on 011 916 1917 during school hours or on 084 807 7974.

This study has been approved by the Human Research Ethics Committee (Medical) of the University of the Witwatersrand, Johannesburg ("Committee"). A principal function of this Committee is to safeguard the rights and dignity of all human subjects who agree to participate in a research project and the integrity of the research.

If you have any concerns or complaints, you can contact the chair and secretariats of the

Wits Human Research Ethics Committee (Medical) **Chairperson**: Dr Clement Penny, who may be contacted on telephone number 011 717 2301, or by e-mail on Clement.Penny@wits.ac.za. The telephone numbers for the Committee secretariat are 011 717 2700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za; Rhulani.Mukansi@wits.ac.za If you are happy to allow your child to take part in the study, please read and sign the consent form.

Laetitia Buurman

B. Occupational Therapy (UFS)

Appendix L Ouer/voog inligtingsbrief

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Department of Occupational Therapy
Wits Education Campus

School of Therapeutic Sciences, Faculty of Health Sciences, 7 York Road, Parktown, 2193, South Africa

Tel: +27 11 717 3701 | Fax: +27 717 3709 | Email: leilane.bogoshi@wits.ac.za | **www.wits.ac.za**

Die verhouding tussen visueel-persepsuele vaardighede, visueel-motoriese integrasie en oculomotoriese beheer van leerders in 'n LSEN skool.

Geagte ouer/voog,

My naam is Laetitia Buurman en ek is 'n arbeidsterapeut wat tans by Prestasieskool werk. Ek is ook tans besig om my meestersgraad aan die Universiteit van die Witwatersrand te voltooi. As deel van my graad, moet ek 'n navorsingsprojek doen.

Die doel van my navorsingsprojek is om te bepaal of daar 'n verhouding is tussen oculomotoriese beheer (oogbewegings) en visuele-inligtingsprosessering (wat hoofsaaklik uit visueel-persepsuele vaardighede en visueel motoriese integrasie bestaan). Arbeidsterapeute evalueer die bogenoemde vaardighede op 'n gereelde basis, maar daar is nie tans duidelikheid oor die verhouding tussen oculomotoriese beheer en visueleinligtingsprosessering nie. Indien daar meer inligting oor die verhouding tussen die aspekte is, kan dit 'n invloed hê op die manier wat arbeidsterapeute die aspekte evalueer en behandel.

Ek nooi u kind uit om deel te neem aan die studie. Indien u toestemming gee dat u kind aan die studie kan deelneem, sal ek of die arbeidsterapeut wat tans u kind by Prestasieskool behandel, u kind vra om die *Beery VMI 6^de^ uitgawe* en die *Test of Visual Perceptual Skills 3^de^ uitgawe* wat die herkenning van 'n verskeidenheid patrone en vorms insluit, te voltooi. U kind sal ook gevra word om die *Developmental Eye Movement Test* wat die lees van nommers insluit en die oogbeweging subtoets van die *Ayers Clinical Observations* waarby u kind gevra gaan word om 'n potlood met hulle oë te volg. Al die bogenoemde toetse word op 'n gereelde basis by Prestasieskool gebruik deur die arbeidsterapeute, tydens die evalusie van leerders. Die evaluasie gaan tydens twee sessies oor twee verskillende dae geskied. Die

Beery VMI 6^de uitgawe en die *Test of Visual Perceptual Skills 3^de uitgawe* sal op dag een afgele word en albei toetse saam neem ongeveer 25 minute om te voltooi.
Die *Developmental Eye Movement Test* en die oogbeweging subtoets van die *Ayers Clinical Observations* sal op dag twee afgelê word en neem ongeveer 10 minute om te voltooi.

Die evaluasie sal gedurende skoolure gedoen word tydens die arbeidsterapiesessietyd in die arbeidsterapie-evaluasiekamer by Prestasieskool. Die evaluasie sal nie met enige skoolwerk inmeng nie.

Indien u toestemming gee vir u kind om deel te neem aan die studie, gaan die navorser vir u kind op die dag van die evaluasie ook toestemming vra of hulle aan die studie wil deelneem. Daar sal 'n ooggetuie wees wat toesien dat u kind wel ook toestemming gee om deel te neem aan die studie.

