VISUAL PERCEPTUAL DEFICITS IN DIFFERENT TYPES OF CEREBRAL PALSY

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Declaration

I, Sharna Berelowitz declare that this research report is my own work. It is being submitted for the degree of Master of Science in Occupational Therapy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

[Signature of candidate] ____________________

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Abstract

Children with cerebral palsy (CP) have been found to have visual perceptual impairments (VPI). Occupational therapists working with children with CP need to consider these deficits when treating children with CP. There is little research related to the trends of VPI in children with different subtypes of CP, specifically in a South African context.

The purpose of this study was to determine the specific VPI in children ages 5-18 years with CP using the Test of Visual Perceptual Skills-3 (TVPS-3) and to compare the subtest scores and composite scores with different subtypes of CP as well as demographic variables. The Test of Visual perceptual Skills 3rd ed. (TVPS-3) was used to assess 80 learners between the ages of 4-18 years with various subtypes of CP.

All the subtypes of CP have VPI, with the right spastic (hemiplegic) unilateral group having the least impairments and the ataxic group the greatest impairments. Different subtypes of CP show different impairments in VPI and there is a significant difference in visual discrimination and figure-ground scores of the TVPS-3. A significant difference is found in the composite basic processes scores between different subtypes of CP as well as between males and females. No significant differences are found between different ages and GMFCS levels.

The results in this study found that learners with all subtypes of CP have VPI. The spastic unilateral (right) CP groups had the highest overall scores and the ataxic group had the lowest scores. The different subtypes of CP showed different trends in VPI. There was a significant difference in the visual discrimination and figure-ground subtest scores as well as the composite basic processes scores between the different subtypes of CP as well as between males and females. Participants with unilateral spastic CP had more impairment in sequential memory and spatial components while the participants with bilateral spastic CP had greater impairments in visual decimation related components. No significant differences are found between different ages and GMFCS levels.

Visual impairment and the level of intellectual impairment were limitations to the study. Further research on a larger sample of South African learners is recommended.

Acknowledgements

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Definitions

Cerebral Palsy	"Cerebral Palsy describes a group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing foetal or infant brain. The motor disorders of CP are often accompanied by disturbances of sensation, perception, cognition, communication, behaviour, by epilepsy and by secondary musculoskeletal problems." (Rosenbaum et al., 2006):p9
Visual Perception	The ability to give meaning or interpret what is being seen. It requires higher levels of the central nervous system to recognise or interpret visual information (Brown et al., 2003)
Occupational Therapy	"Occupational Therapy is a client centred health profession concerned with promoting health and wellbeing through occupation. The primary goal of Occupational Therapy is to enable people to participate in the activities of daily life" (WFOT, 2012).

Abbreviations

CP:	Cerebral Palsy
CNS	Central Nervous System
CHBAH:	Chris Hani Baragwanath Academic Hospital
GMFCS:	Gross Motor Function Classification System
LL:	Lower Limb
LSEN:	Learners with Special Educational Needs
MACS:	Manual Ability Classification System
MID:	Mild Intellectual Disability
MRI:	Magnetic Resonance Imaging
PVL:	Periventricular Leukomalacia
SCPE:	The Surveillance of Cerebral Palsy in Europe
SD:	Standard Deviation
SLD:	Specific Learning Difficulties
TVPS-3:	Test of Visual Perceptual Skills 3rd Edition
UL:	Upper Limb
VPI:	Visual Perceptual Impairment
WHO:	World Health Organisation

CHAPTER 1: INTRODUCTION

1.1 Introduction

Cerebral palsy (CP) occurs as a result of an early, non-progressive lesion to the central nervous system (CNS) in children. These children present with a variety of different developmental disorders depending on the area of the lesion in the brain. Visual perceptual ability is one of the many areas that is often impaired in children with CP. Ego *et al.* (2015) indicate that there is no accepted prevalence rate of visual perceptual impairment (VPI) in children with CP. However, when working with a variety of children with CP, the researcher noted that many of them have visual perceptual deficits.

Visual perceptual impairment (VPI) is the umbrella term for a variety of cognitive and perceptual disorders, some of which include; visual form discrimination, spatial relationships and figure–ground discrimination. These perceptual deficits have functional implications for children with CP and can affect their academic performance in reading ability and learning (Tsai et al., 2006) as well as their activities of daily living (ADL's) such as dressing. Other studies further support this by showing that visual perceptual deficits are related to reading difficulties (Kozeis et al., 2007). Critten *et al.*, (2018) also found an association between visual perceptual impairment and mathematical abilities in children with CP and therefore suggested that by working on underlying visual perceptual skills, mathematics can be improved in children with CP. In occupational therapy, in order to treat visual perceptual impairments in children with CP, a bottom up approach is used, in order for the child to participate optimally at home, at school and in their community (Cho et al., 2015).

The type of visual perceptual deficits and the degree of impairment differs from child to child. Different lesion patterns in the brain, different aetiological factors and clinical characteristics have been associated with children with different subtypes of CP. It has been found that visual perceptual problems appear to differ according to the subtype of CP with which the child presents (Ego et al., 2015).

It is essential that visual perceptual skills of children with CP are assessed in order to gain a better understanding of their impairment and in turn develop effective treatment methods (Ramkumar and Gupta, 2016). Where occupational therapy services are provided for children with CP, it is important to determine the visual perceptual impairment related to the different CP subtypes in order to provide appropriate assessment and treatment. This is particularly valid in South Africa where resources for the treatment of children with CP are limited, especially in the public sector where caseloads are high. It is often necessary to treat children in groups rather than individual sessions in this setting. Determining whether there is a trend in visual perceptual impairments and subtypes of CP will allow for easier clustering of children for group therapy.

1.2 Statement of Problem

Visual perceptual impairment is a complex set of deficits which are usually assessed in occupational therapy using standardized tests and by determining the effect these deficits have on the completion of everyday activities. According to Ego *et al.*, (2015) the research evidence for VPI in different subtypes of CP is low due to inconsistent terminology and previous research on visual perception in different subtypes of CP being completed in the 1950's and 1960's before newer validated assessments were available. Thus, there is limited knowledge about visual perceptual impairment in children with CP. Literature reports that between 40% - 50% of children with CP have VPI (Ego et al., 2015) but there is little research regarding the specific visual perceptual impairment in children with different subtypes of CP in South Africa.

Forest Town School is a school for Learners with Special Educational Needs (LSEN). Therefore, all the children in the school have either physical or learning difficulties. A large team of therapists is employed by the Department of Education, which includes; 5 occupational therapists, 4 speech therapists, 5 physiotherapists and 1 psychologist. The occupational therapy department provides therapy for most of the learners in the school and therefore each therapist has a case load of about 50-60 children a week. They therefore have to provide group therapy in order to see every child weekly. Groups are usually made up of children with similar needs, whether it be physical or cognitive. This study would therefore be beneficial in determining whether children with specific types of CP should be grouped together when aiming to address visual perceptual needs.

1.3 Purpose of the Study

Although research has been completed on the visual perceptual impairments of children with some of the different subtypes of CP, no such research for children in South Africa has been reported. This study will therefore investigate visual perceptual impairment in children with different subtypes of CP in a school for learners with special educational needs (LSEN) in Johannesburg.

1.4 Research Question

What are the differences in VPI's between the children with different subtypes of CP attending a school for learners with special needs (LSEN)?

1.5 Aim of the Study

To describe the differences between the VPI's amongst children with varying subtypes of CP attending a school for learners with special educational needs (LSEN) in Johannesburg.

1.5.1 Objectives of the Study

- To determine the specific VPI in children aged 5-18 years with CP using the Test of Visual Perceptual Skills-3 (TVPS-3)
- To compare the subtest scores and composite scores on the TVPS-3 for children with different subtypes of CP – bilateral spasticity (diplegia and quadriplegia), unilateral spasticity (left or right hemiplegia) and movement disorders (athetoid and ataxic) (Morris, 2007).
- To compare the composite VPI scores of children with CP according to demographic variables.

1.6 Null Hypothesis

There will be no differences in the visual perceptual scores of the children with different subtypes of cerebral palsy.

1.7 Justification for the Study

Children with CP have numerous functional, physical and intellectual impairments. As an occupational therapist working with children with CP it is important to prioritise therapy aims. Occupational therapists are often the designated professionals responsible for the assessment and treatment of visual perception in children with CP. Ramkumar and Gupta, (2016), found that cognitive-perceptual and perceptual motor occupational therapy intervention is effective in improving the visual perception of children with Cerebral Palsy. Improved knowledge of the visual perceptual skills of the child with CP could facilitate improved and appropriate treatment strategies. Increased awareness into the prevalence of visual perceptual impairment in different types of CP will result in increased awareness of the need to assess and treat visual perception in these children. Insight into trends of visual perceptual impairment in different subtypes of CP will allow the therapist to treat groups of children more appropriately and effectively.

1.8 Layout of the Study

This study consists of six chapters which describe the process of determining the VPI's in children with CP in an LSEN school in Johannesburg.

1.8.1 Chapter 1: Introduction

This chapter introduces the topic involving VPI in children with CP and explains the rationale for the research study. It highlights the purpose of completing the study by identifying the problem statement, research question and the aim and justification for the study.

1.8.2 Chapter 2: Literature Review

This chapter reviews the literature around CP and VPI and further identifies the specific visual perceptual deficits in children with CP. The prevalence, classification, aetiology and pathogenesis of CP is reviewed. It includes the literature around the neurophysiology of VPI, visual perceptual models and assessment of visual perception.

1.8.3 Chapter 3: Methodology

This chapter covers the steps taken to complete the research. It explains the chosen quantitative, cross-sectional research design, the population of children with CP and research site used in the study. It further explains the measuring techniques that were used including the TVPS-3 assessment. It also looks at the ethical considerations that were adhered to.

1.8.4 Chapter 4: Results

This chapter includes the results of the study. It presents the results of the demographic information as well as looks at a comparison between the results of the TVPS-3 subtests scores and overall and composite scores. Additionally, it looks at the comparison between the scores of the participants on different GMFCS levels.

1.8.5 Chapter 5: Discussion

In this chapter, the findings of the study are discussed according to the objectives of the study. This is done by discussing the findings of the specific VPI in children aged 5-18 years with different subtypes of CP, as well as comparing the subtest and composite scores. The demographics are also discussed by comparing the composite VPI scores according to age, GMFCS level and gender.

1.8.6 Chapter 6: Conclusion

This chapter presents the conclusion drawn from the study. It also presents the limitations and recommendations for future studies.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

In this chapter relevant literature related to the research question and objectives of the study was reviewed. The first section covers literature related to CP and includes the classification, prevalence, aetiology and pathogenesis as well as the impairments associated with CP. The second section reviews visual perception, visual perceptual impairments, tests used to assess visual perception and the impact that visual perceptual disorders have on function. The last section links these two topics by reviewing literature related to visual perceptual impairment in children with CP. Literature was sourced from Science Direct, Ovid, Pub Med, EBSCO Host, and ERIC Databases. Literature from 1950's till 2000's is included as this was the period when iconic work on visual perception was completed in occupational therapy.

2.2 Cerebral Palsy

The definition, classification, prevalence, aetiology, pathogenesis and prevalence resulting in associated impairments in CP are considered.

The definition of CP has gone through a number of adjustments and alterations with contributions from the World Health Organisation (WHO) and International Classification of Function, Health and Disability (ICF). According to Rosenbaum *et al.*, (2006) a definition which is acceptable to health researchers and clinicians' states that-

> "Cerebral Palsy describes a group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing foetal or infant brain. The motor disorders of CP are often accompanied by disturbances of sensation, perception, cognition, communication, behaviour, by epilepsy and by secondary musculoskeletal problems." (Rosenbaum et al., 2006):p9

This definition contributes to a collective language of those involved in investigating and providing appropriate services to children with CP by including consequences and impairments associated with the condition. This is important for occupational therapy as it does not only take motor impairments into consideration but also associated impairments and activity limitations which can be addressed in therapy (Rosenbaum et al., 2006).

Despite the international definition created to find common ground amongst health professionals, there is still some controversy about what should be defined as CP. This includes the definition of hypotonia, post-natal causes of brain damage and developmental co-ordination disorder (DCD) (Armstrong, 2007). For this reason, the prevalence of CP is hard to establish when different criteria are used to diagnose the condition.

2.3 Prevalence of Cerebral Palsy

In the developed world, the estimated incidence of CP is between 2 and 3 per 1000 live births (Morris, 2007) (Shevell et al., 2013) (Steultjens et al., 2004). However the prevalence estimates of CP around the world range from 1,5 to more than 4 per 1000 live births (Johnson, 2002) (Winter et al., 2018). There is little accurate reporting of the prevalence of CP within developing countries. In Africa, Donald *et al.*, (2015) estimates this is between 2 to 10 per 1000 live births. Therefore, it is evident that the prevalence of CP in African countries is different to that of the rest of the world. The severity of the disability of children in Africa and other resource constrained countries is higher (Couper, 2002). Within South Africa, there is a lack of reliable data about the prevalence of disability. A study in rural Kwa-Zulu Natal found disability prevalence of 10 in 1000 live births accounted for children with CP (Couper, 2002).

2.3.1 Classification of Cerebral Palsy

All cerebral lesions can be detrimental to brain function. The severity of CP, however, is dependent on the cause, extent, location and duration of the lesion (Kozeis et al., 2007). Thus, since the 1890's CP has been classified into different types based on clinical descriptions of motor dysfunction and at that stage included hemiplegia, total spasticity, paraplegia, chorea and bilateral athetosis (Tsai et al., 2006).

The report on the Surveillance of Cerebral Palsy in Europe (SCPE), published in 2000 (Johnson, 2002), provided a standardized classification of CP that is now used internationally. The five key points which clarified and defined CP were:

1. CP is an umbrella term

2. CP is permanent and does not change

3. CP is a disorder of movement, posture and motor function

4. CP occurs as a result of non-progressive lesion

5. The lesion occurs in an immature brain.

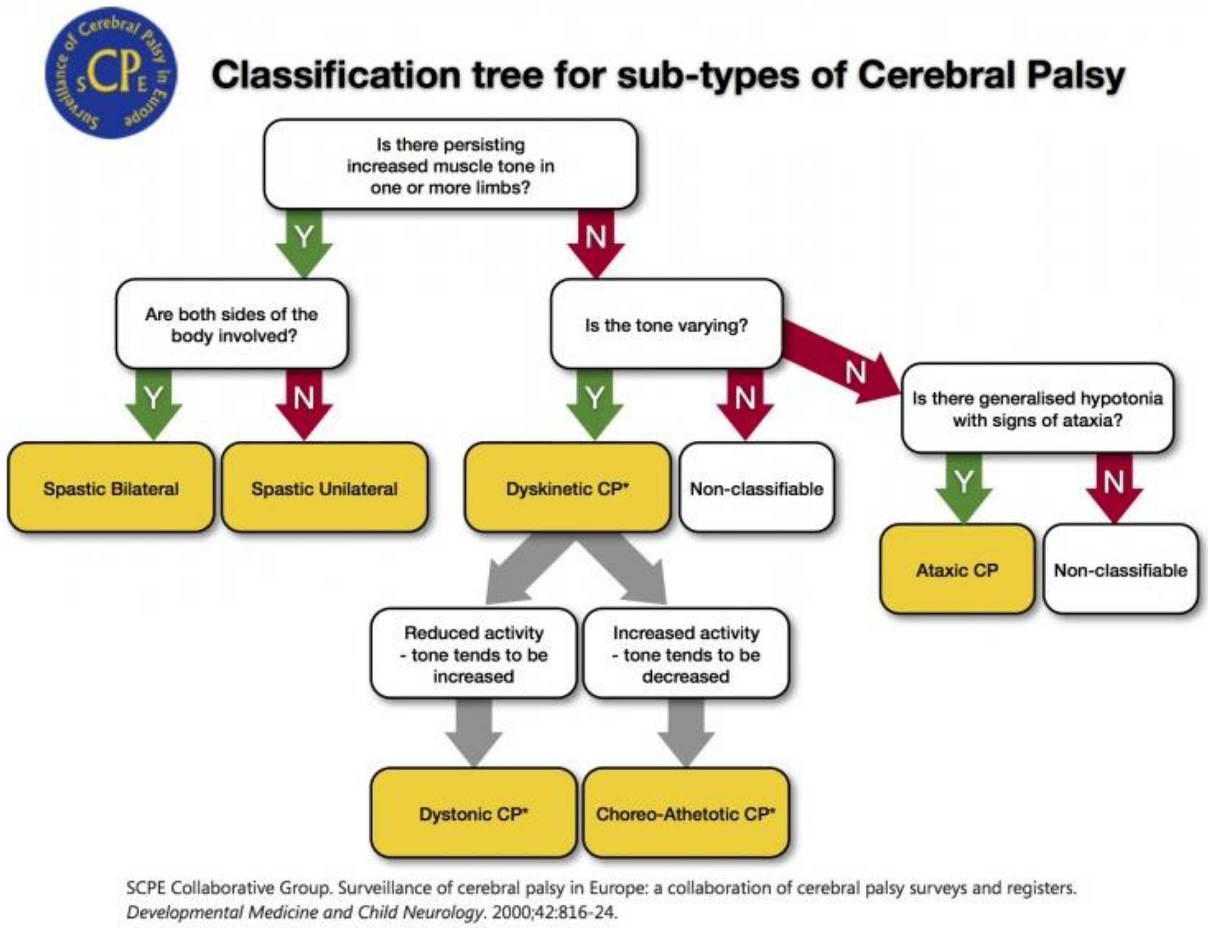


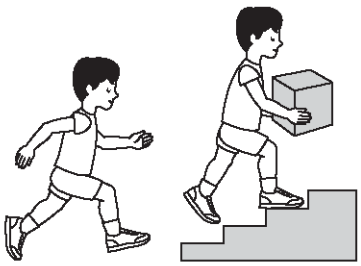
Figure 2.1 Surveillance of Cerebral Palsy in Europe Classification Tree (SCPE) (*Johnson,* 2002)

The SCPE provides a flow chart (Figure 2.1) which helps to classify children into categories with clearly defined symptoms and requirements. The categories include spastic (unilateral and bilateral), ataxic, dyskinetic (dystonic or choreo-athetoid), or not classifiable. Rather than hemiplegia, diplegia and quadriplegia this terminology uses unilateral and bilateral spastic CP (*Developmental medicine and child neurology*, 2002). There is no different classification for spastic diplegia and spastic quadriplegia in this category since the SCPE rather considers the number of associated impairments and functional ability to participate in activities (Morris, 2007).

The functional classification systems that are included by the SCPE for children with CP are the Gross Motor Function Classification System (GMFCS) and the Manual Ability Classification System (MACS). The need to use both these classification systems for research purposes, as well as the clinical assessment, has been emphasised. For this research, the SCPE was used to classify children with CP. The Gross Motor Function Classification System – Expanded and Revised (GMFCS-E&R) was used to compare the TVPS-3 results with the motor ability of the child. The MACS was not used as the child's hand function was not a factor due to the TVPS-3 being a motor free assessment.

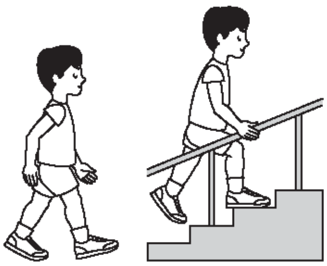
The GMFCS is a motor classification, based on self-initiated movement, related to sitting, transfers and mobility. It was developed in 1997 for children between the ages of 6 and 12 years and in 2007 the GMFCS-E&R was developed to further include youth between the ages of 12 and 18 years (Palisano et al., 2007). The GMFCS takes the functional skills of a child into account, rather than the distribution and location of the lesion. It is useful in measuring the extent of physical disability however it does not provide insight into perceptive-motor function (Ferrari and Giovanni, 2010). A child is classified according to the criteria in Figure 2.2 and 2.3 (Palisano et al., 2007).

GMFCS E & R between 6th and 12th birthday: descriptors and illustrations



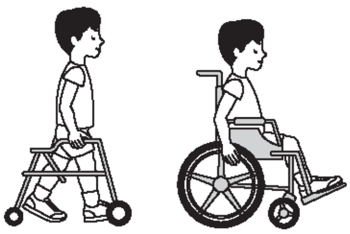
GMFCS level I

Children walk at home, school, outdoors and in the community. They can climb stairs without the use of a railing. Children perform gross motor skills such as running and jumping, but speed, balance and coordination are limited.