Terugvoer aangaande u kind se resultate sal aan u verskaf word en met u toestemming sal die resultate ook aan die arbeidsterapeut wat u kind by Prestasieskool behandel verskaf word. U kind se behandelingsprogram sal dan aangepas word indien nodig om te verseker dat u kind die beste behandeling ontvang.

U of u kind kan enige tyd gedurende die studie onttrek sonder om 'n rede vir die onttrekking te verskaf. Indien u kies om te onttrek van die studie sal die arbeidsterapie wat u kind ontvang by Prestasieskool op geen manier beinvloed word nie.

U kind se persoonlike inligting soos naam, geboortedatum en uitslae van die toetsing sal vertroulik gehou word en slegs bekend wees aan die navorser en die arbeidsterapeut wat u kind behandel by Prestasieskool. Om te verseker dat u kind se persoonlike inligiting vertroulik bly, sal data op die evaluasietoetse 'n kode ontvang en geen name sal op evaluasievorms geskryf word nie. Indien u enige vrae het, is u welkom om my Laetitia Buurman by Prestasieskool te kontak by 011 916 1917 gedurende skoolure of op 084 807 7974.

Die studie is goedgekeur deur die Menslike Navorsings Etiekkommitee (Medies) by die Universiteit van die Witwatersrand. Een van die hoof prioriteite van die kommitee is om die regte en waardigheid van alle persone wat deelneem aan die navorsingsprojek te beskerm.

Indien u enige bekommernisse of klagtes het is u welkom om die hoof en sekretaris van die Wits Menslike Navorsings Etiekkommitee (Medies): **Voorsitter**: Dr Clement Penny, wie telefonies gekontak kan word by 011 717 2301, of per e-pos by Clement.Penny@wits.ac.za. Die telefoonnommers vir die kommitee se sekretaresse is 011 717 2700/1234 en per e-pos Zanele.Ndlovu@wits.ac.za; Rhulani.Mukansi@wits.ac.za.

Indien u instem dat u kind kan deelneem aan die studie, lees en teken asseblief die toestemmingsbrief.

Laetitia Buurman

B. Occupational Therapy (UFS)

Appendix M Parent Consent Form

PARENT CONSENT SHEET

WITS UNIVERSITY

The relationship between visual perceptual skills, visual motor integration skills and oculomotor control, in learners attending a LSEN school

- I hereby confirm that I have been informed of the study by the researcher, Laetitia Buurman. I have been given a Participant Information Sheet which explains the nature and processes involved in this study, which is attached hereto;
- I believe I fully understand why the study is being conducted and what the intended outcomes will be;
- I understand that there will be no immediate benefit to my child, should I agree that my child participates, nor will I receive any payment; conversely, participation will not cost me anything but my time;
- I understand that, even if I initially give consent for my child to take part in the study, I may subsequently withdraw permission at any time and would not be required to give any reasons; if that happened, any data collected about my child for the purposes of the study would immediately be destroyed, unless I give consent for it to be retained
- I have been given a range of contact details, listed below. If I require further information

Name of child: ________________________________

Name of parent or guardian: ____________________________

I would like the results of all the tests to be made available to the occupational therapist who is treating my child at School of Achievement: Yes ☐ No. ☐

Signature of parent of guardian Date

You may contact the researcher by phoning Laetitia Buurman at School of Achievement on 011 916 1917 during school hours or on 084 807 7974 if you have questions about the research.

If you have any concerns or complaints, you can contact the chair and secretariats of the Wits Human Research Ethics Committee (Medical): **Chairperson**: Dr Clement Penny, who may be contacted on telephone number 011 717 2301, or by e-mail on Clement.Penny@wits.ac.za. The telephone numbers for the Committee secretariat are 011 717 2700/1234 and the e-mail addresses are Zanele.Ndlovu@wits.ac.za; Rhulani.Mukansi@wits.ac.za.

Appendix N Ouer/voog Toestemmingsbrief

OUERSTOESTEMMINGSBRIEF

Die verhouding tussen visueel-persepsuele vaardighede, visueel-motoriese integrasie en oculomotoriese beheer van leerders in 'n LSEN skool.