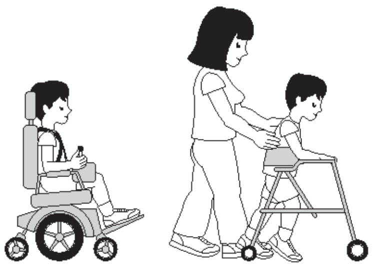
GMFCS level II

Children walk in most settings and climb stairs holding onto a railing. They may experience difficulty walking long distances and balancing on uneven terrain, inclines, in crowded areas or confined spaces. Children may walk with physical assistance, a hand-held mobility device or used wheeled mobility over long distances. Children have only minimal ability to perform gross motor skills such as running and jumping.



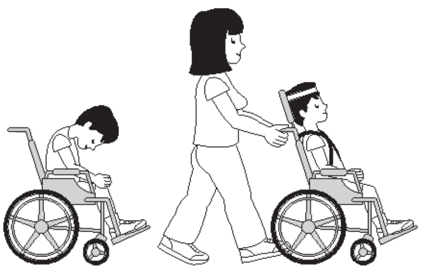
GMFCS level III

Children walk using a hand-held mobility device in most indoor settings. They may climb stairs holding onto a railing with supervision or assistance. Children use wheeled mobility when travelling long distances and may self-propel for shorter distances.



GMFCS level IV

Children use methods of mobility that require physical assistance or powered mobility in most settings. They may walk for short distances at home with physical assistance or use powered mobility or a body support walker when positioned. At school, outdoors and in the community, children are transported in a manual wheelchair or use powered mobility.



GMFCS level V

Children are transported in a manual wheelchair in all settings. Children are limited in their ability to maintain anti-gravity head and trunk postures, and control leg and arm movements.

GMFCS descriptors: Palisano et al. (1997) Dev Med Child Neurol 39:214-23
CanChild: www.canchild.ca

Illustrations copyright © Kerr Graham, Bill Reid and Adrienne Harvey, The Royal Children's Hospital, Melbourne

Figure 2.2 Gross Motor Function Classification System – Expanded and Revised between 6th and 12th birthday: descriptors and illustrators (Palisano et al., 2007)

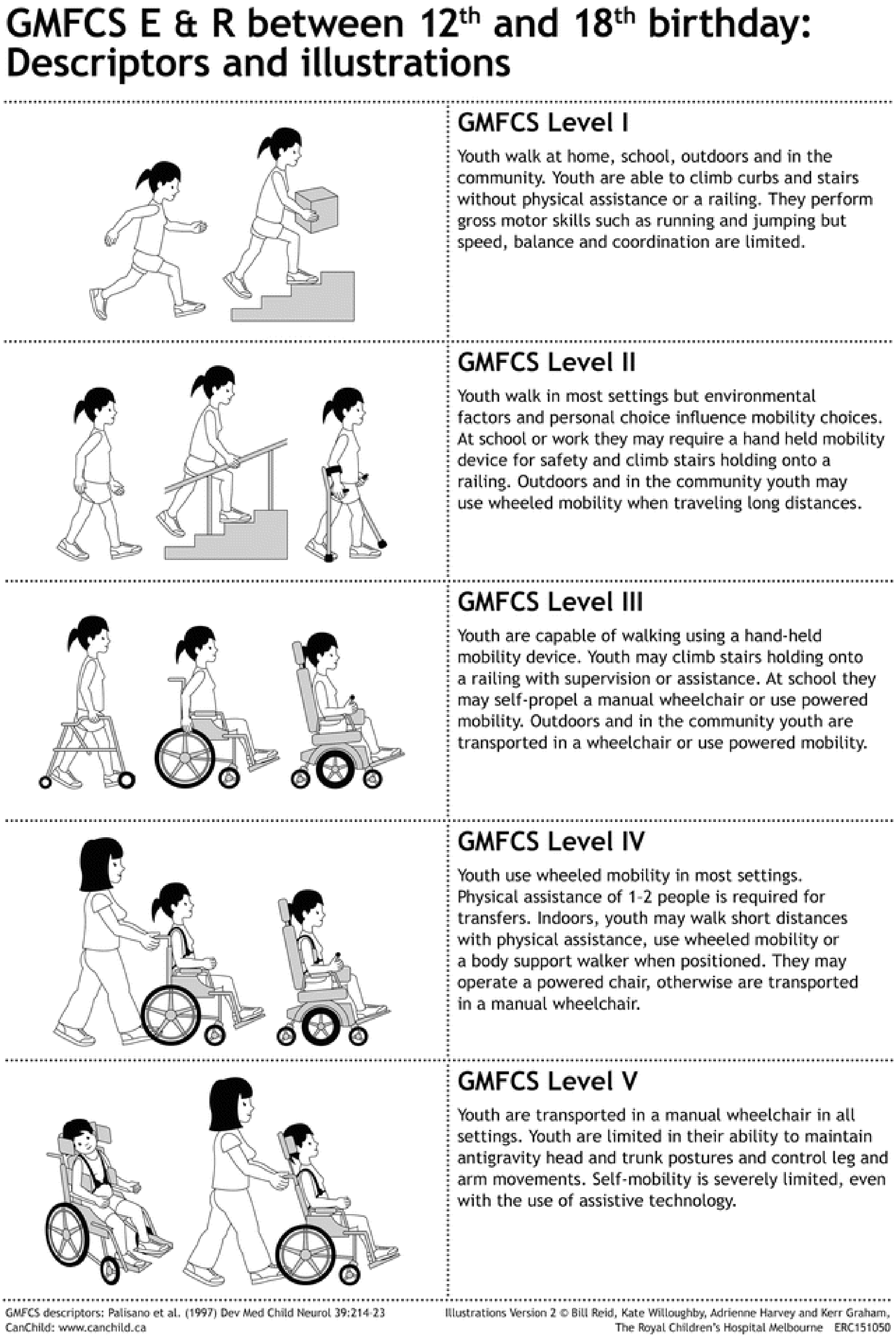


Figure 2.3 Gross Motor Function Classification System – Expanded and Revised between 12th and 18th birthday: descriptors and illustrators (Palisano et al., 2007)

This classification does not consider the aetiology of CP but rather allows clinicians to understand the functioning of the child in relation to their physical abilities and motor deficits. Fernandes et al. (2004), found a positive correlation between the degree of motor impairment and the loss of visual acuity in children with spastic CP (Da Costa et al., 2004) and therefore the GMFCS level needs to be considered when assessing visual perceptual skills in children with CP.

2.3.2 Aetiology and pathogenesis of Cerebral Palsy

Literature indicates that the aetiology is very diverse and dependent on a variety of factors (Sankar and Mundkur, 2005). The causes of CP can be congenital, genetic, inflammatory, infectious, anoxic, traumatic or metabolic (Sankar and Mundkur, 2005; Wu and Colford, 2000). The injury can occur in the prenatal, natal or postnatal periods or in the first few years of life. It has been found that 75-80% of cases occur in the perinatal period from 22 weeks gestation to 7 days post-delivery and less than 10% is due to birth trauma or birth asphyxia (MacLennan, 1999). Intra-uterine infections, teratogenic exposures, placental complications, multiple births and maternal conditions such as mental retardation, seizures and hyperthyroidism are also some of the prenatal risk factors for CP. Prenatal maternal chorioamnionitis is also a risk factor accounting for up to 28% of CP seen in premature infants and 12% of term infants. Perinatal risk factors include infections, intracranial haemorrhage, seizures, hypoglycaemia, hyperbilirubinemia and birth asphyxia. Toxic infectious meningitis, encephalitis and trauma are postnatal causes of CP (Sankar and Mundkur, 2005) (Koman et al., 2004) (Eunson, 2016).

While there are many risk factors for CP, it is important to understand that these may not be the direct cause of CP. Prematurity and low birth weight have been found to account for many of the known CP cases which could be due to the vulnerability of the CNS during the gestational weeks 26-32 (Case-Smith and O'Brein, 2010). Volpe, (2009) showed that abnormalities in neurons and axons occur causing white matter vulnerability, with injury to the cerebral cortex, thalamus and cerebellar relay nuclei. In the low birthweight infants, 59% had perinatal/neonatal aetiology, most commonly intraventricular haemorrhages, periventricular haemorrhages, periventricular leukomalacia or cerebral infarctions. Sixty to one hundred percent of infants who present with cystic periventricular leukomalacia present with CP (Wu et al., 2003) (Wu and Colford, 2000)(Sankar and Mundkur, 2005). Volpe, (2009) highlights the importance of considering cerebellar dysfunction when looking at the aetiology and pathogenesis of CP in premature low birth weight infants. He found that cerebellar dysfunction is a common cause of CP in the premature infant and depends on the type of dysfunction (Volpe, 2009).

It has been found that more than half of children born with CP are born full term (Sankar and Mundkur, 2005; Wu et al., 2003), with 40% of children with CP having low birthweight (<2500g) compared to 60% with normal birthweight (>2500g) (Meberg and Broch, 2005). The percentage of the different subtypes of CP that occur with full term birth, reported for the USA in 2008, are due to perinatal ischemic stroke (22%), congenital malformation (15%), white matter disorder (12%), hypoxia-ischemia (5%), intrauterine exposure to inflammation (11%-12%) and birth asphyxia (5%), while complications of multiple birth account for 6% (Nelson, 2008).

Magnetic Resonance Imaging (MRI) is used to diagnose CP in children. This diagnosis can be classified into 4 categories according to the timing of etiological factors:

1. Early brain formation disorders
2. Prematurity associated injuries (periventricular white matter injury or periventricular leukomalacia (PVL)
3. Injury in the full-term infant
4. Heterogenous group of disorders in early childhood (Koman et al., 2004)

2.3.2.1 Aetiology and Pathogenesis of Cerebral Palsy in Africa and South African contexts

The WHO estimated that 80% of the world’s disabled population are from low income countries, mainly Africa. Therefore, the expectation is that the rate of CP in these areas is high. There are many challenges with obtaining information regarding aetiology and pathogenesis of CP in Africa due to lack of clarity of the definition of CP, different identification methods, as well as CP research being of low priority in low income areas (Gladstone, 2010). In a systemic review completed by Donald et al. 2014 it was found that the most common causes of CP in Africa include birth asphyxia, kernicterus, and neonatal infections (Donald et al., 2014).

Very limited research is available regarding the aetiology of CP in South Africa. One of the Millennium Development Goals, 2015, was to reduce mortality of infants and children under the age of 5 years by two thirds. The goal was not fully reached, however, just over 50% of a reduction was achieved. Neonatal mortality rates declined slower than post neonatal mortality. Forty four percent of all under five deaths occur during the neonatal period. A quarter of these were due to intrapartum-related factors such as birth asphyxia. A majority of these occur in low to middle income countries. The data in South Africa are no different, in which 28% of all neonatal deaths are hypoxia related. When analysing infants with birth weight >1000g, hypoxia related deaths make up 41% of all early neonatal deaths which accounts for the highest mortality rate amongst infants.

Accurate figures for intrapartum-related causes of CP in SA are unknown, however the large number of deaths due to intrapartum hypoxia indicates that there is a high number of infants surviving this condition in comparison to high-income countries. Mahlaba completed a study at CHBAH in which 144 children attending a CP clinic were reviewed. Eighty-eight of the 144 children had neuroimaging reports available of which 42% had hypoxic ischaemic encephalopathy which is much higher than the prevalence reported in the high income countries (Couper, 2002).

2.3.2.2 Aetiology and Pathogenesis of the different subtypes of CP

The different subtypes of CP are classified according to the area of brain that is damaged (Koman et al., 2004). A range of factors causing CP results in different subtypes of the condition. Spastic (unilateral and bilateral) CP is the most common clinical subtype found in near or full-term infants whereas in preterm and very preterm infants spastic (bilateral) diplegia is more common (Van den Broeck et al., 2007).

2.3.2.2.1 Spastic Cerebral Palsy

Spastic CP occurs due to damage to the cortex (pyramidal) (Stanton, 2012).The cortical spinal tract (pyramidal tract) carries motor impulses from the cortex to initiate movement. Damage to this tract during brain development often results in spastic CP. More recent research has also discovered that damage to the sensory pathways can also result in spastic CP (Koman et al., 2004).

Seventy percent of children with CP have spastic or mixed forms where more than one type of motor pattern is present or one pattern is not clear, resulting in diplegia, quadriplegia or hemiplegia (Koman et al., 2004). The SCPE classifies spastic CP into spastic bilateral and spastic unilateral. Spastic bilateral includes diplegia and quadriplegia CP and spastic unilateral includes hemiplegia (*Developmental medicine and child neurology*, 2002).

Spastic Bilateral Cerebral Palsy

Spastic bilateral CP results in tone and movement disorders of all four limbs but the lower limbs have more severe involvement. Spastic (bilateral) CP results from global hypoxic-ischemia events although this is not the only possible cause of this type of CP (Rennie et al., 2007). Other associated causes include intrauterine infection, ischemia and metabolic disorders. Maldevelopment of periventricular oligodendrocytes specifically in the corticospinal fibres innervating the lumbosacral segments of the spinal cord results in spastic bilateral CP (Turlough Fitzgerald et al., 2012).

Spastic bilateral CP affecting the lower limbs usually occurs in children born prematurely with periventricular leukomalacia which causes a lesion in the cortico-spinal tract to the lower limbs (Ferrari and Giovanni, 2010). In recent years, there has been a rise in the survival rate of very premature infants with very low birth weight. Because spastic bilateral (diplegia) CP is strongly associated with prematurity and low birth weight, there has been a rise in the incidence of children with this type of CP (Case-Smith and O'Brein, 2010).

Spastic unilateral Cerebral Palsy

Spastic unilateral CP results in hemiplegia due to a focal, or sometimes a multifocal, pathology and occurs as a result of unilateral cerebral lesions with some involvement of cortical-subcortical areas (Ferrari and Giovanni, 2010). This results in disorders of muscle tone and voluntary movement on one side of the body. The extent of involvement can affect either the upper or lower limb to a greater extent. Involvement is usually more distal in the limbs but can be proximal. Intellectual development can be affected when the affected side corresponds with the dominant hemisphere. The cause of unilateral CP correlates to isolated porencephalic cysts, internal capsule lesions, periventricular lesions or damage to the cerebral hemisphere (Ferrari and Giovanni, 2010).

2.3.2.2.2 Dyskinetic Cerebral Palsy

Thirty percent of children with CP have extrapyramidal (dyskinetic) forms which include dystonic, rigid, choreo, ataxic and hypotonic. These types of CP all result in an impairment in the ability to control movements (Koman et al., 2004). Dyskinetic CP was defined according to the SCPE as "Involuntary, uncontrolled, recurring, occasionally stereotyped movements. Primitive reflex patterns predominate, muscle tone varies" (Park et al., 2015)p659. This group has been further classified into dystonic and choreo athetotic subtypes. Dystonic CP occurs as a result of damage to the pathways between the cortex and the basal ganglia (Koman et al., 2004). Choreo-athetotic CP occurs as a result of damage to the basal ganglia and or cerebellum (Stanton, 2012). This type of CP has been found to correlate with perinatal asphyxia. The striatum in the basal ganglia is particularly affected and thus results in movement disorders (Turlough Fitzgerald et al., 2012).

Dystonic Cerebral Palsy

Dystonia has been associated with neuronal loss and axonal injury in the basal ganglia and thalamus, resulting dyskinesias (Nagasunder et al., 2011). The lesion is often found in the basal nuclei often caused by perinatal asphyxia (Ferrari and Giovanni, 2010). This is usually caused by hypoxia at birth, jaundice or genetic diseases (Koman et al., 2004). It results in irregular tone, which is reduced during rest however consistently increases with stimulation, which causes uncontrolled movements patterns. It results in inco-ordination and hyperkinetic movements especially in the face and mouth. Impairment in cognitive development is seldom noted (Ferrari and Giovanni, 2010).

Choreo-Athetotic Cerebral Palsy

Choreo-Athetotic CP is often attributed to foetal asphyxia and hyperbilirubinemia. It has been found that in recent years the incidence of choreo-athetotic CP has decreased in developed countries (Case-Smith and O'Brein, 2010). Athetoid CP is extra-pyramidal and is caused by a lesion in the basal ganglia and/or cerebellum (Stanton, 2012) (Himmelmann et al., 2007). Athetosis is caused by dysfunction in the extrapyramidal system, particularly the caudate and putamen. This results in hypotonia with slow, arhythmical, continuous movements. Development of intelligence is not strongly impaired (Ferrari and Giovanni, 2010).

2.3.2.2.3 Ataxic Cerebral Palsy

Ataxic CP is caused by damage to the cerebellum and cerebellar pathways (Stanton, 2012) (Ferrari and Giovanni, 2010). Ataxia is the least common type of CP. It results in disorders of co-ordination and balance (Koman et al., 2004) (Ferrari and Giovanni, 2010). Ataxic CP is characterized by the marked hypotonia and delay in motor development. Cerebellar ocular nystagmus, speech difficulties and delay as well as intellectual deficits are common (Ferrari and Giovanni, 2010).

The different cerebral lesions responsible for the different subtypes CP according to the SCPE classification result in the comorbid cognitive impairments. These deficits may be in attention, language or memory (Ego et al., 2015). Differing deficits of visual perception have been recorded and these may result in difficulty reading and learning as well as other academic skills (Tsai et al., 2006). Only impairments related to visual perception will be considered for this review.

2.4 Visual Perception

Visual perception has been defined by Ramkumar (2016) as a process in which reception and cognition of visual stimuli occurs. It is a system that allows people to perceive the world around them and plan how to interact with the environment (Fazzi et al., 2004). Visual stimuli are processed in a way that makes sense of what is seen. It is a very complex, integrative system that allows for understanding and interpretation of visual stimuli. Meaning is attached to the visual stimuli which allows us to function in our daily lives (Martin, 2006). According to the Occupational Therapy Practice Framework III (OTPF III), visual perception is one of the occupational performance areas required to allow for active engagement and participation in daily life tasks (AOTA, 2014). Visual perceptual impairment does not occur separately and is usually accompanied by a range of perceptual and cognitive impairments which makes it very difficult to investigate in isolation (Fazzi et al., 2004).

2.4.1 Neurophysiology of visual perception

The process of visual perception involves images received by the retina being transformed into images that are compared to previous memories, knowledge and sensory input. It requires the interpretation, understanding and definition of incoming visual information (Brown et al., 2012).

Mishkin and Ungerleider, (1982) completed numerous studies on monkeys and concluded that a lesion in the inferior temporal areas had effects on identifying objects while a lesion in the posterior parietal area affected spatial perception. They concluded that visual information about the quality of objects and the spatial location of objects is processed in these two different areas of the brain and that these two areas receive different projections from the striate cortex (Goodale and Milner, 1992). A vast amount of research has been done since 1982 confirming that visual processing and perception takes place in two streams in the brain which include, the dorsal (occipito-parietal "where" "how") and ventral (occpito-temporal "what") stream. The ventral stream and dorsal stream both originate in the primary visual cortex (Ferrari and Giovanni, 2010) (Hebart and Hesselmann, 2012).

More recent research has found that these two streams originate from 2 main subdivisions of retinal cells. One of the streams terminates in the parvocellular layer and the other terminates in the magnocellular layer of the lateral geniculate nucleus (Goodale and Milner, 1992). These two sub divisions remain separated in the primary visual cortex (V1) and the adjacent visual areas (V2). They also predominate in the V4 area and middle temporal area, which provides important visual information to the inferior temporal and posterior parietal cortex. Recent findings have concluded that the distinction between the magno and parvocellular sub divisions is not as clear as initially thought thus concluding that the dorsal and ventral streams also receive information from both the magno and parvo pathways (Goodale and Milner, 1992).

The "ventral stream" projects to the inferotemporal cortex and the "dorsal stream" reaches the posterior parietal region. The dorsal stream starts at the striate cortex, travels along the dorsal surface into the posterior parietal cortex (Hebart and Hesselmann, 2012) and is involved in spatial elements of vision such as movement and spatial localisation (Ferrari and Giovanni, 2010). The dorsal stream is known as the "vision for action" pathway and plays a role when reaching for an object based on location, orientation and other spatial aspects of objects (Hebart and Hesselmann, 2012).

The ventral stream starts at the striate cortex and travels to the inferotemporal cortex (Goodale and Milner, 1992). It is involved in object vision such as shape recognition (Ferrari and Giovanni, 2010). The ventral stream extends along the ventral surface into the temporal cortex (Hebart and Hesselmann, 2012). The ventral stream is known as the "vision for perception" pathway and functions in recognition and discrimination of objects by identifying features such as, shape, texture and colour (Schenk and McIntosh, 2010).

These two pathways are interconnected and therefore work together to process information (Hebart and Hesselmann, 2012) so that visual functions involve the collaboration of these two streams as well as other brain systems. Even though they each have their own processing function, neither stream is able to work independently of the other (Schenk and McIntosh, 2010). The development and maturation of visual perceptual skills are reliant on these pathways and impact function of the visual system.

2.4.2 Assessment of Visual Perceptual Skills

Occupational Therapists working with children with CP often assess and treat visual perceptual impairments. This is of great importance as visual perceptual impairments can have a negative impact on many occupational performance areas and functional skills such as activities of daily living, personal management tasks, social engagement, participation in play and completion of school based tasks (Brown et al., 2003) (Ego et al., 2015).

In order to assess visual perceptual skills, subskills or components described by Warren, (1993) in the Hierarchical Framework of Visual Perception are considered. This framework, based on a developmental model, proposes the sequential development of visual perception and that certain components are essential for the development of higher-level skills.

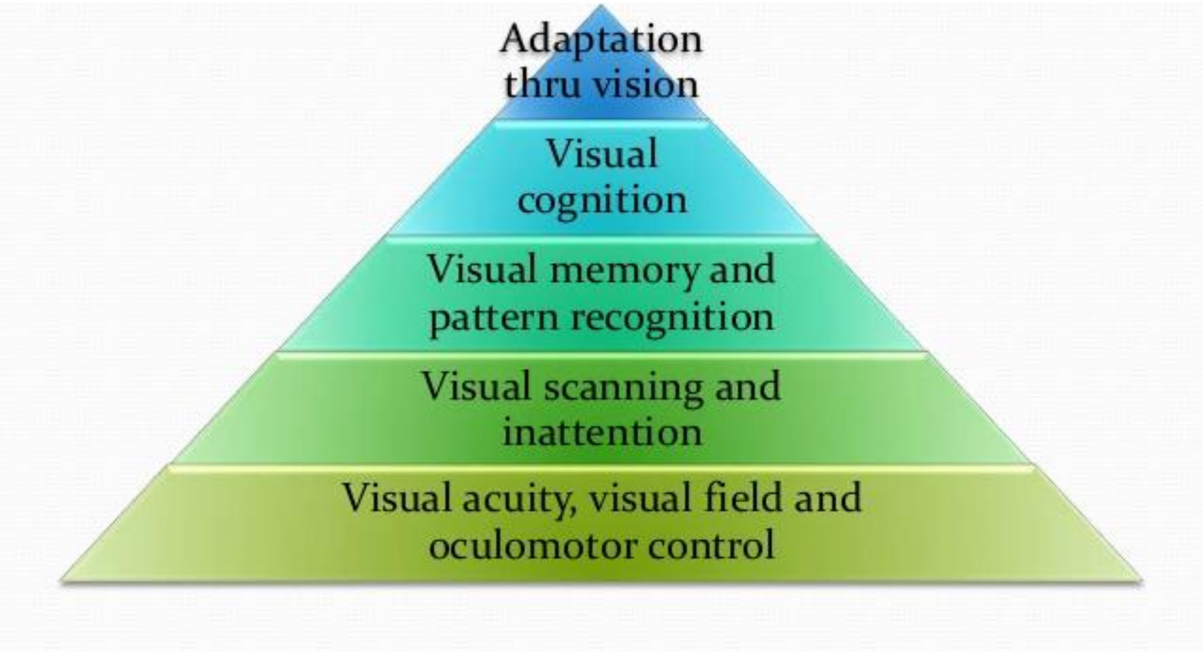


Figure 2.4 Hierarchy of visual perceptual skill development in the central nervous system (Warren, 1993)

2.4.2.1 Vision and visual perception

Warren's, (1993), Hierarchy of Visual Perceptual Skill Development indicates that in order for visual perception to occur, appropriate visual functioning is necessary. Visual functioning occurs when a variety of subsystems work together. Visual acuity, visual field and oculomotor control are described by Warren (1993), as the basic visual functions that affect all other visual and perceptual functions.

Visual acuity is the ability to discriminate a detail. Visual field is the area in which objects are visible at the same time when gaze is focused in one direction. Oculomotor control is the ability to focus the fovea on a target and maintain the focus even when the object is moving in different positions (Ferrari and Giovanni, 2010). Dysfunction in these functions results in inaccurate representation of the image. Visual scanning and visual attention are the next level on the hierarchy. This is the ability to attend to visual stimuli in order to scan the environment and ignore unimportant stimuli to focus on important stimuli. Without this function, information cannot be perceived (Warren, 1993).

The next level involves visual memory and pattern recognition which include visual discrimination skills such as form constancy, visual closure, figure-ground as well as spatial perception and visual imagery (Schenk, 2006). These assumptions underlie the tests that are used to assess these constructs and explain the difficulty a child experiences supports mastery of skills.

Visual cognition and adaptation thru vision are the next 2 levels which are the highest order VP skill. Visual cognition is the process where visual information is mentally manipulated and integrated with other sensory information. Adaptation thru vision then results in higher order skills such as problem solving, planning and decision making as well as academic skills such as reading, writing and mathematics (Warren, 1993).

2.4.2.2 Tests used to assess visual perception in CP

It is important to use assessments for visual perception that are reliable and have validity (Brown et al., 2003). Occupational therapists, therefore, commonly use standardised assessments that have been validated and which have reliable measurement properties (Tsai et al., 2006). These assessments allow for the identification of underlying components related to visual perception that may account for children's poor performance in school-based tasks (Stewart, 2010). The L94 Visual Perceptual test (Ortibus et al., 2009), Developmental Test of Visual Perception 2nd ed (DTVP-2) (Hammil et al., 1993), Benton Neuropsychological Battery (Stern and White, 2003), Wechsler Intelligence Scale for Children-Revised Picture Completion Subtest Task (Wechster, 2014) and TVPS-3 (Martin, 2006), are often used to assess visual perception in children with CP (Ferrari and Giovanni, 2010) (Ego et al., 2015).

2.4.2.2.1 Test of Visual Perceptual Skills 3rd ed (TVPS-3)

The test that was used in this study is the Test of Visual Perceptual Skills 3rd ed (TVPS-3). This test was chosen as it can be used to assess children with motor or speech impairments and is ideal for use in research (Martin, 2006). From the limited research available it has been found that visual perceptual tests including the Beery VMI-6, DTVP-3 and TVPS-3 are valid for children in South Africa (Visser et al., 2017). The TVPS-3 was also chosen as it contains 7 visual perceptual subtests in comparison to some of the other perceptual tests which only contain 3 or 5 subtests. These 7 subtests provide an opportunity to explore the differences between the subtypes of CP more extensively.

One of the tests used to identify specific visual perceptual deficits is the Test of Visual Perceptual Skills 3rd ed (TVPS-3) which was revised in 2006. The TVPS-3 assesses the visual perceptual skills of children aged 4-0 to 18-11 without requiring involvement such as placing objects, writing or drawing (Martin, 2006). Due to the test being motor free, it can be used with children with physical disabilities as it eliminates the effect that motor performance would have on overall visual perceptual scores (Colarusso and Hammil, 2006). The TVPS-3 was standardized on 2000 children between the ages of 4 to 18 years 11 months. Tsai *et al.*, (2006) explored the reliability of the Test of Visual Perceptual Skills (TVPS) and concluded that it is reliable to make clinical judgements, plan for treatment and measure the intervention outcome. Each subtest was computed using Chronbach's coefficient alpha and split half coefficient. The coefficient alphas range from 0.75 to 0.88 for subtests and 0.96 for the entire test. The TVPS-3 has a high level of homogeneity and the test retest correlation is 0.97 and ranges from 0.34 – 0.81 for the subtests. This means that the test provides consistent measurement when tested by different examiners and is therefore highly reliable. Testers can therefore have a high degree of confidence in the test's results (Martin, 2006).

The TVPS-3 was designed as a diagnostic tool but also for research purposes. It contains seven subtests which include visual perception (VP), visual discrimination (VD), visual memory (VM), visual-spatial relations (VSR), form constancy (FC), visual sequential memory (VSM), visual figure-ground (VFG) and visual closure (VC). Each subtest has 16 items which are ordered from easy to difficult. Each visual perceptual component for the subtests is described below.

Visual Discrimination

Visual Discrimination is the ability to identify exact features of an object when it is amongst other similar objects (Brown et al., 2003). A design is shown to the child and is then required to point to the same design amongst the choices at the bottom of the page (Martin, 2006). Children with visual discrimination difficulties can be expected to struggle to match socks, identify the difference between objects (e.g. coins and keys) In the classroom they may struggle to see differences between similar looking numbers/letters/words (e.g. 5/S, b/d, car/cat).

Visual Memory

Visual memory requires the ability to recognise an object after a brief interval (Colarusso and Hammil, 2006). It aims at testing the child's immediate recall (after 5 seconds), remembering an object and identifying it amongst similar objects (Brown et al., 2003). The child is shown a design for 5 seconds and is required to remember the design from the choices on the next page (Martin, 2006). Visual memory difficulties could affect a child's ability to recognise numbers and letters, remember sight words or copy work from the board or a book.

Visual Spatial Relations

Spatial relations requires individuals to orientate themselves in space. It also requires orientation of objects in relation to the individual and other objects (Colarusso and Hammil, 2006). The Visual Spatial Relations subtest requires the child to identify the design that is different from the rest (Martin, 2006). Children who struggle with spatial relations may have difficulty putting their clothes on the right way around and may confuse their letters (b/d, p/q, W/M, 6/p, S/3). They may also have difficulty spacing their letters and words when writing.

Form Constancy

Form constancy requires the child to identify a similar object when it is rotated, different in size, reversed or hidden (Brown et al., 2003). Children who struggle with form constancy may not recognise shapes, numbers and letters when the colour, size or font changes, or when they are presented in a different context.

Visual Sequential Memory

This requires the ability to recall (after 5 seconds) a sequence of objects amongst four incorrect sequences (Brown et al., 2003). The number of elements increases as the test goes on and the child is required to identify the matching sequence from the previous page (Martin, 2006). Visual sequential memory is essential for spelling and reading as well as multiple digit addition and subtraction, where the child needs to remember the sequence of letters or numbers.

Visual Figure-Ground

Figure-ground is the ability to identify objects in a busy background (Colarusso and Hammil, 2006). The child is required to find a design that is hidden amongst many other designs in a complex background (Martin, 2006). Children who struggle with figure-ground may not be able to find their shoes in a messy room or milk in the fridge. They may also struggle to read or copy work from the board, or may skip words or lines while reading.

Visual Closure

Visual closure is the ability to perceive a whole object when parts are missing (Colarusso and Hammil, 2006). The child is required to match a completed design with an incomplete design at the bottom of the page (Martin, 2006). Children with visual closure difficulties may not be able to recognise words/letters if they are smudged, or find objects that are partially covered. These skills are important for learning sight words and reading fluently.

2.4.2.2.2 Test of Visual Perceptual Skills 3rd ed – validity for use in South African Population

In a study completed by Visser et al (2017), the Beery VMI-6, DTVP-3 and TVPS-3, were completed on a South African population in order to determine their validity and reliability. They concluded that caution needs to be taken when administering an assessment on a population with different cultures and languages from the ones in which the instrument was standardised (Visser et al., 2017)

Sixty-eight typically developing South African children, between the ages of 5 years 6 months and 5 years 11 months, were assessed. The data was compared to the norms of the test. The results showed that the children's median scaled score was lower than the normative range and the American norm of 10 on 6 of the seven subtests: visual discrimination (Scaled score 7), spatial relations (Scaled score 6), form constancy (Scaled score 6), sequential memory (Scaled score 6), figure-ground (Scaled score 7) and visual closure (Scaled score 7). The only subtest in which the children obtained a scaled score within normative range was visual memory (Scaled score 8). The difference in the results of these two studies could be due to different populations or age groups being used (Visser et al., 2017).

In another study by Monique Harris, (2017), it was found that the TVPS-3 norms of South African mainstream children, ages 6-9 years, were normally distributed. There was no significant difference between the South African group and the USA norm-based group. The South African group scored higher on the spatial relations subtest with a mean scaled score of 13.10. They scored lower on visual discrimination with a mean scaled score of 8.81 and form constancy with a mean scaled score of 8.81. It is thus important for therapists to be aware of these findings and perhaps use other visual perceptual assessments or observations in conjunction with the TVPS-3.

2.4.3 Impact of Visual Perceptual Impairment on Activities of Daily Living

Activities of daily living (ADL), are the tasks that an individual completes on a day to day basis and include self-care and self-maintenance. If an individual is unable to complete these tasks, their level of independence can be significantly impacted. Visual perceptual difficulties can impact on ADL completion (James et al., 2015a).

James et al., (2015) completed a study which identified the relationship between visual perceptual ability and ADL completion on children with unilateral CP. The Assessment of Motor and Process Skills (AMPS) and the TVPS-3 was used to assess 102 participants with spastic unilateral CP. They found that components of visual perception such as visual closure and visual sequential memory are associated with functional task performance in the AMPS and therefore concluded that visual processing significantly influences an individual's ability to carry out ADL's (James et al., 2015b). These results are supported by Craje et al., (2009) research who found that visual information systematically impacts on motor planning in children with unilateral CP.

2.5 Vision and Visual Perception in children with Cerebral Palsy

2.5.1 Deficits in visual functioning in children with Cerebral Palsy

In order to see clearly visual acuity, refraction and complete visual fields need to be intact. Visual efficiency related to oculomotor control, accommodation and stereopsis are also important. Aspects such as fixation, visual tracking or pursuits and saccadic eye movements are required for visual processing and obtaining information from the environment (Schenk and McIntosh, 2010). Population studies have reported that 50% of children with CP have associated visual defects. These visual impairments can be caused by periventricular leukomalacia, intraventricular haemorrhage, hypoxic ischaemic encephalopathy or a cerebral infarction (Ferrari and Giovanni, 2010). It is important to be aware that even though acuity is often impaired in children with CP, other factors that might also influence the child's visual perceptual skills include visual fields, eye movements and binocular nystagmus.

Numerous studies have been conducted regarding visual impairment in children with CP (A Schenk-Rootlieb et al., 1992)(Ipata et al., 1994)(Fedrizzi et al., 1998)(Guzzetta et al., 2001). Schenk-Rootlieb et al., (1992) found that 71% of children in a study of 164 children with CP presented with low visual acuity (Schenk-Rootlieb et al., 1992). Ipata et al (1994) obtained similar results from a study in which 71,6% of children with CP were found to have visual acuity difficulties. These impairments were mostly found to be due to cerebral visual impairments and not due to ophthalmological impairments. When comparing the incidence of visual impairment amongst the different subtypes of CP, it was found that children with tetraplegic and dyskinetic CP had the highest incidence followed by those with diplegic CP (Ipata, et al., 1994). Fedrizzi found that children with diplegia often have difficulty with eye movements (Fedrizzi, et al., 1998). Guzzetta (2001), evaluated the visual dysfunction in children with hemiplegia. Forty-seven children were tested for acuity, visual field size, nystagmus and eye movements. More than 80% of these children were found to have visual dysfunction. An interesting finding, was that visual acuity was the least impaired whereas more than 50% had visual field and nystagmus dysfunction (Guzzetta et al., 2007). Ferrari and Giovanni's (2010) study also concluded that more than half of the children in their study with hemiplegia had visual field reduction.

Brain damage results in disorganised visual search patterns which affects their ability to construct visual models of the world (Martin, 2006). Visual scanning or tracking is necessary in visual perceptual tasks such as pattern and object recognition. If this is affected the person will have difficulty separating objects from a busy background (figure-ground) as well as identifying an object when part of it is missing (visual closure) (Martin, 2006).

2.5.2 Deficits in visual perception in children with Cerebral Palsy

Visual perceptual impairment occurs as a result of malfunctioning of associative visual systems rather than posterior visual pathways (Fazzi et al., 2004). It is often caused by a neurological disorder or lesion, such as CP (Brown et al., 2012). Numerous studies have been completed on visual perception in children with CP (Kozeis et al., 2007)(Ego et al., 2015)(Ferrari and Giovanni, 2010). A study by Kozeis *et al.*, (2007), found VPI in 105 children with CP between the ages of 6 and 15 years. Findings indicated that 57.14% of the children had visual perceptual skills less or equal to 6-year-old level, 26.66% had visual perceptual skills equal to children between the ages of 6-7.5 years and only 16.19% children had visual perceptual skills equal to children of more than 7.5 years. This confirmed that visual perception is impaired in a high percentage of children with CP which was supported in a systematic review by Ego *et al* (2015) who reported 40%-50% of children with CP presented with VPI with a mean perception quotient of 70 to 90 (Ferrari and Giovanni, 2010).

In an early study by Menken, Cermak and Fisher, (1987) using the first edition of the TVPS to compare visual perceptual scores of children with CP. This was one of the first occupational therapy studies which concluded that children with CP score lower than normal children on visual perceptual tests. This study included 24 CP children and therefore it was recommended that to study the differences between subgroups of CP, larger numbers are needed. It was suggested that further research on the differences of visual perceptual impairment in the different subtypes of CP is needed. This would further assist with the understanding of development of visual perceptual skills in children with CP.

The systematic review by Ego *et al.*, (2015) concluded that more studies regarding visual perception need to be completed, according to specific populations-based registries, while exploring their cognitive impairments. A wider CP population needs to be assessed reliably in order to get more accurate results. Even though the study did not present exact figures of prevalence and trends of VPI in CP, it suggests that visual perceptual dysfunction must be considered as a core issue in children with CP. More research is needed on this topic in order to determine the specific impact of perceptual and cognitive impairment on different CP sub-types. The benefits of these studies are to assist with the development of early intervention and prevention programmes (Ego et al., 2015). Assessment of visual perceptual skills allows the therapist to understand the child and develop more effective treatment methods (Ramkumar and Gupta, 2016).

2.5.2.1 Visual perceptual impairment in children with different subtypes of CP

While the studies considered CP subtype, IQ level, side of motor impairment, neuro-ophthalmological impairment or seizures, none reported which feature significantly influenced visual perceptual skills in children with CP. Information related to the characteristics of the lesion itself is also very scarce. Early research done in the 1950's to 1960's, identified the need for the assessment of visual perception and trends in the type of CP and severity of motor impairment with the degree of perceptual impairment (Menken et al., 1987).

In a study completed by Abercrombie, (1964), where perceptual assessments were administered to children with dyskinetic, bilateral spastic and unilateral spastic (right and left) CP, the children with dyskinetic CP were found to have fewer VPI's than spastic children, therefore stating that VPI is associated with CP where spasticity is the predominant sign. Spastic bilateral (quadriplegic and diplegic) and left spastic unilateral groups also scored significantly lower than right spastic unilateral groups although both right and left spastic unilateral groups presented with VPI (Abercrombie, 1964).

Another study completed by Skatvedt, (1960) also identified the highest incidence of VPI is in children with bilateral spasticity, followed by left spastic unilateral CP and then right spastic unilateral CP. These studies included a wide range of ages and commonly included children with left and right spastic unilateral CP but not spastic bilateral (quadriplegic) subjects. Some of the studies used assessment tools that required motor control which would directly impact on the results of the test when completed by an individual with motor impairment (Menken et al., 1987). These early studies were inconclusive and inconsistent and did not clarify trends of VPI in children. With the advent of newer, better validated tests which are motor free, more reliable assessment of visual perception can be completed on children with CP.

In a more recent study by Stiers *et al.* (2002), 96 children with CP, between the ages of 4 years 11 months to 21 years 5 months, were assessed using the visual-perceptual battery L94 (Stiers et al., 1998). Forty percent of the children with CP presented with visual-perceptual impairment. The sample size was small (11 hemiplegia, 28 diplegia, 21 quadriplegia, 4 dyskinesia and ataxia) and therefore no visual perceptual trends were identified in the different subtypes of CP. Challenges with visual perception have been associated with white matter injury, right-sided brain lesions, preterm birth and spastic diplegic CP, with specific visual perceptual deficits being associated with different subtypes of CP (Ego et al., 2015).

2.5.2.1.1 Spastic Bilateral (Quadriplegic) Cerebral Palsy

Children with spastic CP often have ophthalmological deficits which include, oculomotor abnormalities, refractive error and loss of visual acuity (Hertz and Rosenberg, 1992) (Schenk-Rootlieb et al., 1993). They also frequently suffer from cortical visual impairment which is caused by a deficit in the functioning of the retrochiasmatic visual pathway (Schenk-Rootlieb et al., 1993). In a study by Fernandes et al. (2004), it was found that the degree of motor impairment positively correlates with the loss of visual acuity in children with spastic CP and therefore children with more severe motor impairment have more severe visual acuity impairment (Da Costa et al., 2004).

Pueyo et al., (2009) found that visuospatial abilities were the most impaired functions in children with bilateral spastic CP which had no significant relationship to visual acuity.