- Hiermee bevestig ek dat Laetitia Buurman my ingelig het van die studie. Ek het die Deelnemer Iniligtingsstuk ontvang wat beskryf wat die studie behels en watter proses gevolg gaan word; wat hierby aangheg is.
- Ek glo dat ek ten volle verstaan hoe die studie uitgevoer gaan word en wat die voorgenome uitkomste van die studie sal wees.
- Ek verstaan dat daar geen dadelike voordeel vir my kind sal wees en ek sal ook nie enige vergoeding ontvang indien ek besluit om deel te neem aan die studie.

  Deelname aan die studie sal geen koste vir u die deelnemer inhou nie.
- Ek verstaan al gee ek toestemming vir my kind om aan die studie deel te neem, kan ek enige tyd gedurende die studie onttrek sonder om enige rede te verskaf. Indien u sou besuit om te onttrek sal enige data wat ingesamel is dadelik verniettig word tensy u toestemming gee dat dit as deel van die studie kan gebruik word.

Naam van u kind: ________________________________

Naam van ouer of voog: ________________________________

Ek gee toestemming dat al die uitslae van die toetse aan die arbeidsterapeut, wie my kind by Prestasieskool behandel, bekend gemaak word: Ja ☐ Nee ☐

______________________ ___________________

Handtekening van ouer of voog Datum

U is welkom om die navorser, Laetitia Buurman, te kontak deur Prestasieskool by 011 916 1917 gedurende skoolure of 084 807 7974 indien u enige verdere vrae het. Indien u enige bekommernisse of klagtes het is u welkom om die hoof en sekretaris van die Wits Menslike Navorsings Etiekkommitee (Medies): **Voorsitter**: Dr Clement Penny, wie telefonies gekontak kan word by 011 717 2301, of per e-pos by Clement.Penny@wits.ac.za. Die telefoonnommers vir die kommitee se sekretaresse is 011 717 2700/1234 en per e-pos Zanele.Ndlovu@wits.ac.za; Rhulani.Mukansi@wits.ac.za.

Appendix O Assent for child participants

ASSENT FOR CHILD PARTICIPANTS

The relationship between visual perceptual skills, visual motor integration skills and oculomotor control, in learners attending a LSEN school

Hallo, my name is Laetitia. I am an occupational therapist. How are you today? Would you please come with me to do some drawings, copying and matching?

Thank you.

____

Name of witness

______________________________ ______________________________

Signature of witness Date

____

Signature of researcher

Appendix P Toestemmingsbrief vir kind deelnemer

TOESTEMMINGSBRIEF VIR KIND DEELNEMER

Die verhouding tussen visueel-persepsuele vaardighede, visueel-motoriese integrasie en oculomotoriese beheer van leerders in 'n LSEN skool.

Hallo, my naam is Laetitia. Ek is 'n arbeidsterapeut. Hoe gaan dit vandag? Sal jy asseblief saam met my kom om tekeninge te maak en prentjies bymekaar te pas?

Dankie.

Naam van getuie

Handtekening van getuie

Datum

Appendix Q Permission to change title of research

UNIVERSITY OF THE
WITWATERSRAND
JOHANNESBURG

Private Bag 3 Wits, 2050
Fax: 027117172119
Tel: 02711 7172076

Reference: Mrs Sandra Benn
E-mail: sandra.benn@wits.ac.za

04 January 2019
Person No: 1935050
TAA

Mrs L Buurman
Unit 771
Greenstone Ridge
Greenstone
1609
South Africa

Dear Mrs Laetitia Buurman

Master of Science in Occupational Therapy: Change of title of research

I am pleased to inform you that the following change in the title of your Research Report for the degree of **Master of Science in Occupational Therapy** has been approved:

From:

To: **The relationship between visual perceptual skills, perceptual skills, visual motor integration skills and oculomotor control, in learners attending a LSEN school**

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences

Appendix R Turnitin Report

Turnitin

ORIGINALITY REPORT

4%	3%	2%	5%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	pdfs.semanticscholar.org Internet Source	2%
2	Submitted to University of Witwatersrand Student Paper	2%
3	edoc.site Internet Source	1%

Exclude quotes	On	Exclude matches	< 1%
Exclude bibliography	On		