2.5.2.1.2 Spastic Bilateral (Diplegia) Cerebral Palsy

Visual perceptual impairment in children with spastic diplegia is often attributed to poor eye movements and control. Fedrizzi and co-workers (1998) completed a study on eye movements and visual perception in children with CP. They found that children with spastic diplegia presented with significantly lower results than controls. Their results suggested that it is important to take into consideration the child’s scanning ability in shifting their gaze from one target to another, as well as their anticipatory saccadic movements used to gather information, when looking at their visual perceptual ability. This is also sometimes associated with visual inattention disorder. These areas were identified as having an impact on the children’s visual perceptual ability. Children with diplegia needed more time to finish and had more omissions and mistakes due to this (Fedrizzi et al., 1998).

Children with diplegia scored lower than children with other subtypes of CP in the Developmental Test of Visual Perception (DTVP). They concluded that visual perceptual impairment occurs as a pattern of neurophysiological dysfunction in preterm children with spastic diplegia. This dysfunction results in reading and writing difficulties at school (Abercrombie, 1964).

In 1992, Koeda and Takeshita, completed a study on 18 diplegic children in which they aimed to identify the correlation of visual perceptual disorders with MRI data. They found that cerebral lesions cause visual perception impairment in children with spastic diplegia. The volume of peritrigonal white matter of the parietal and occipital lobes, linked directly with visual perceptual impairment. Recent studies have found that periventricular leukomalacia with a reduction of occipito-parietal and posterior-parietal white matter has a strong association with impaired visual perceptual performance (Fazzi et al., 2004) and when exploring the VPI in the different CP subtypes, studies have suggested that children with spastic bilateral CP have visual perceptual impairment due to periventricular leukomalacia, compared to children with other CP subtypes. It has not yet been concluded whether this is due to the occipitoparietal pathway being affected or from preterm birth, which can also affect visual motor skills in children with CP (Ego et al., 2015). Pagliano *et al.*, (2007) completed a study in which they compared the visual perceptual skills of preterm and full-term children with spastic diplegia. They found that diplegic children born preterm with periventricular leukomalacia appear to have more significant visual motor difficulties than those born at full term. Visuo-motor perceptual skills were more impaired than nonmotor visuo-perceptual skills in preterm children. The side of the lesion has also not been found to play a role in VPI but rather the severity of the damage (Ego et al., 2015).

2.5.2.1.3 Spastic Unilateral (Hemiplegia) Cerebral Palsy

Craft *et al.*, (1995) found that children with hemiplegic CP had significantly lower performance in visual attention than the typical children when assessed by covert orienting task which involves inhibition, disengagement and redirection. They did not differentiate between children with left and right sided hemiplegia and Wood (1955), also did not find any significant differences between left and right hemiplegic children with regards to figure-ground and visual closure (Wood, 1955).

However, a study by Wedell, (1960) found that right hemiplegic spastic groups score higher than bilateral and left spastic groups on visual perceptual tests. He explained this by considering the physiological dominance in the different hemispheres of the brain. The dominant area for visual perceptual processing is in the right cerebral hemisphere and therefore left hemiplegics had poorer visual perceptual scores than right hemiplegics who have damage in the left hemisphere. Lidzba *et al.*, (2006) research, supports this as they also found that children with left hemiplegia had significantly lower scores on visuospatial tasks that involve hand manipulation than the children with right hemiplegia. Language function was intact in children with right hemiplegia, despite damage on the left side of the brain suggesting that language function is reorganised to the right side of the brain. This may lead to "crowding" in the right hemisphere, affecting the neural substrates available for visual perceptual function.

2.5.2.1.4 Dyskinetic Cerebral palsy (Choreo – Athetoid, Dystonic)

In an early study by Wedell, (1960), it was found that dyskinetic groups scored higher in visual perceptual tests than spastic CP groups. Abercrombie (1964) and Marozas and May, (1986) found similar results in their studies as they concluded that there is a distinction between the visual perceptual and visuomotor impairments of children with spastic and athetoid CP, with spastic CP having more severe impairment in these areas. This was confirmed in a study by Pueyo et al., (2009), which compared the visual perceptual functioning of 23 children and adults with bilateral spastic CP and six with dyskinetic CP. The participants with dyskinetic CP performed significantly better on visuospatial and visual memory assessments with 50% having deficits compared to the participants with bilateral spastic CP amongst whom 78,6% had deficits.

Wedell, (1960) further explained this by considering the area of the brain that is affected as spastic CP is due to cortical damage which is where visual perceptual processing predominantly occurs. The brain lesions associated with dyskinetic CP involve the basal ganglia and are more mild and homogeneous (Pueyo et al., 2009).

2.5.2.1.5 Ataxic Cerebral palsy

Stiers *et al.*, (2002) also concluded from their study that children with ataxic CP have less severe impairment than children with spastic diplegia, quadriplegia and hemiplegia. No other research specific to visual perceptual skills in ataxia CP were found. The research evidence for ataxic CP due to its rarity is inconclusive and most studies have one or two participants with this type of CP.

2.5.3 Visual Perception and Gross Motor Function Classification System level and other factors

A study by Dalvand *et al.*, (2012) found that GMFCS E&R level and intellectual function correlates strongly. They found that children with CP on GMFCS level 4 and 5 had a lower intellectual level than children on higher levels of the GMFCS. However, it is interesting to note that another study by Hamid *et al.*, (2016) compared the visual perceptual skills and the severity of GMFCS level in children with CP. Sixty-seven children were assessed using the TVPS-R. No significant differences were found in the comparison of the test results and the GMFCS level of the children and thus it was concluded that even though GMFCS level has an impact on intellectual function it does not directly impact on the visual perceptual skills of children with CP (Hamid et al., 2016).

Stiers *et al.*, (2002) also found no significant association between visual perception scores and visual acuity deficits or verbal intelligence scores in children with CP and concluded that visual perception deficits are related to differences in location of brain damage or vulnerability of visual neural structures at birth. Van Den Hout *et al.* (2004) also maintain that visual perceptual deficits are not specifically related to nonverbal intelligence scores.

2.6 Summary

Visual perception is a process of reception and cognition of visual stimuli (Ramkumar and Gupta, 2016) and allows us to perceive and interact with our environment (Fazzi et al., 2004). It is an occupational performance area which allows for engagement and participation in daily life tasks (AOTA, 2014). Therefore, an impairment in visual perceptual skills results in difficulty completing daily life tasks.

In Rosenbaum, (2006), definition of CP he explains that the motor disorder is often accompanied by disturbances of perception. Numerous studies have found that children with CP have visual perceptual impairments (Kozeis et al., 2007), (Ego et al., 2015) (Ferrari and Giovanni, 2010). These studies did however indicate that further research is required around this topic. Limited current research is available on the specific visual perceptual impairments in different subtypes of CP especially in a South African population. Studies have indicated that spastic CP is strongly associated with visual perceptual impairment in comparison to other types of CP (Abercrombie, 1964). Right hemiplegic unilateral CP have been found to have the highest VP scores in comparison to other spastic CP subtypes (Abercrombie, 1964; Skatvedt, 1960).

Visual perceptual skills are often assessed by occupational therapists using standardised assessments. The TVPS-3 is a motor-free standardised assessment which can be used with children with CP as it does not require motor output which may affect the results of the test in children with motor disturbances (Colarusso and Hammil, 2006) (Martin, 2006). Studies have been completed using the TVPS-3 on a South African population and have indicated that caution needs to be taken when using this assessment on a population with diverse culture and language (Harris, 2017; Visser, 2003).

CHAPTER 3: METHODOLOGY

3.1 Introduction

This chapter describes the research design, sampling and research instruments and procedure, as well as the data analysis used in this study.

3.2 Research Design

A quantitative and cross-sectional design was used to determine the visual perceptual deficits in children with different types of CP. The study was quantitative as the TVPS-3 is a standardised assessment measure which provides numerical data. This research design was suitable for use in this study as it provided information about the visual perceptual skills of the children with different subtypes of CP that could be compared. The data compared the participants' scores to normative data as well as the cluster of the scores amongst different subtypes of CP. Each child was assessed using the TVPS-3 and no reassessment took place. The study was thus a cross-sectional design which involves the collection of data from participants at one single time period (Da Silva, 2011) and is often used to determine the prevalence of an outcome of a specific population (Levin, 2006). The research did not have a treatment component which required retesting or observation over a period of time. This type of design can however be limiting as it does not take into account the fact that the child may not be at their optimal level of performance at the time of data collection and does not consider previous experience. (Removed sentence)

3.3 Population and Research Site

3.3.1 Research Site

The study was based at Forest Town School in Johannesburg South Africa, which is a school for learners with special educational needs (LSEN). Forest Town School is a government school which caters for children with specific learning difficulties (SLD). The school has a large population of children with a diagnosis of CP. Forest Town School has a large Grade R section which feeds into two streams offered at the school. There is the remedial stream which is made up of two sections, Foundation phase which is

Grade 1 to Grade 3 and Intersen phase which includes grade 4 to grade 7. The other stream is the modified stream which goes from junior modified to senior modified and then the work experience programme.

3.3.2 Population

The population for the study included children with different subtypes of CP. Total population sampling of children with a medical diagnosis of CP was used. The population was limited to children with a congenital and non-progressive cause of brain damage. Medical information is available for each child at the school and the children at Forest Town School have been through a process of screening and assessment by a multidisciplinary team to determine whether they are suited to the school. Their diagnosis in terms of CP is recorded in their file at the school.

Forest Town School caters for children with mild intellectual disability (MID) and therefore this was the criterion for the intellectual level. Children are often screened by the department of education and placed in appropriate schools for their level. Children on this level are able to follow the instructions required of the assessment and make informed decisions and are able to complete testing similar to that required for the TVPS-3.

3.3.3 Sampling

Total population sampling was used in this study and therefore all the children in the school that fitted the inclusion criteria were included in the study. The TVPS-3 test is norm referenced for age and therefore there was no age criterion for selection and recruitment. Children that fell within the appropriate ages for the TVPS-3 assessment which is between 4 years and 18 years 11 months were recruited into the study. The test accommodates age when administered. When a child can no longer answer questions in one subtest the examiner moves on to the next subtest. Therefore the examiner is able to obtain accurate and reliable results of children of all ages (Martin, 2006).

Inclusion criteria

- Children between the ages of 4 years – 18 years
- Attending Forest Town School

- Mild Intellectual Disability (MID) and above as indicated in the child's file
- Medical diagnosis of CP – diplegia (bilateral spasticity), quadriplegia (bilateral spasticity), hemiplegia (unilateral spasticity (left or right)) and athetosis (movement disorders) or ataxic (movement disorder) CP.
- Attended OT for at least 6 months (in order to control variables of length of time having been receiving therapy including intervention for visual perceptual deficits).
- Children with severe visual deficits were excluded from the study.

3.3.4 Sample size

The sample size therefore included 19 children with spastic unilateral CP, 35 children with spastic bilateral CP, 17 children with dyskinetic CP and 9 with ataxic CP. Four of the participants had to be excluded as they were unable to be tested using the TVPS-3 due to non-compliance and poor concentration.

3.4 Measurement Techniques

3.4.1 Demographic Questionnaire

The questionnaire was designed by the researcher to capture demographic information and included date of birth, gender, diagnosis, GMFCS level, grade or class, whether they receive occupational therapy and the length of time they have received occupational therapy. The demographic questionnaire aimed to determine if the child met the inclusion criteria for the study (Appendix A -).

3.4.2 Test of Visual Perceptual Skills-3 (TVPS-3)

The TVPS-3 used in this study (Appendix B Test of Visual Perceptual Skills 3rd Ed Scoresheet

The TVPS-3 is standardized and contains 7 subtests: Visual Discrimination, Visual Memory, Spatial Relationships, Form Constancy, Visual Sequential Memory, Figure-Ground and Visual Closure (Martin, 2006). Each subtest has two sample items which allow the child to practice and 16 scored items. The items become increasingly difficult (Brown et al., 2012). Each item contains four or five forms. The TVPS-3 provides the examiner with scores that can be analysed both for intervention and research purposes.

The advantage of the TVPS-3 is that it can be used to test children with motor or speech impairments and is ideal for use in research (Martin, 2006). The validity of using visual perceptual tests including the TVPS-3 with children with cognitive disability has been under scrutiny (Brown, 2009). Limited studies have been completed to determine the validity of using the TVPS-3 with children with CP in a South African population. The information that is available does however appear to state that visual perceptual tests including the Beery VMI-6, DTVP-3 and TVPS-3 are valid for children in South Africa (Visser et al., 2017). Harris, (2017) completed a study on the validity and reliability of visual perceptual standardised tests in children from Gauteng. Typically developing children and children diagnosed with specific learning disabilities were assessed using the TVPS-3 and the scores were compared to normative data reported on USA samples in the test manual. She found that the scores on the TVPS-3 were valid in comparison to the mean standard and scaled scores reported for the USA samples. The mainstream South African group had lower mean scaled scores for visual discrimination and form constancy and both groups had higher mean scaled scores for spatial relations. Although these differences do affect the validity of the subtests on a South African sample, the composite scores were all comparable to the USA scores. The South African participants with learning disabilities had higher standard composite scores than the children with learning disabilities in the TVPS-3 manual. Test results of children in a South African population must therefore be interpreted with caution (Harris, 2017). The research studies have supplied values for typical children, but not those with CP.

3.4.2.1 Scoring

The TVPS-3 allows the examiner to compare the scores of the participant with a large normative sample in the United States of America. The examiner scored the assessment by marking the participants' answer on the score sheet. A ceiling is reached after 3 incorrect answers are given and then the examiner moves on to the next subtest. On completion of the assessment the examiner added up the raw scores for each subtest. These were converted into scaled scores and percentile ranks. These scaled scores were grouped into the appropriate index scores which include overall, basic processes, sequencing and complex processes. These composite scores allow the examiner to compare the skills that are related to each other, such as basic processes which includes visual discrimination, visual memory, spatial relations and form constancy; sequencing which includes sequential memory; and complex processes which includes figure-ground and visual closure. The added scaled scores were converted to standard scores and percentile ranks (Martin, 2006).

3.5 Ethical Considerations

Ethical clearance for the study was obtained from the Human Research Ethics Committee (HREC) at the University of the Witwatersrand (M170817) (Appendix C) as well as permission from the Gauteng Department of Education (Appendix D) and the Principals and the Head of the Occupational Therapy Departments at the school (Appendix E).

Parents/legal guardians of the children were provided with an information sheet (Appendix F) and asked to sign informed consent (Appendix G). The information sheet was written in an easy to understand manner in English. The language of instruction at Forest Town School is English and therefore it is expected that the guardians have an understanding of English. However, the researcher's contact details were provided in case the parents had any questions or queries. Informed verbal assent (Appendix H) was be obtained from the participants by explaining the research to them in a very easy to understand manner. All children were asked to provide verbal assent in the presence of a witness.

Confidentiality was maintained by using codes instead of students' names. The score sheets were modified to include code instead of names. The sheet containing names correlating to codes were kept separately from the results. All score sheets and demographic questionnaires were stored in a locked cupboard in the Forest Town School Occupational Therapy department.

Parents and children were informed that they could withdraw their consent or assent at any time during the research. Participation was voluntary and therefore there were no consequences for the parents who did not wish their children to participate or the children who did not wish to participate. In order for there to be carry over of the assessment results obtained by this research, permission to share the results with the child's treating therapist was included in the parent consent form. Therefore, if intervention was required in specific areas the treating therapist could address them. Feedback on the results of the study were available on request. Information sheets and test scores were safely stored and will be kept for a period of 6 years as per HPCSA regulations.

3.6 Research Procedure

Class lists were screened to identify which children would possibly meet the inclusion criteria of the study. Other treating therapists were also consulted to assist with the identification of children. Consent forms, information sheets and demographic questionnaires were sent to the parents of these identified children. When parental signed informed consent was obtained and the child met the inclusion criteria, the child was included on the list for assessment.

3.6.1 Data collection

If the child gave verbal assent, testing was completed by the researcher who has experience in using the TVPS-3. The researcher is based full time at the school and was able to assign time for data collection in the timetable. A list of participants was compiled and times were allocated for the children to come to the occupational therapy department for testing.

Testing specifically took place in the mornings in order to ensure that the children could concentrate optimally. Teachers were made aware of the research in the morning staff meeting and therefore were aware that children may be called out of class for the assessment. The teacher was consulted about the child’s other therapies or activities and if they were able to attend the assessment at the allocated time. If they were unavailable, another time was allocated and a different participant was tested if possible.

Testing took place at Forest Town School Occupational Therapy Department in the assessment room which is a quiet room with few visual distractions. Comfort was maintained by ensuring temperature control, ventilation and adequate lighting. A small and large table and chairs were placed in the room to accommodate for the child’s height. On arrival, the participant was told about the research and asked if they want to participate. This explanation was adapted to the child’s age and understanding to ensure they knew what was expected of them and were able to make an informed decision. If they agreed and were able to write, they were asked to sign the consent form otherwise they gave verbal assent in front of a witness. The witness was usually another occupational therapist working in the department.

The test was administered individually in the standardised manner in accordance with the manual. Instructions for each subtest were given loud and clear and repeated if necessary. The test plates were placed in front of the child on the table. The subtests were started with number one and were presented chronologically. The child was asked to indicate the correct response by either pointing or saying the number. The examiner recorded the performance on a record form. The subtests were concluded when the child reached the ceiling and could no longer identify the correct answers after three attempts.

The test was not timed and therefore the length of time taken for them to select an answer did not affect their performance. The test took about 20-30minutes to administer on the younger children or children with poorer visual perceptual skills as they reached a ceiling sooner. However, it took between 45 minutes to an hour to administer on the older children or the children with stronger visual perceptual skills. Children were allowed rest breaks when necessary (Martin, 2006).

3.6.2 Control of interfering variables

The assessments all took place in the assessment room in Forest Town School's Occupational Therapy Department. This is a quiet room with few visual distractions. All assessments were completed in the morning to accommodate for fatigue later in the day.

The TVPS-3 has been found to be a reliable and valid measure of visual perception for 4-18 year olds (Brown et al., 2012). It provides a consistent measure and is relatively free of error. It has a high level of homogeneity and high test-retest reliability (Visser et al., 2017). All TVPS-3 assessments were conducted by the researcher however bias was prevented as the TVPS-3 is a standardised test which provides objectivity By having one person complete the assessments the intra-rater reliability increases. The children are not familiar with the test as none of them had been assessed using this assessment previously.

3.7 Data Analysis

The demographic data, subtypes of CP and the other information related to motor function levels and education were analysed using descriptive statistics and frequencies.

The frequency of the standard scores and z scores were calculated for the sample of children with CP. The scaled scores for the TVPS-3 were calculated for the different subtypes of CP. These scores were compared for each subtest of the TVPS-3 as well as the standard scores for the composite sections of the TVPS-3 using the Kruskal – Wallis test to determine if a significant difference existed.

The composite standard scores for the TVPS-3 were also compared according to the variables of gender, age and motor function on the GMFCS using the Kruskal –Wallis test to determine if a significant difference existed based on these variables.

Data analysis answered the question as to what the different visual perceptual deficits were for the different types of CP. This was achieved using descriptive statistics for each group and non-parametric inferential stats to compare the groups.

CHAPTER 4: RESULTS

4.1 Introduction

In this chapter the results for 80 participants are presented including the demographic data on the participants, as well as a comparison of the TVPS-3 scores for different CP subtypes. The participants were conveniently selected from a special needs school and reflect the distribution of diagnoses in the school. The whole school was screened and it was found that 80 children met the criteria for the study. The numbers in each group were therefore unevenly distributed according to CP diagnosis and could not be stratified. The sample included 19 children with spastic unilateral CP (9 with right side affected and 10 with the left side affected), 27 children with bilateral spastic CP with only lower limb involvement and 8 with bilateral spastic CP with both upper and lower limb involvement. There were 17 children with dyskinetic movement disorder and 9 children with ataxic movement disorder. This accommodates the studies that report of the prevalence of CP that the spastic subtype is more common than movement disorders including dyskinetic or ataxic CP (Braun *et al.*, 2016).

4.2 Demographics of the Sample

4.2.1 Distribution of Cerebral Palsy

The distribution of the CP subtypes in the participants (Table 4.1) indicates that the highest percentage of participants presented with a spastic bilateral diagnosis (44%) with 77% of these participants having involvement of the lower limbs only.

Table 4.1 Distribution of Cerebral Palsy subtypes of participants (n=80)

CP Subtype	**n**	**(%)**
Spastic Unilateral (Right)	9	11
Spastic Unilateral (Left)	10	13
Spastic Bilateral (LL)	27	34
Spastic Bilateral (LL and UL)	8	10
Dyskinetic	17	21
Ataxic	9	11

Participants with both upper and lower limb spasticity represented only 10% of the total sample. Approximately one third (32%) had diagnoses that related to dyskinetic and ataxic CP and one quarter (24%) had a spastic unilateral diagnosis. The percentage was almost evenly distributed, with 11% having involvement of the right side and 13% having involvement of the left side.

4.2.2 Age Demographics

The participants in the study were between 5 years 0 months and 18 years 11 months of age. The highest percentage fell between the ages of 9 years 0 months to 13 years 11 months in the junior school group. The highest percentage of participants in the spastic unilateral and the spastic bilateral CP groups also fell into this group, with the highest percentage of dyskinetic participants in the foundation phase at school between 5 years 0 months to 8 years 11 months. The highest percentage of ataxic participants fell into the adolescent group attending senior school between 14 years 0 months and 18 years 11 months (Table 4.2).

Table 4.2 Age Demographics of participants (n=80)

Age (years, months)	Total group	Spastic Unilateral (Right) n=9	Spastic Unilateral (Left) n=10	Spastic Bilateral (LL) n=27	Spastic Bilateral (LL and UL) n=8	Dyskinetic n=17	Ataxic n=9
	n (%)						
5 years– 8 years 11 months	27 (33)	5 (6)	2 (2)	10 (12)	2 (2)	7 (8)	1 (1)
9 years– 13 years 11 months	37 (46)	4 (5)	4 (5)	15 (18)	4 (5)	6 (7)	3 (3)
14 years– 18 years 11 months	16 (20)	0 (0)	4 (5)	2 (2)	2 (2)	4 (5)	5 (6)

4.2.3 Gender Demographics

Fifty five percent of participants were males. Thirty-six percent of the males had dyskinetic CP, 20% had spastic bilateral (LL) CP, 18% had spastic unilateral (right) CP, 9% had spastic bilateral (LL an UL) CP and ataxic CP and 6% had spastic unilateral CP (L). Of the females, 50% had spastic bilateral (LL) CP, 19% had spastic unilateral (left) CP, 14% had ataxic CP, 11% had spastic bilateral (LL and UL) CP, 3% had dyskinetic CP and 3% had spastic unilateral (right) CP (Table 4.3).

Table 4.3 Gender Demographics of participants (n=80)

Gender	Total group	Spastic Unilateral (Right) n=9	Spastic Unilateral (Left) n=10	Spastic Bilateral (LL) n=27	Spastic Bilateral (LL and UL) n=8	Dyskinetic n=17	Ataxic n=9
	n (%)						
Male	44 (55)	8 (10)	3 (3)	9 (11)	4 (5)	16 (20)	4 (5)
Female	36 (45)	1(11)	7 (8)	18 (22)	4 (5)	1 (1)	5 (6)

4.2.4 Gross Motor Function Classification System Level

The GMFCS level of the participants was recorded however this did not impact directly on the child's participation in the assessment as it is motor free. The majority of the participants (34%) were on GMFCS level 2. Thirty percent of the participants were on GMFCS level 3, 21% were on GMFCS level 1, 10% were on GMFCS level 4 and 5% were on GMFCS level 5 (Table 4.4).

Table 4.4 Gross Motor Function Classification System levels of participants (n=80)

***Gross Motor Function Classification System* Level**	Total group	Spastic Unilateral (Right) n=9	Spastic Unilateral (Left) n=10	Spastic Bilateral (LL) n=27	Spastic Bilateral (LL and UL) n=8	Dyskinetic n=17	Ataxic n=9
	n (%)						
1	17 (21)	6 (7)	5 (6)	1 (1)	0 (0)	2 (2)	3 (3)
2	27 (34)	3 (3)	5 (6)	5 (6)	2 (2)	6 (7)	6 (7)
3	24 (30)	0 (0)	0 (0)	20 (25)	0 (0)	4 (5)	0 (0)
4	8 (10)	0 (0)	0 (0)	1 (1)	5 (6)	2 (2)	0 (0)
5	4 (5)	0 (0)	0 (0)	0 (0)	1 (1)	3 (3)	0 (0)

4.2.5 Education

The Grade R phase at Forest Town School has the largest percentage (43%) of children with CP compared to the rest of the sections at the school. Majority of these participants have spastic bilateral (LL) CP. This phase feeds into the junior modified section and the remedial section. The children that cannot cope with the remedial section move into the junior modified section. Therefore, the next highest percentage (15%) of participants were in the junior modified phase followed by (11%) the senior modified phase. These children then move into the Work Experience Programme (10%). The remedial section which are the higher functioning children have the lowest percentage of children with CP and include foundation phase (10%) and Intersen phase (11%).

Table 4.5 Education Phase of participants (n=80)

Phase	**Total group n=80**	**Spastic Unilateral (Right) n=9**	**Spastic Unilateral (Left) n=10**	**Spastic Bilateral (LL) n=27**	**Spastic Bilateral (LL and UL) n=8**	**Dyskinetic n=17**	**Ataxic n=9**
	n (%)						
Grade R	34 (43)	5 (6)	4 (5)	13 (16)	3 (3)	8 (10)	1 (1)
Foundation Phase	8 (10)	2 (2)	1 (1)	2 (2)	1 (1)	1 (1)	1 (1)
Intersen Phase	9 (11)	0 (0)	1 (1)	5 (6)	0 (0)	2 (2)	1 (1)
Junior Modified	12 (15)	1 (1)	1 (1)	4 (5)	1 (1)	3 (3)	2 (2)
Senior Modified	9 (11)	1 (1)	0 (0)	3 (3)	2 (2)	2 (2)	1 (1)
Work Experience Programme	8 (10)	0 (0)	3 (3)	0 (0)	1 (1)	1 (1)	3 (3)

4.3 Test of Visual Perceptual Skills -3rd Edition

4.3.1 Overall Visual Perceptual Impairment in children with Cerebral Palsy

The overall standard scores of the TVPS-3 with a mean of 100 and standard deviation of 15 and z scores were calculated. A standard score of 100 indicates age appropriate performance and a score of 115 indicates that their performance is 1SD above age related performance.

Table 4.6 Overall Standard Scores and SD of children with Cerebral Palsy

Number of Participants (%)	Standard Score	z scores	Scaled scores
8 (10)	<55	-3	2
36 (45)	55-69	-2	4
30 (38)	70-84	-1	7
5 (6)	85-114	Mean	10
1 (1)	115-130	+1	13

Table 4.6 indicates that 6 out of the 80 participants (8%) scored within normal range or above average for their age group. That means that 92% of the participants presented with overall visual perceptual difficulties and z scores below -1SD.

When the scaled scores for each of the subtests for the participants with CP were compared to the scaled scores reported for typical South African children attending mainstream schools and children attending LSEN schools, the scores for the participants were significantly lower.

This confirms that the participants with CP present with more visual perceptual problems than other children, even those with learning disabilities.

Table 4.7 Visual Perceptual Scores of Mainstream, LSEN and Cerebral Palsy learners in a South African Population

	Participants with CP attending an LSEN school (6 years - 9 years 11 months) (n=80)	South African children attending mainstream schools (Harris 2017) (n=48)	p value	South African children attending LSEN schools (Harris 2017) (n=48)	p value
	Mean scaled score (SD)			Mean scaled score (SD)	
Visual discrimination	4.59 (2.83)	8.81 (2.80)	0.006**	8.47 (4.23)	0.011**
Visual memory	4.62.(3.63)	10.79 (4.27)		10.86 (4.16)	
Spatial relations	3.86.(3.65)	13.10 (3.43)		11.54 (4.32)	
Form constancy	5.62 (3.32)	8.81 (3.49)		7.81 (4.26)	
Visual sequential memory	4.38 (2.93)	10.79 (3.51)		9.25 (3.74)	
Figure-ground	4.59.(3.62)	9.58 (3.63)		8.86 (4.78)	
Visual closure	4.31.(3.26)	10.02 (3.32)		9.19 (3.96)	
General Composite Score	72.69 (14.90)	100.31 (10.42)		98.5 (14.51)	

Significance p ≤ 0.05 *, p ≤ 0.01 **

4.3.2 Comparison of the Subtests of the Test of Visual Perceptual Skills -3rd Edition according to Cerebral Palsy subtypes

Table 4.8 presents the results for the comparisons between the subtests of the TVPS-3 for the subtypes of CP.

Table 4.8 Test of Visual Perception -3rd Edition subtest scaled scores in different Cerebral Palsy subtypes (n=80)

CP subtype	Spastic Unilateral (Right) n=9	Spastic Unilateral (Left) n=10	Spastic Bilateral (LL) n=27	Spastic Bilateral (LL and UL) n=8	Dyskinetic n=17	Ataxic n=9	p value
	Mean (SD)						
Visual Discrimination	5.44 (2.65)	4.40 (3.13)	4.74 (2.84)	3.75 (2.19)	2.71 (2.64)	2.22 (2.33)	**0.03***
Visual Memory	5.55 (3.97)	3.90 (4.43)	4.26 (3.73)	3.13 (3.09)	3.24 (3.40)	1.78 (2.39)	0.27
Spatial Relationships	6.11 (3.86)	3.80 (4.02)	4.81 (3.08)	5.13 (3.72)	3.12 (2.78)	2.44 (2.70)	0.10
Form Constancy	4.11 (2.26)	4.10 (2.77)	3.81 (3.66)	4.50 (4.44)	4.47 (3.48)	1.78 (2.11)	0.33
Sequential Memory	4.22 (3.19)	4.20 (3.61)	4.70 (2.95)	5.13 (2.30)	3.06 (2.66)	2.67 (2.55)	0.24
Figure-Ground	6.11 (5.58)	4.40 (4.48)	4.52 (3.37)	3.38 (2.83)	2.59 (2.32)	2.56 (3.13)	**0.03***
Visual Closure	5.00 (4.95)	3.70 (2.83)	4.07 (3.05)	3.75 (3.20)	3.24 (2.31)	3.44 (4.12)	0.93

Significance $p \leq 0.05$ *, $p \leq 0.01$ **

It was found that scores for the visual discrimination (p=0.03) and the figure-ground (p=0.03) subtests had statistically significant differences between the subtypes of CP. Whereas the scores for visual memory, spatial relations, form constancy, sequential memory and visual closure were not statistically significant different when the CP subtypes were compared.

The figures below indicate the strengths and weakness of the various subtypes of CP for the subtest in the TVPS-3:

4.3.2.1 Visual Discrimination

Figure 4.1 demonstrates the differences for the subtypes of CP for visual discrimination. The spastic unilateral (right) group and spastic bilateral (LL) group had the highest mean scaled scores. The ataxic groups had the lowest mean scaled scores followed by the dyskinetic group, the spastic bilateral (LL and UL) and spastic unilateral (left) group.

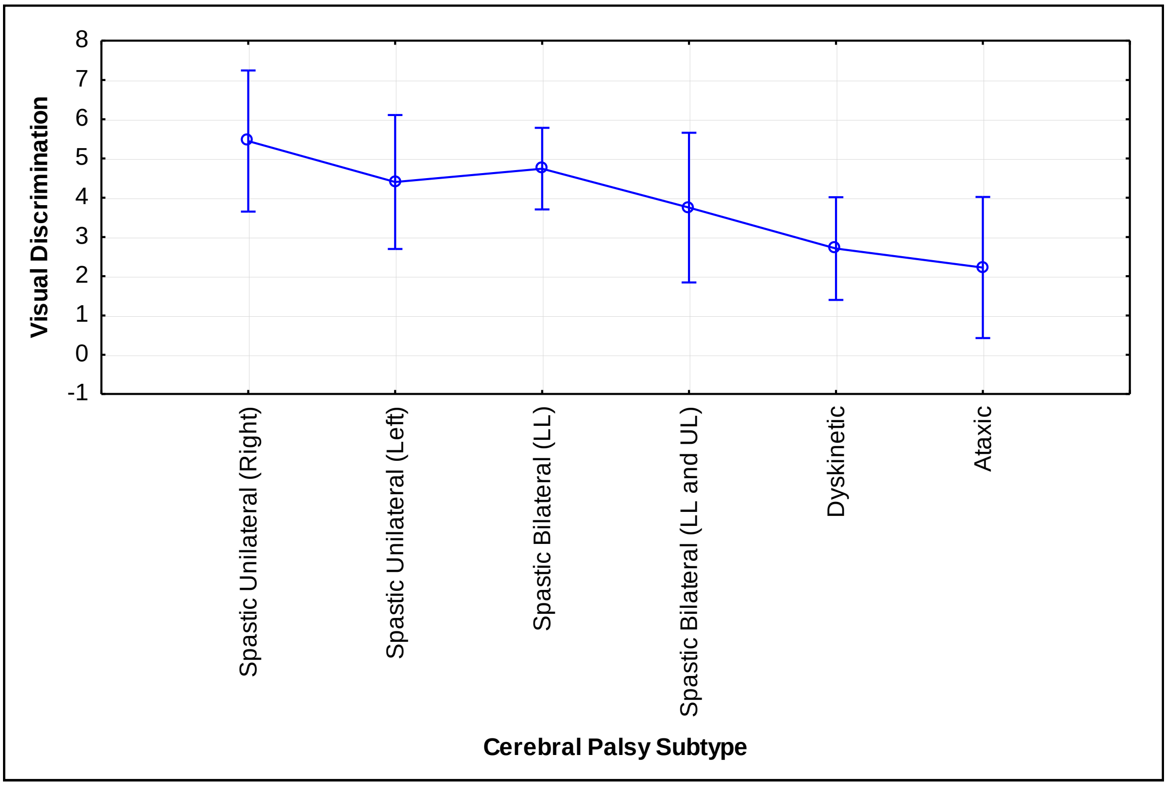


Figure 4.1 Comparison of Visual Discrimination scores of different subtypes of Cerebral Palsy (n=80)

4.3.2.2 Visual Memory

When comparing the scaled scores of the different CP subtypes for visual memory, the results appear to be the same as those of visual discrimination in which the spastic unilateral (right) and spastic bilateral (LL) CP groups scored the highest and the ataxic group scored the lowest. However, in this subtest the dyskinetic CP group appeared to score higher than the spastic bilateral (LL and UL) CP group.

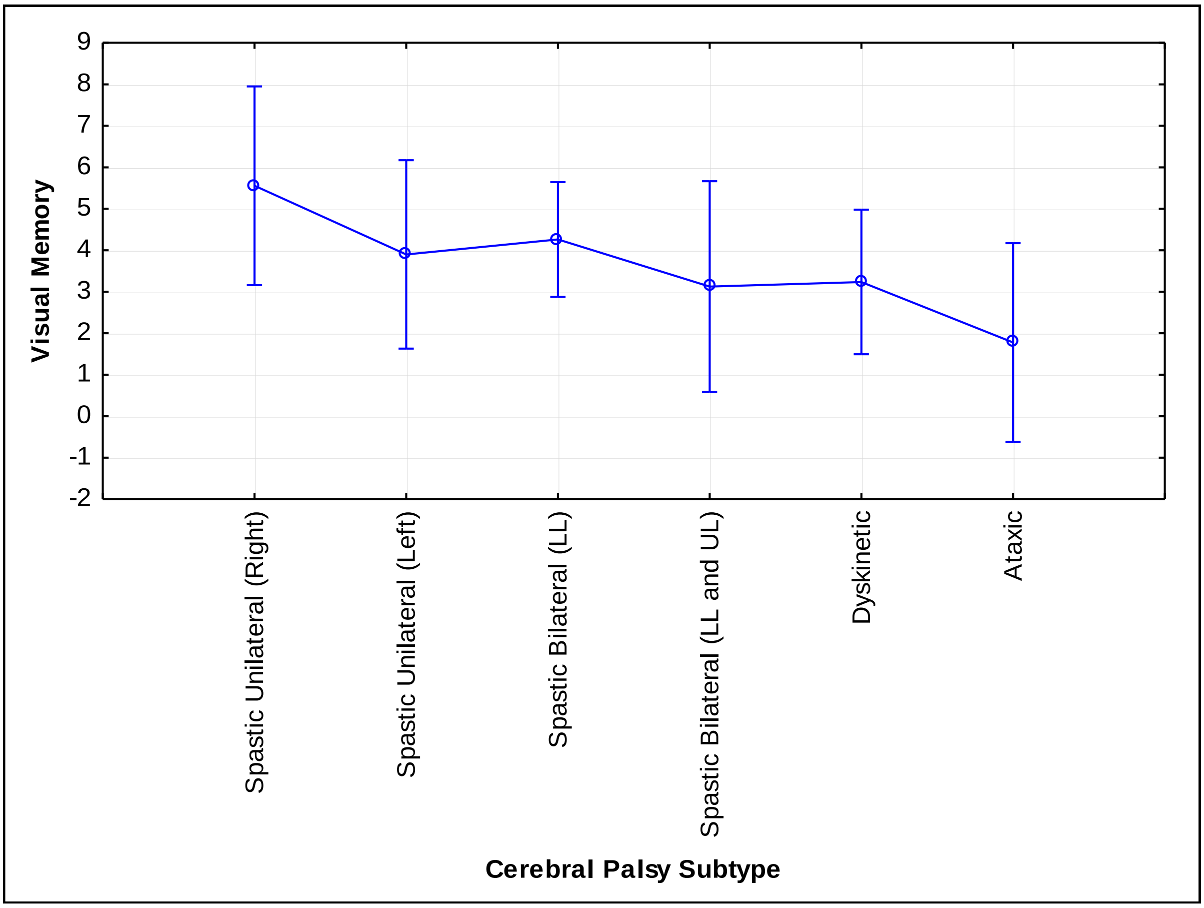


Figure 4.2 Comparison of Visual Memory scores of different subtypes of Cerebral Palsy (n=80)

4.3.2.3 Visual Spatial Relationships

The spastic unilateral (right) CP group had the highest mean scaled score for the spatial relationships subtest. There was a large difference in scores between the spastic unilateral (right) CP group and the spastic unilateral (left) CP group for this subtest. In this test it is interesting to see that the spastic bilateral (LL and UL) CP groups scored higher than the spastic bilateral (LL) CP group in comparison to the two previous test results where the spastic (LL) CP group scored higher. Again in this subtest the ataxic CP group had the lowest scores.

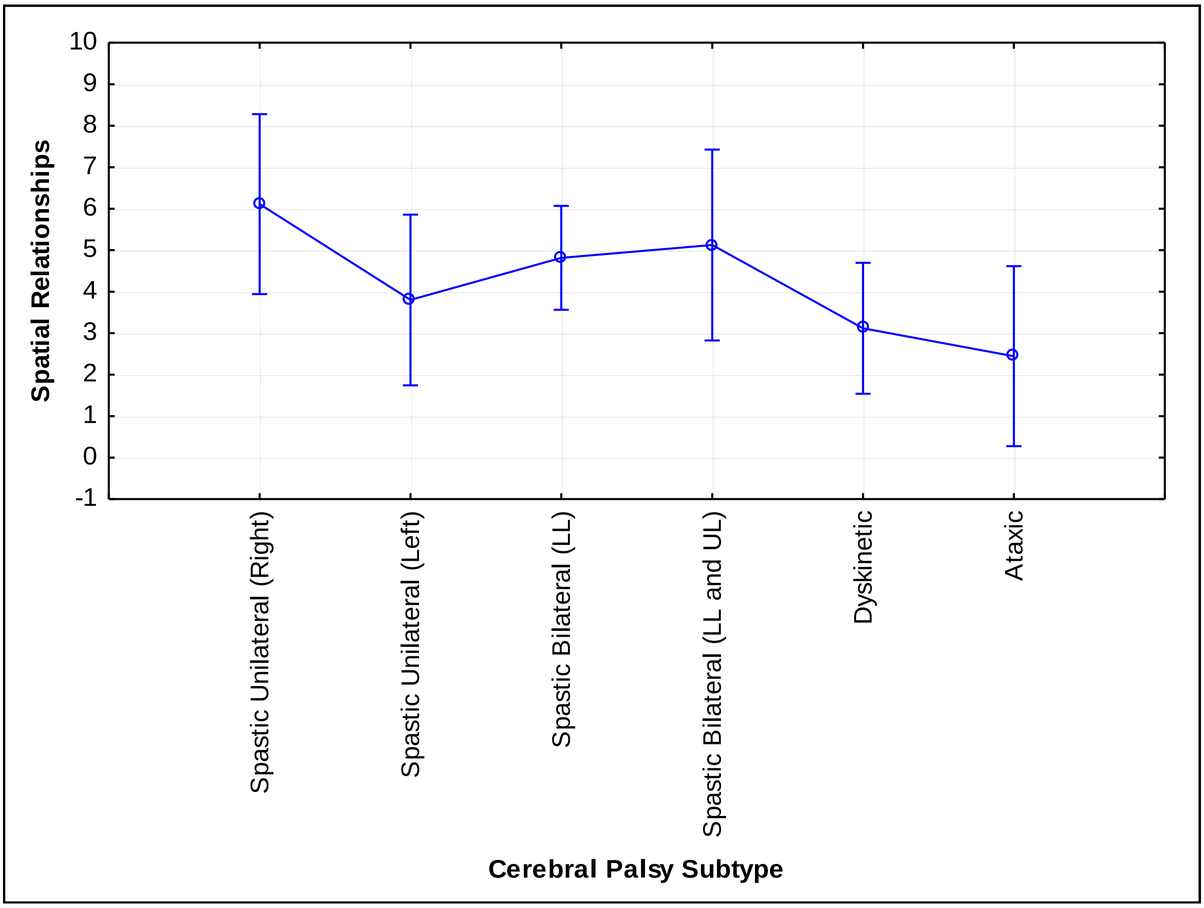


Figure 4.3 Comparison of Spatial Relationships scores of different subtypes of Cerebral Palsy (n=80)

4.3.2.4 Visual Form Constancy

The mean scaled scores for this subtest differ from all the rest in that the highest scoring groups were the spastic bilateral (UL and LL) and the dyskinetic CP groups . In this subtest the spastic unilateral (right) and spastic unilateral (left) CP group's scores were similar. Again it can be seen that the ataxic CP group had the lowest scores.

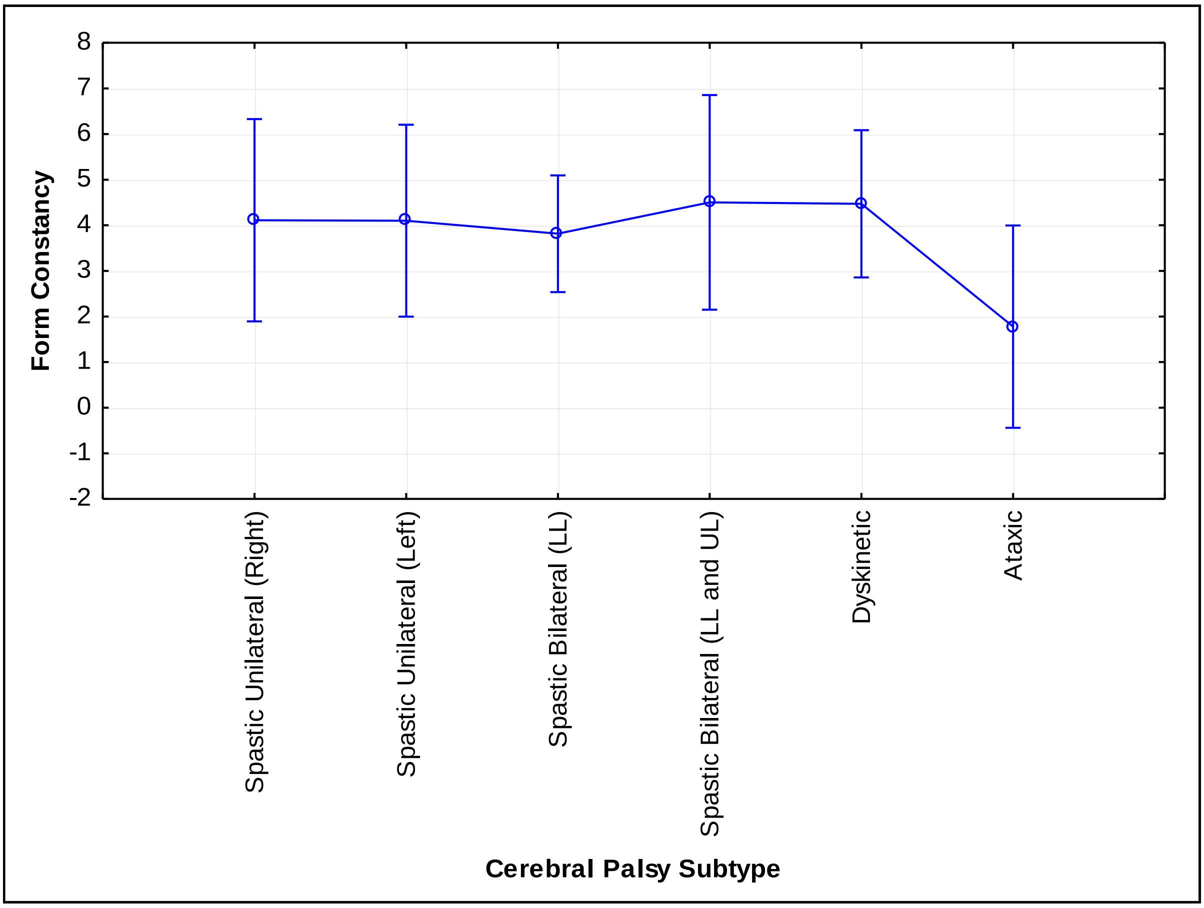


Figure 4.4 Comparison of Form Constancy scores of different subtypes of Cerebral Palsy

4.3.2.5 Sequential Memory

In the sequential memory subtest, the highest scoring group was the spastic bilateral (UL and LL) followed by the spastic bilateral (LL) CP group. Again, in this test the spastic unilateral (right) and spastic unilateral (left) CP groups had similar scores.

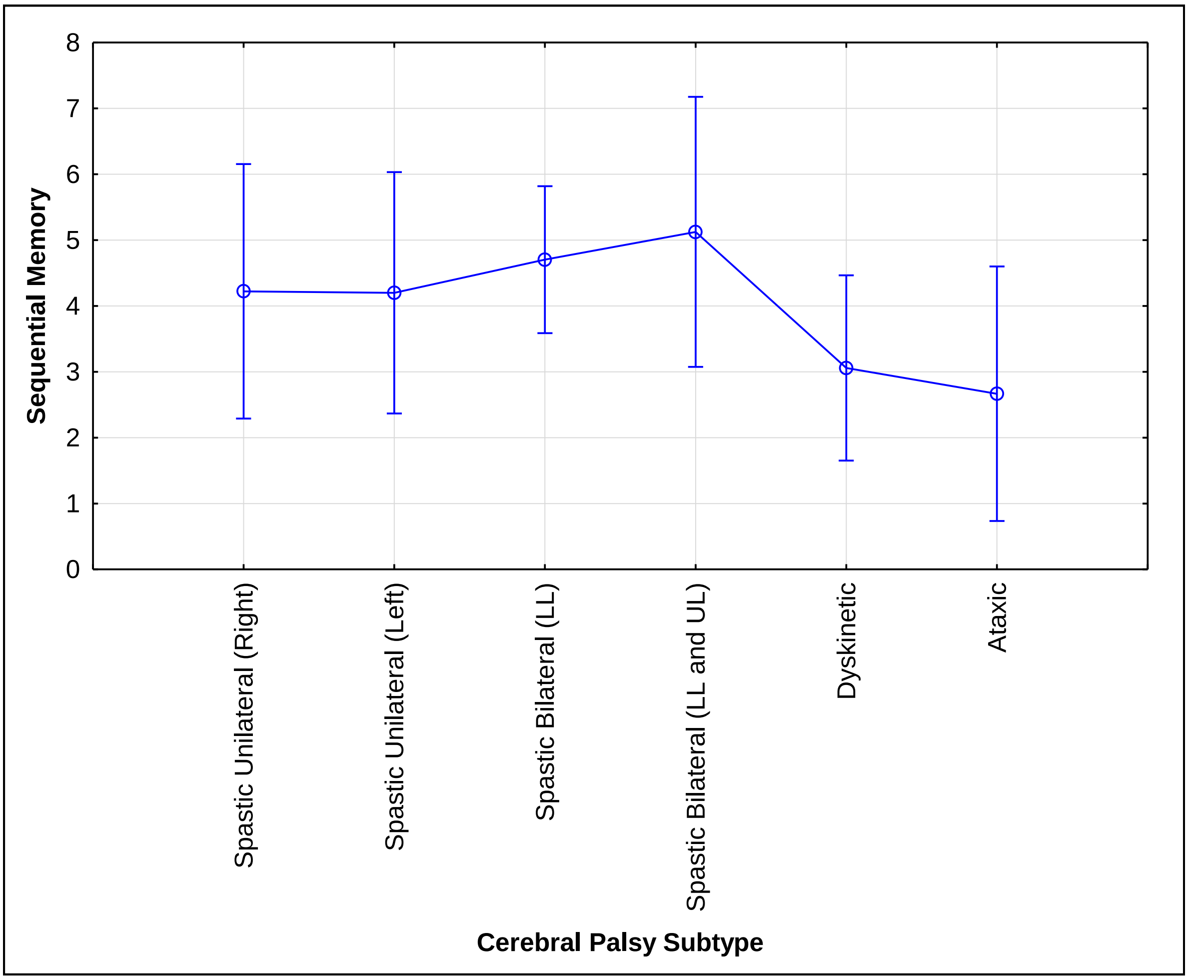


Figure 4.5 Comparison of Sequential Memory scaled scores of different Cerebral Palsy subtypes (n=80)

4.3.2.6 Figure-Ground

The differences for the CP subtype groups for figure-ground were significant, with the spastic unilateral (right) CP group and spastic bilateral (LL) CP group having the highest mean scaled scores. The ataxic and dyskinetic CP groups had similar low mean scaled scores for this subtest followed by the spastic bilateral (LL and UL) and spastic unilateral (left) CP group.

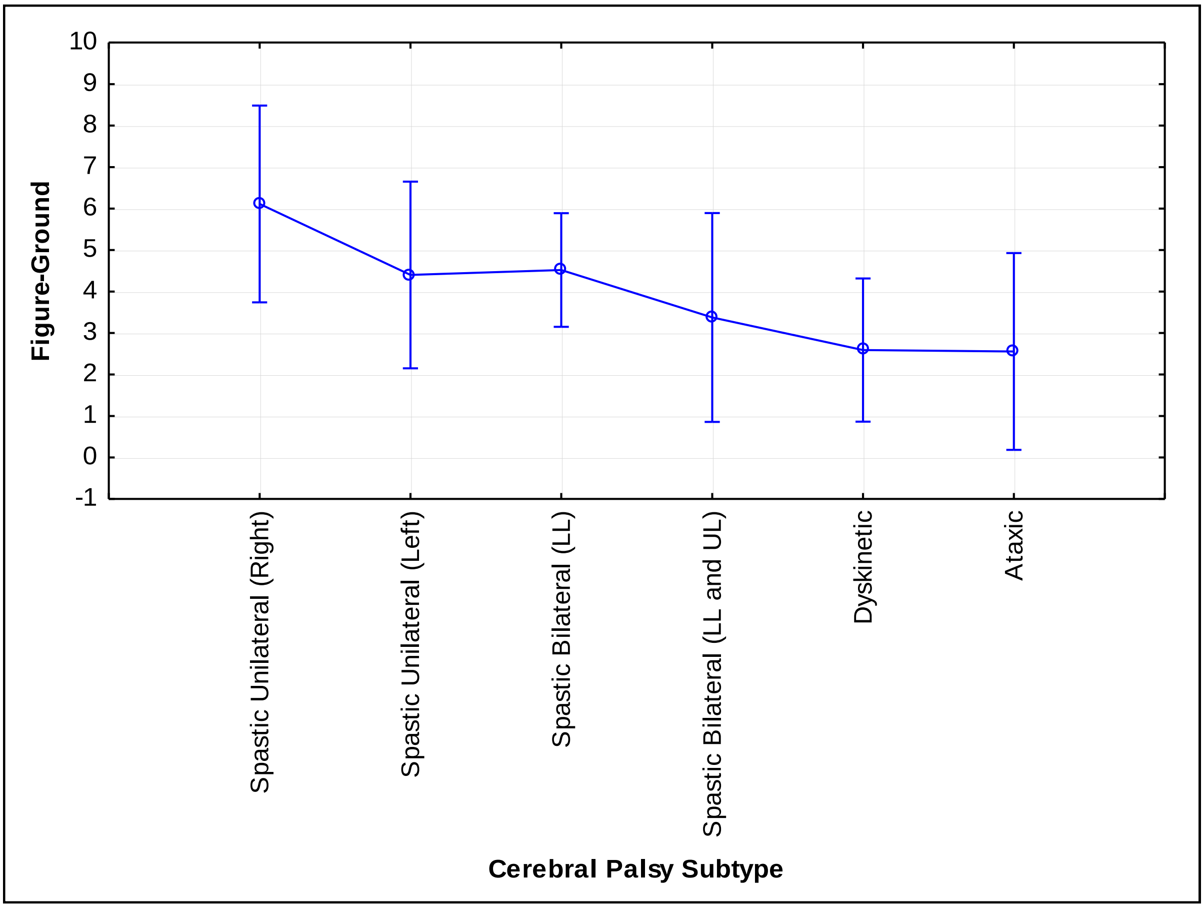


Figure 4.6 Comparison of Figure-Ground scaled scores of different subtypes of Cerebral Palsy(n=80)

4.3.2.7 Visual Closure

This is the first subtest where the ataxic CP group had higher scaled scores than the dyskinetic CP group. The spastic unilateral (right) CP group scored higher than the spastic unilateral (left) CP group.

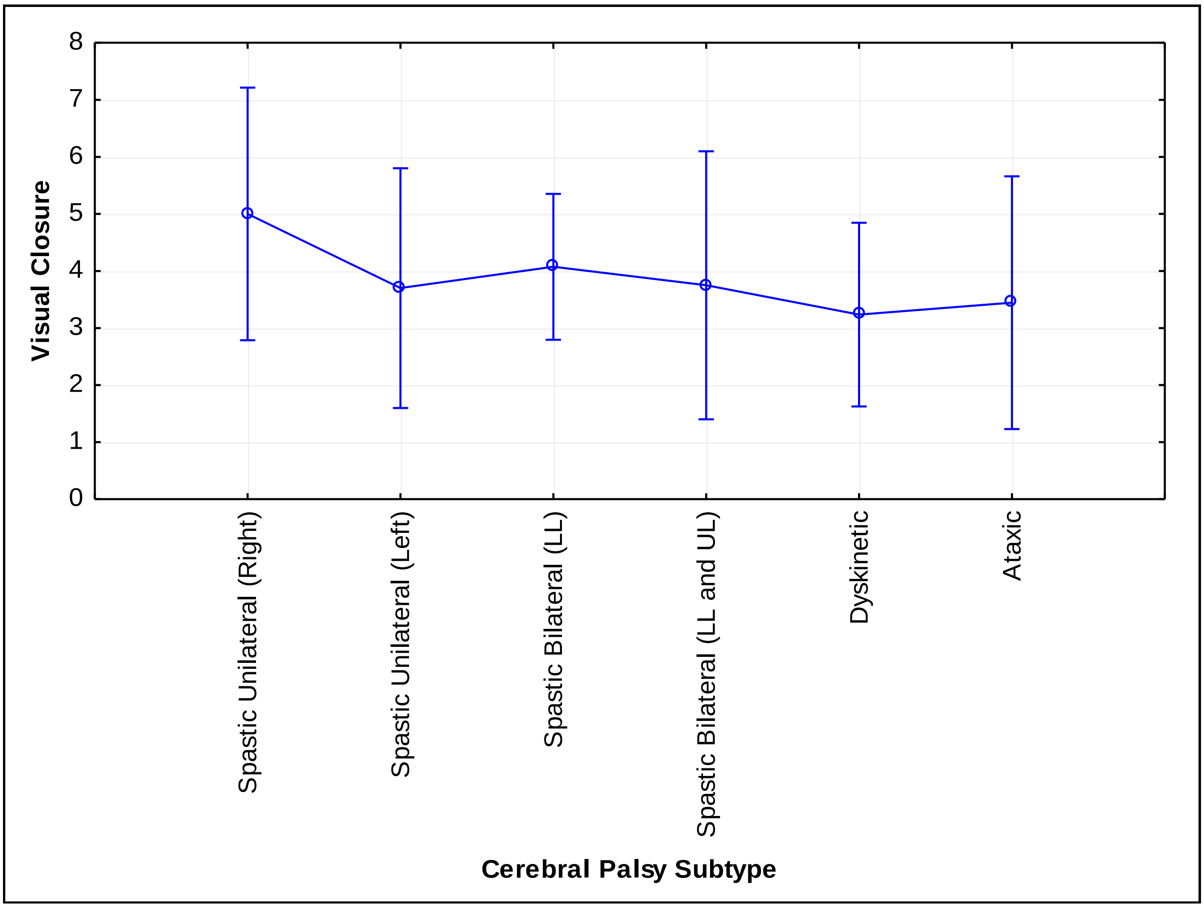


Figure 4.7 Comparison of Visual Closure scaled scores of different subtypes of Cerebral Palsy

4.3.3 Comparison of the Overall and Composite Scores of the Test of Visual Perceptual Skills -3 according to Cerebral Palsy diagnoses(n=80)

There was a significant difference in the Basic Processes standard scores (p=0.002) of the different subtypes of CP. There was no significant difference found in the complex processes and sequencing scores of the different CP subtypes (Table 4.9).

Table 4.9 TVPS-3 Composite standard scores of different subtypes of Cerebral Palsy (n=80)

CP subtype	Spastic Unilateral (Right) n=9	Spastic Unilateral (Left) n=10	Spastic Bilateral (LL) n=27	Spastic Bilateral (LL and UL) n=8	Dyskinetic n=17	Ataxic n=9	p value
	Mean (SD)						
Overall	75.89 (14.46)	65.10 (12.10)	72.11 (11.52)	74.87 (21.15)	65.82 (7.23)	56.33 (23.46)	
Basic Processes	76.55 (12.50)	65.50 (12.22)	71.04 (12.36)	70.50 (13.18)	63.88 (19.12)	43.55 (33.32)	**0.002***
Sequencing	65.55 (28.22)	60.30 (24.63)	69.81 (23.99)	69.37 (28.46)	53.53 (32.19)	52.22 (31.34)	0.362
Complex Processes	77.00 (24.55)	64.60 (13.60)	67.85 (23.79)	55.37 (35.11)	64.59 (8.73)	48.44 (38.74)	0.167

Significance p ≤ 0.05 *, p ≤ 0.01 **

4.3.3.1 Basic Processes

The basic processes score is comprised of visual discrimination, visual memory, spatial relations and form constancy.

There was a significant difference (p=0.002) between the basic processes subtest scores of the different subtypes of CP. Figure 4.8 indicates that the ataxic group had the lowest scores, with mean standard score of 43.55 and the highest scores were for the spastic unilateral (right) group, with a mean standard score of 76.55.

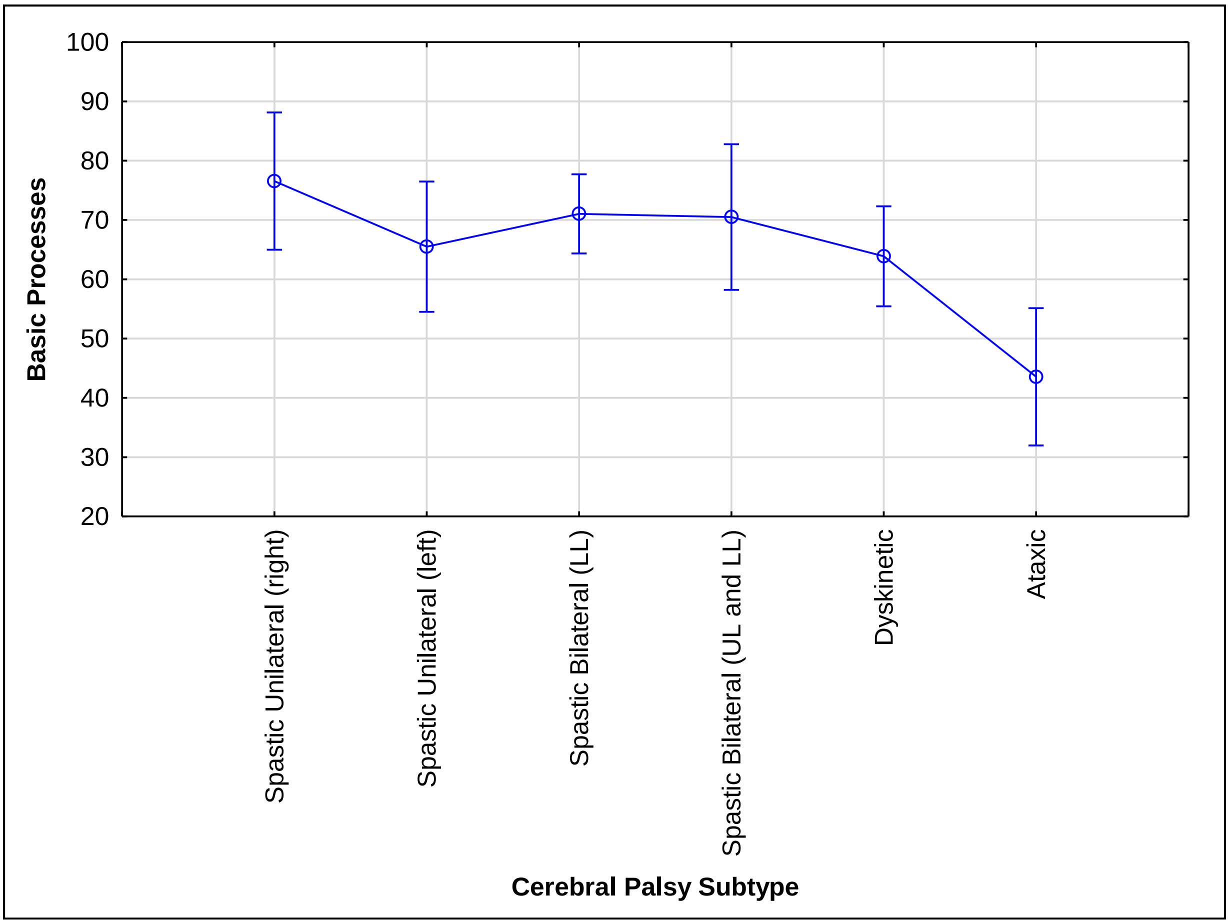


Figure 4.8 Comparison of Basic Processes standard scores between different subtypes of Cerebral Palsy(n=80)

4.3.3.2 Sequencing

The sequencing score is only comprised of one subtest which is sequential memory. The scores for this subtest however did not have a significant difference. These scores were however interesting as the highest scores were the spastic bilateral (LL) CP group with a mean standard score of 69.81 and the spastic bilateral (LL and UL) CP group which had a mean standard score of 69.37 as seen in Figure 4.9. The lowest scoring CP subtype was the ataxic subtype with a mean standard score of 52.22.

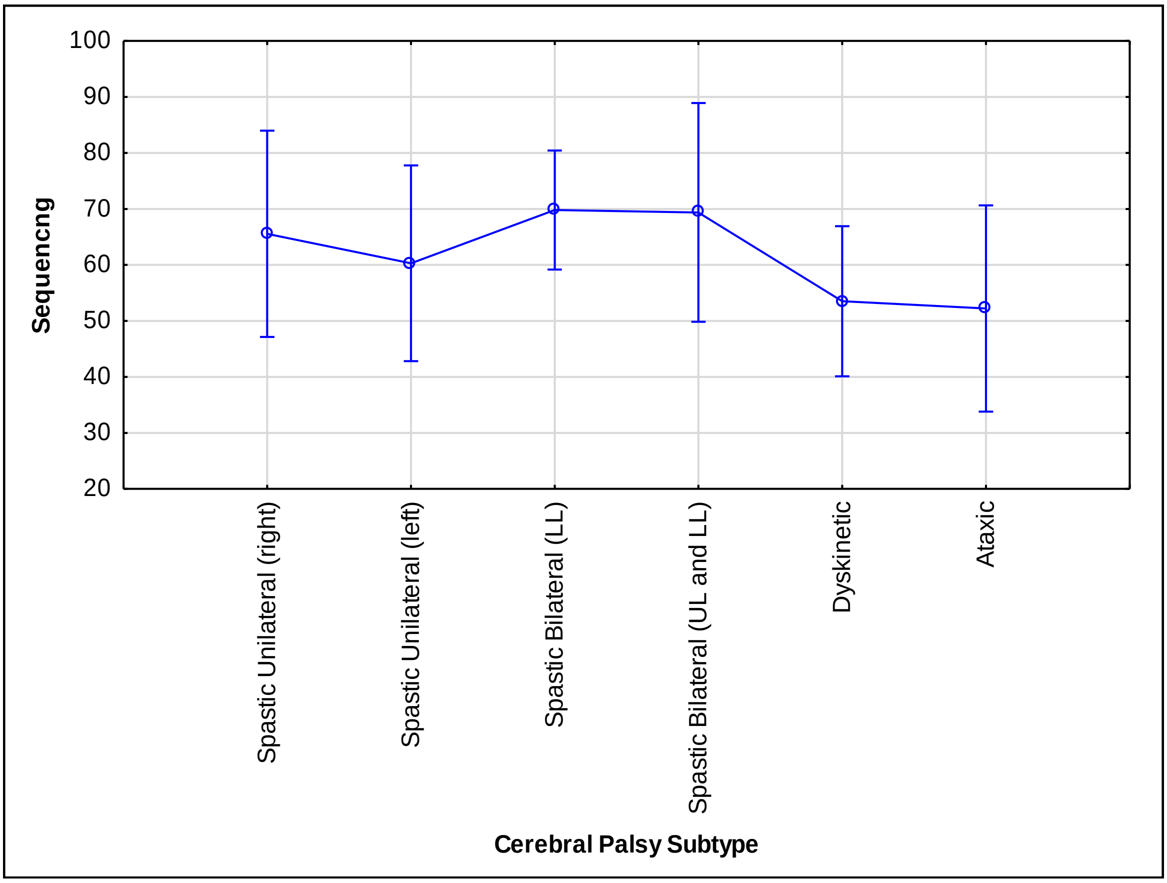


Figure 4.9 Comparison of Sequencing standard scores between different subtypes of Cerebral Palsy

4.3.3.3 Complex Processes

The complex processes scores are comprised of figure-ground and visual closure. These are higher order skills which require basic processes to be intact in order to function adequately. It is interesting to see that the results for basic processes were similar to those of the complex processes in that the lowest scores were those of the ataxic CP group with a mean standard score of 48.44 and the highest scores were those of the spastic unilateral (right) CP group with a mean standard score of 77.00.

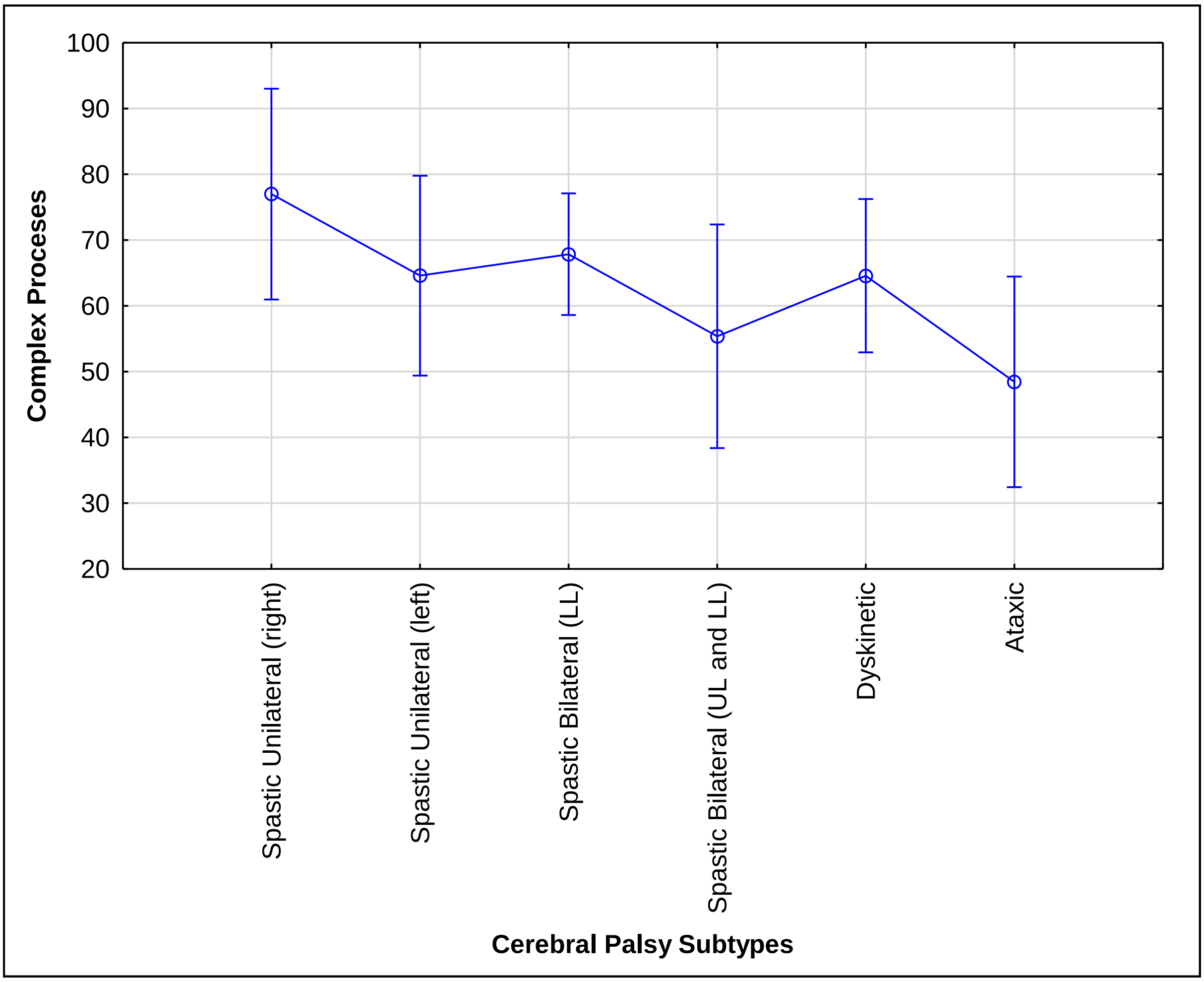


Figure 4.10 Comparison of Complex Processes standard score between different subtypes of Cerebral Palsy (n=80)

4.3.4 Comparison of the Composite Scores of the Test of Visual Perceptual Skills -3rd Ed to Gender

A significant difference was found (p=0.031) in the basic processes standard scores of male and female participants. Males had significantly higher scores than females in the basic processes tests which include visual discrimination, visual memory, spatial relations and form constancy. The sequencing standard scores (p=0.702) and complex processes standard scores (p=0.156) scores of males and females did not have significant differences (Table 4.10).

Table 4.10 Comparing Gender in Composite Scores(n=80)

	Male		**Female**		**P value**
	Mean	SD	Mean	SD	
Basic Processes	70.45	16.31	61.22	21.27	**0.031***
Sequencing	63.75	28.39	61.33	27.47	0.702
Complex Processes	67.88	24.79	60.03	23.96	0.156

Significance p ≤ 0.05 *

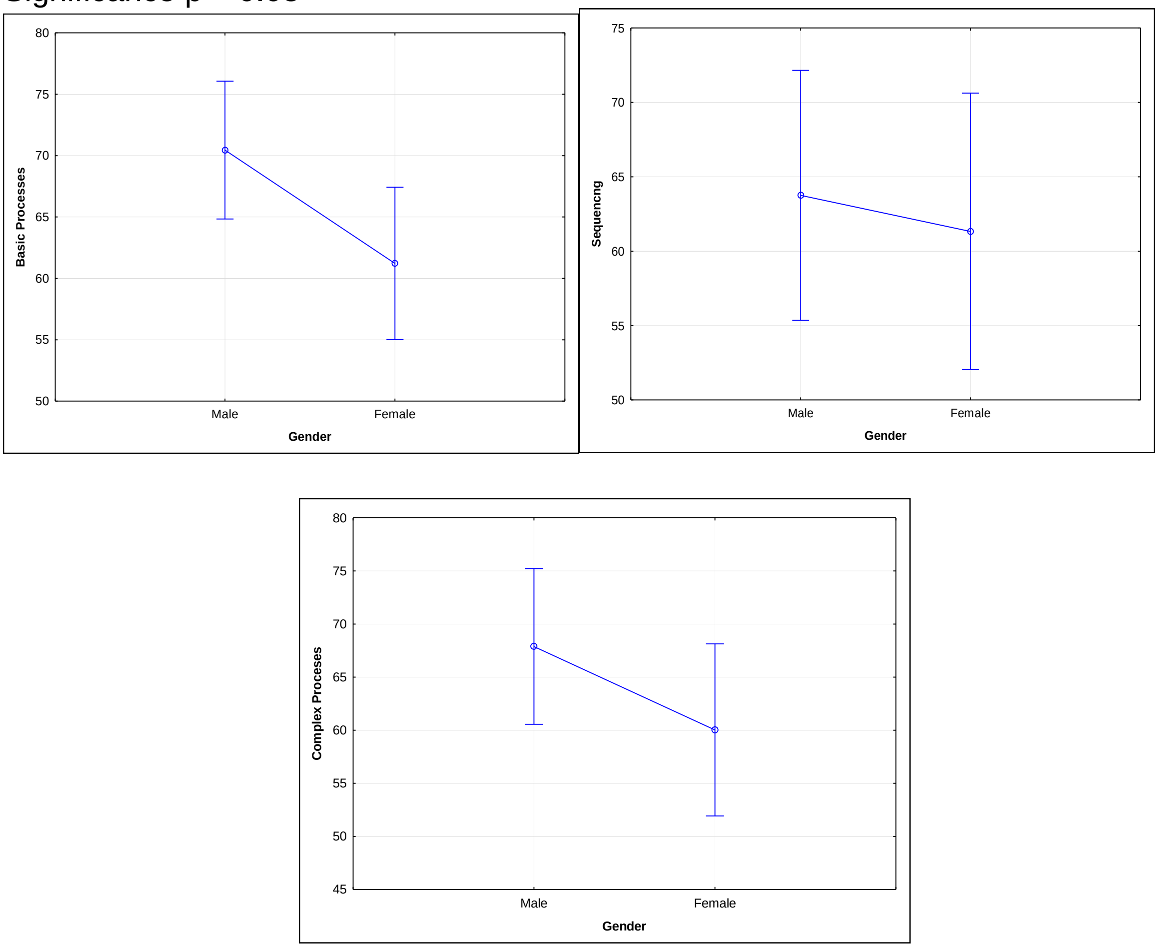


Figure 4.11 Comparing Gender in Basic Processes. Sequencing and Complex Processes(n=80)

When looking at gender differences, Figure 4.11 indicates that males had higher standard scores in all areas including basic processes, sequencing and complex processes.

4.3.5 Comparison of the Composite Scores of the Test of Visual Perceptual Skills -3rd Ed according to age

There was no significant difference in the standard scores for the different age groups on any of the composite scores on the TVPS-3 (Table 4.11).

Table 4.11 Comparing Age in Composite Scores (n=80)

	5yrs - 8yrs 11mo		**9yrs - 13yrs 11mo**		**14yrs – 18yrs 11mo**		**P value**
	Mean	SD	Mean	SD	Mean	SD	
Basic Processes	71.45	9.72	68.69	11.97	53.52	33.26	0.21
Sequencing	66.25	23.18	64.95	25.55	52.35	36.83	0.53
Complex Processes	69.50	18.62	62.89	24.39	60.41	31.78	0.72

Significance $p \leq 0.05$ *

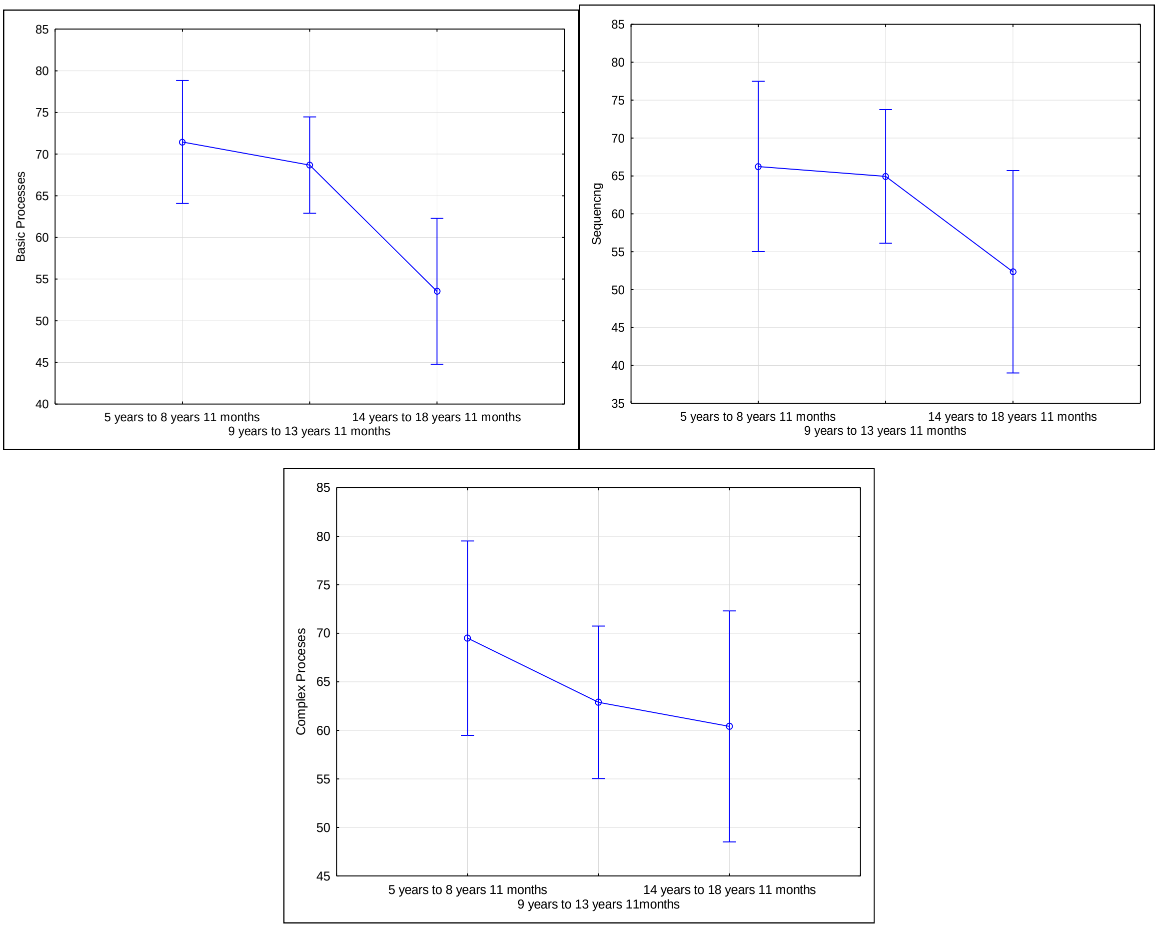


Figure 4.12 Comparing Age in Basic Processes. Sequencing and Complex Processes(n=80)

4.3.6 Comparison of the Composite Scores of the Test of Visual Perceptual Skills -3rd Ed according to Gross Motor Function Classification System

Table 4.12 and Figure 4.13 indicates there was no significant differences in the scores of the different GMFCS levels.

Table 4.12 Comparing Gross Motor Function Classification System in Composite Scores (n=80)

	GMFCS 1		GMFCS 2		GMFCS 3		GMFCS 4		GMFCS 5		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**P value**
Basic Processes	64.82	21.50	63.78	25.19	69.33	11.50	72.87	11.32	58.25	5.68	0.60
Sequencing	58.70	30.73	63.33	30.00	67.50	18.53	58.12	36.74	55.00	36.97	0.82
Complex Processes	71.23	26.02	61.18	21.65	66.20	25.16	62.00	26.01	50.00	33.65	0.52

Significance p ≤ 0.05 *

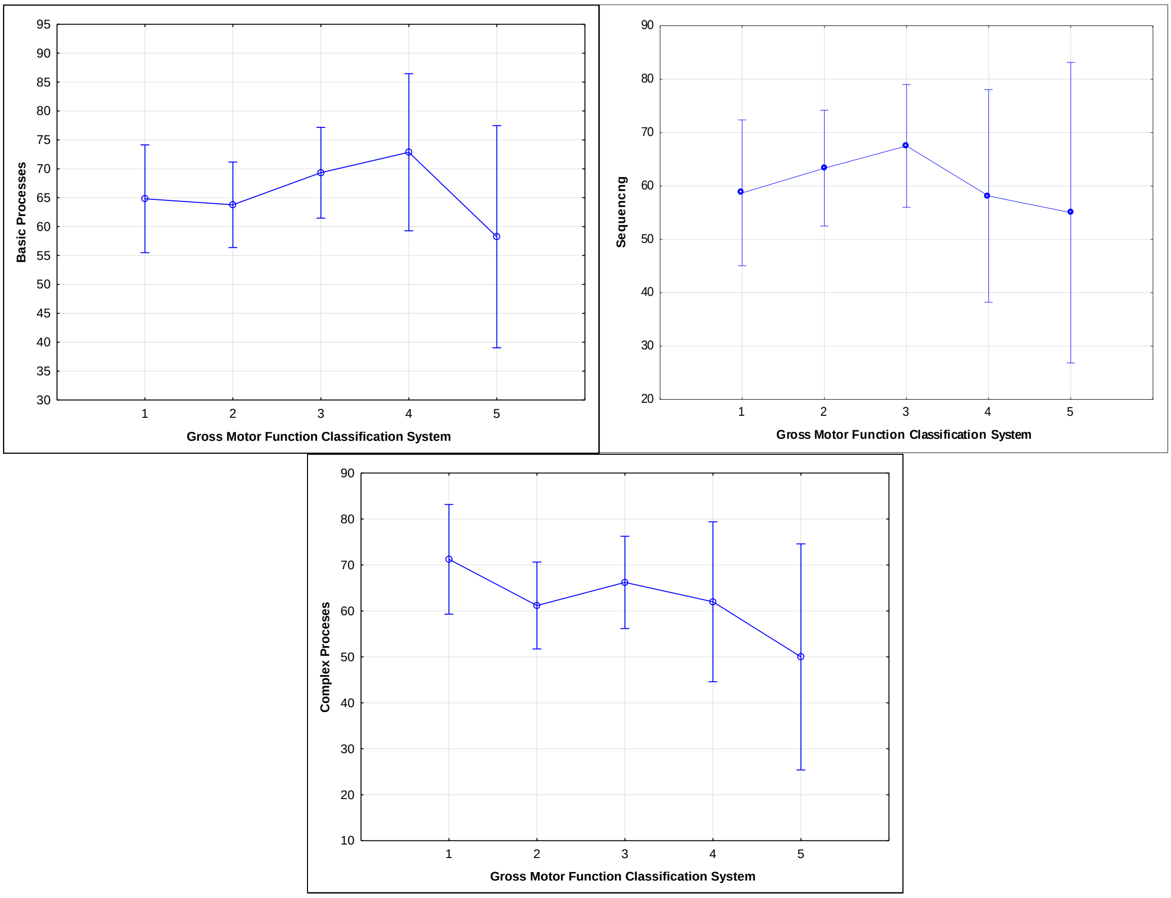


Figure 4.13 Comparing Gross Motor Function Classification System in in Basic Processes. Sequencing and Complex Processes(n=80)

4.4 Summary

This study aimed to determine the specific VPI in 80 children between the ages of 5-18 years with CP using the TVPS-3. Ninety-two percent of the participants presented with a z-score of below -1SD which indicates overall visual perceptual difficulties.

The subtest scores and composite scores for children with different subtypes of CP (bilateral spasticity (diplegia and quadriplegia), unilateral spasticity (left or right hemiplegia) and movement disorders (athetoid and ataxic)) were compared. Significant differences were found for the children with different subtypes of CP in the visual discrimination and figure-ground subtests of the TVPS-3. The spastic unilateral (right) CP group had the highest scores in these subtests and the lowest scores were obtained by the ataxic CP group. The rest of the subtests did not present with significant differences. The different subtypes of CP also presented with a significant difference in the basic processes composite scores. Again, the spastic unilateral (right)

CP group had the highest scores and the lowest scores were obtained by the ataxic CP group.

The composite VP scores of the participants were also compared according to demographic variables which included gender, age and GMFCS level. The scores of the male group on the basic processes composite score was significantly higher than that of the female group. No significant differences were found with regards to the scores of the different age groups, indicating that age does not influence the VPI. The GMFCS level also did not influence the VPI of the participants as no significant differences were found between the participants on different GMFCS levels.

Thus, the null hypothesis can be rejected for the visual discrimination and figure-ground subtests as well as the basic processes composite scores, as significant differences in these scores were found between the children with different subtypes of CP.

CHAPTER 5: DISCUSSION

5.1 Introduction

In this chapter the findings of the results will be discussed according to demographics of the participants, as well as the objectives of the study, to determine the specific VPI in children with CP using the Test of Visual Perceptual Skills-3 (TVPS-3) and to compare the subtest scores and composite scores for children with different subtypes of CP. The total sample will be discussed, followed by a comparison between the specific subtypes of CP and their VPI. The composite VPI scores of children with CP will also be discussed according to demographic variables which include age, gender and GMFCS level. Limitations of the study will then be considered.

5.2 Demographics

South African learners from Forest Town LSEN school participated in this study and were sourced using total population sampling. A total sample of 80 learners with CP participated in the study with an almost equal number of males (55%) and females (45%) (Table 4.3).

Majority of the participants had a diagnosis of spastic CP (68%) followed by dyskinetic (21%) and ataxic (11%) CP subtypes respectively (Table 4.1). Research and literature indicate that 70% of children with CP suffer from spastic forms of CP (Johnson 2002). The distribution of the subtypes of CP at Forest Town School was similar to that described in the literature (Stiers et al., 2002)(Ego et al., 2015)(Pueyo et al., 2009).

Fifty percent of the participants with spastic CP presented with spastic bilateral (LL) CP. This high percentage could be due to the reduction in infant mortality since the Millennium Development Goal was implemented (Couper. 2002) resulting in an increase in the survival rate of premature and low birth weight children (Case-Smith and O'Brein. 2010). The greater percentage of participants with spastic bilateral (LL) CP could also account for the GMFCS level 2 (34%) and level 3 (30%) being more prevalent in this study sample (Table 4.4) as children with spastic bilateral (LL) CP are usually able to walk with assistance from a hand held device or walker. The low GMFCS levels were further supported by the high percentage of participants in the spastic unilateral CP group which made up the second largest group in the study

(Table 4.1). The participants in this group fell within GMFCS levels 1 (58%) and 2 (42%) (Table 4.4). The reason for this, is that spastic unilateral CP only affects one side of the body and therefore these children are able to mobilise without assistive devices (Palisano *et al.*. 2007).

Just over a third of the participants (37%) fell within the age band of 9 years to 13 years 11 months. In the younger age-band 4 participants had to be excluded as they were unable to be tested using the TVPS-3 due to non-compliance and poor concentration. At Forest Town School the curriculum only goes up to Grade 7. Therefore, the learners in the academic stream move to alternative high schools that offer grade 8 to grade 12 syllabi. The learners who are unable to cope with an academic syllabus due to more severe learning disabilities, remain at Forest Town School in the senior modified section. Therefore, there were fewer learners available in the older age-band of between the ages of 14 years to 18 years 11 months resulting in a lower percentage of participants (20%) in this age band. The ages of the participants in this study reflect those in a number of other studies on visual perception in children with CP (Stiers et al., 2002)(Ortibus et al., 2009). The wide age range has been included in order to obtain samples that are representative of different sub types of CP.

Fifty five percent of the participants in this study were male and 45% were female. Demographic studies have found that CP is more common in males than in females (Johnston and Hagberg, 2007). A European dataset found that the incidence is 30% higher in males than females (Jarvis et al., 2005). In this study, males dominated spastic unilateral (right) CP (88%) and dyskinetic CP (94%) subtypes. The females dominated spastic unilateral (left) CP (70%), spastic bilateral (LL) CP (66%) and ataxic CP (55%). There was an even number of males and females with spastic bilateral (LL and UL) CP. These results differ from other epidemiological studies that found differences regarding CP subtypes. Dyskinetic and spastic bilateral CP, especially diplegia, have been found most often in males. A Swedish study from 1990 to 2005 by Chounti *et al.*, (2013) found that males dominated all CP subtypes, except for ataxic CP (42%) (Chounti et al., 2013).

5.3 Visual perceptual impairment in children with Cerebral Palsy

The first objective of the study was to determine the specific VPI in participants aged 5-18 years with CP using the Test of Visual Perceptual Skills-3 (TVPS-3).

5.3.1 Visual perception in total sample

In this study, the prevalence of visual perceptual impairment in this population of participants with CP was 92.5%. According to Stiers *et al.*, (2002) the prevalence of visuomotor and perceptual impairment can range from 39% to 100% for children with CP, but most studies report a prevalence of 40-50% as found in the systematic review completed by Ego *et al.*. (2015). The findings in the current study are similar to those of Pueyo et al., (2009) who found that 90% of the children with CP in their study had visuo-spatial impairment and 60% visuo-perceptual impairment. The high percentage found in the current study may be attributed to the chosen population being at a special needs school and thus all having some sort of learning disability. The results are however in line with Menken et al (1987) study which found that children with CP scored lower on the TVPS-3 than typical children.

When the scores of the participants in the current study were compared to those of a South African sample of mainstream learners between the ages of 6 years and 9 years 11 months (Harris, 2017), the scores of the learners with CP in an LSEN school are significantly lower (Table 4.7). This confirms results of other studies which showed lower performance in children with CP compared to typically developing children (Menken et al., 1987)(Stiers et al., 2002)(Burtner et al., 2006), although not all of them found significant differences. The current study also found that the participants with CP scores significantly lower on the TVPS-3 than a sample of learners with a diagnosis of specific learning disability from another LSEN school in Gauteng the study by in Harris, (2017). This indicates that even though these learners are in an LSEN school and present with some learning disabilities, their scores are much lower than those of other children at an LSEN school without CP.

The severity of the perceptual problems found that 92% of the participants scored below -1SD which is below the mean for the overall tests. This indicates all children with CP should be assessed for visual perceptual deficits as many of them may require therapy for visual perceptual deficits.

5.3.2 Visual perception in different subtypes of Cerebral Palsy

The second objective was to compare the subtest scores and composite scores on the TVPS-3 for children with different subtypes of CP – bilateral spasticity (diplegia and quadriplegia), unilateral spasticity (left or right hemiplegia) and movement disorders (athetoid and ataxic) (Morris, 2007).

Visual perceptual deficits are comorbid impairments in children with CP due to damage to the areas of the brain that allow for visual perception to occur. Visual perception is not isolated to one area of the brain but is rather a very complicated integrated process in which different areas of the brain interpret the information that is being received by the retina. The areas involved include the occipital, temporal and parietal cortices (Brown *et al.*. 2012). In this study, all the subtypes of CP were found to have visual perceptual deficit however the extent of their deficits differed.

The CP subtypes with the highest overall scores on the TVPS-3 were the spastic unilateral right subtype, spastic bilateral (LL and UL) subtype and the spastic bilateral (LL) subtype. The participants with dyskinetic and spastic unilateral left CP subtype achieved lower scores with the lowest overall scores being achieved by the ataxic subtype. In Wedell, (1960) and Lidzba et al., (2006) research it was found that the right side of the brain is dominant for visual perceptual processing resulting in visual perceptual impairment when the right side of the brain is damaged. This explains why the participants with spastic unilateral left CP achieved lower scores in this study. In this study, the overall scores of all the spastic CP subtypes were higher than the dyskinetic CP subtype except for the spastic unilateral (left) CP subtype. This does not correlate with the findings of a study by Abercrombie, (1964) which found that children with dyskinetic CP had higher visual perceptual scores than all the children with different subtypes of spastic CP and thus concluded that visual perceptual impairment is associated with CP where spasticity is dominant (Abercrombie. 1964). Ferrari and Giovanni, 2010 explain that children with ataxic CP have decreased precision and accuracy or ocular movements due to having ocular nystagmus which could account for their low scores in this study.

In two of the subtests of the TVPS-3, which included visual discrimination (p=0.03) and figure-ground (p=0.03), significant differences were found between the different subtypes of CP with the ataxic group again having the lowest scores. Martin, (2006) explains that visual scanning and tracking are necessary for visual perceptual tasks and that if these systems are affected an individual will have difficulty with tasks such as figure-ground and visual discrimination. Visual discrimination is one of the basic processes subtests in the TVPS-3 (Martin, 2006) which contributed to the significant difference in the basic processes score. It involves identifying exact features of objects in comparison to similar objects (Brown et al., 2003). Figure-ground on the other hand is one of the complex processes subtests and requires an individual to separate objects from a busy background (Martin, 2006). Figure-ground in children with CP as reported by Gargiulo, (2010) was first investigated by Werner and Strauss in 1941, followed by Werner and Thuma in 1942, who found that figure-ground impairment in children with CP occurs as a result of the inability to organise the perceptual field. This results in the child responding to the background information, therefore missing the foreground figure (Marozas and May, 1985). This may also explain the finding of Marozas and May, (1985), that found improvement in the performance of children with CP on the figure-ground assessments, when the black and white colours are reversed, although they did not specify difference between the CP subtypes in their study.

Previous studies have reported no differences for specific composite scores, only the overall score for the TVPS-3, whereas in this study significant differences for different subtypes of CP were found. This finding indicates the need for differences in subtests and composite scores to be established, since it is clear that the visual perceptual deficits vary between the subtypes dependent on the specific areas of the brain and vision that is affected. The different subtypes of CP are associated with damage to different areas of the brain and therefore due to the visual perception being so complex, it was found that all the subtypes of CP had visual perceptual impairments. The extent of deficit will be further explained by looking at each subtype in further detail.

5.3.2.1 Spastic Cerebral Palsy

5.3.2.1.1 Spastic Unilateral Cerebral Palsy

The SCPE subgroup unilateral CP is divided into the left and right hemiplegia and the results were compared in order to determine if this would have an impact on the visual perceptual functioning of the child.

For all the participants with ***Left Spastic Unilateral Cerebral Palsy- (Left Hemiplegia)*** all the scores of this group fell at -1SD and - 2SD. Their highest scores were on the visual discrimination and figure-ground subtest (Table 4.8) with the lowest scores for the visual closure, spatial relations and visual memory subtests. Their basic processes scores and complex processes scores were higher than their sequencing composite scores which consider sequential memory (Table 4.68). Straub and Obrzut, (2009) do report some issues with visual memory for children with left spastic unilateral CP which may support the findings for sequential memory for this group. Lidzba et al., (2006) also reported differences for other components of pattern recognition which include sequential memory as well as spatial perception which support the findings for those with left unilateral spastic CP in the current study.

The participants with ***Right Spastic Unilateral Cerebral Palsy - (Right Hemiplegia)*** had the highest visual perceptual scores in all the subtests, scoring at -1SD for most except for the sequencing composite scores which consider sequential memory, where they had lower scores than participants with the spastic bilateral (UL and LL) CP and spastic bilateral (LL) CP (Table 4.68).

The lower scores for sequential memory for both right and left spastic unilateral participants has no specific research which supports this finding in the literature. The finding was contrary to research by Lidzba et al., (2006) who reported a significant difference for sequencing on the Block Tapping test (Schelling, 1997) for adolescents and young adults (16-27 years) with left and right unilateral spastic CP. Only the scores for left unilateral spastic CP reported in their study matched the z scores for the current study. The different tests, since the block test may also include a spatial element, and different age range of the participants in the studies may have affected these findings but this is an aspect which should be investigated further.

When a comparison between right and left spastic unilateral right CP was made the findings in this study correlate with the findings of Abercrombie (1964) and Lidzba *et al.*, (2006) in that spastic bilateral and spastic unilateral (left) subtypes have lower visual perceptual scores for other aspects of visual perception than the spastic unilateral (right) group.

The participants with left spastic unilateral CP scored consistently lower than those with right spastic unilateral CP on all subtest scores. They had lower scores for all the composite sections of the TVPS-3, particularly basic and complex process. This was also supported in a previous study reported by Wedell, (1960) which was accounted for by the dominance of the right cerebral hemisphere which is affected in left spastic unilateral CP displaying superiority for visual processes including spatial relationships and the alignment between objects (Beaumont, 2008). Lidzba *et al.*, (2006) also reported similar differences in visuospatial perception on the Rey Osterrieth Copy test (Rey, 1941) and the Tube Figures test (Stumpf& Fay, 1983) for adolescents and young adults with left spastic unilateral CP. They supported this finding by suggesting language “crowding” in the right hemisphere as a result of alternate language development in that hemisphere, which affects the perceptual ability in those with left spastic unilateral CP.

The distribution of genders differed with the right spastic unilateral CP group having more males (8) than females (1) and the left spastic unilateral CP group having more females (7) than males (3) (Table 4.3). Since males were found to have higher visual perceptual scores than females (Figure 4.11) this could have also contributed to the right spastic unilateral (right) CP group having higher scores than the left spastic unilateral CP group.

5.3.2.1.2 Spastic Bilateral Cerebral Palsy

The results for the participants with ***Spastic Bilateral (Lower Limb) Cerebral Palsy - diplegia*** on the TVPS-3 showed that the mean scores for all the subtests fell between -1 and -2 SD below the mean, thus indicating that they have visual perceptual impairment. This group’s highest scores were on the spatial relations and visual discrimination in the basic processes which is congruent with the findings of Menken, Cermak and Fisher (1987) for children with this subtype of CP. The higher scores for sequential memory subtest in composite sequential score is not reflected in other studies and as suggested above requires further investigation. The group’s lowest scores were on form constancy in the basic processes and this subgroup struggled with figure-ground, visual memory and visual closure which were below -2SD (Table 4.8). Figure ground and visual closure scores were also lower for this subtype of CP in the study by Menken, Cermak and Fisher (1987) and indicate more deficits in the development of complex perceptual processes.

The low TVPS-3 scores for the participants with this subtype of CP can be related to studies that have found that children with spastic bilateral (LL) CP have visual perceptual impairments due to periventricular leukomalacia which can be attributed to damage to the occipitoparietal pathways or preterm birth (Ego *et al.*. 2015). Koeda and Takeshita (1992) found that there was a direct correlation between the amount of damage to the parietal and occipital white matter and the severity of visual perceptual impairment. The TVPS-3 requires the child to scan the items as well as shift their gaze from one area of the page to another. Children with Spastic Bilateral (LL) CP often have difficulty with eye movements and control which negatively affect their visual perception (Fedrizzi *et al.*. 1998). The participant's eye movements and control were not assessed however this may be a contributing factor to their low scores.

In the current study however, the participants with spastic bilateral (LL) CP achieved higher scores than the participants in all other subtypes with the exception of those with right spastic unilateral CP and spastic bilateral (UL and LL) CP for three subtests.

On the TVPS-3 results of the ***Spastic Bilateral (UL and LL) Cerebral Palsy subgroup - quadriplegia***, the mean scores for all the subtests and composite scores were -1SD below the mean, indicating VPI. This subgroup's highest scores were on sequential memory subtest in the sequencing composite and in spatial relations in the basic processes composite. The spastic bilateral (UL and LL) CP subgroup had the highest scores on sequential memory subtest in comparison to all the other CP subtypes. Their higher scores on the spatial relations and low figure-ground scores were similar to that found by the Menken, Cermak and Fisher (1987) in their study using the TVPS with children with CP (Table 4.8).

In the current study, this group of participants also had lower scores for visual memory, which was not reported in other studies but may be related to their visual acuity. Fernandes *et al.*, (2004) found that the degree of motor impairment positively correlates with loss of visual acuity in children with spastic CP and since the majority of these participants were on GMFCS levels 4 and 5, they were more likely to have impaired visual acuity, which may have had an impact on their results. The sample of participants in this CP subtype was very small, with only 8 participants and therefore these results need to be interpreted with caution.

When the spastic bilateral CP subgroups were compared, the spastic bilateral (LL) CP group scored higher than the spastic bilateral (LL and UL) group in the visual discrimination, visual memory, figure-ground and visual closure subtests. The spastic bilateral (LL & UL) CP subgroup had higher scores on the spatial relationships, form constancy and sequential memory subtests (Table 4.8). The composite scores of these two subtypes of spastic bilateral CP are very similar with the spastic bilateral (LL) CP group having higher scores in the basic processes, sequencing and particularly the complex processes.

However, in the current study the participants with spastic bilateral (LL & UL) CP had a higher overall score on the TVPS -3 than the participants with spastic bilateral (LL) CP. These results are not supported by Menken, Cermak and Fisher (1987) who reported that children with spastic bilateral (LL & UL) CP consistently had lower scores on the TVPS in their study. Stiers *et al.*, (2002) in their study using the L94 tasks (Stiers et al., 1998) however did find that the children with spastic bilateral (LL & UL) CP had higher scores for NOISE (line drawings occluded by noise); and the De-Vos task, than children with spastic bilateral (LL) CP and spastic unilateral left CP. This confirms the findings in the current study that children with spastic bilateral (LL & UL) CP may have less impairment in certain aspects of visual perception than participants with spastic bilateral (LL) CP. The sample size of the spastic bilateral (LL) group was the largest in the current study however the sample size of the spastic bilateral (LL & UL) groups was the smallest in the current study and therefore the difference in results must be interpreted with caution (Table 4.1).

In summary of participants with spastic CP, those with right unilateral spastic CP had the highest overall scores, although their scores for sequencing were lower than those with bilateral spastic CP. The participants with left unilateral spastic CP had the lowest overall scores and the lowest scores for basic processes and sequencing, indicating this subtype had the greatest impairments in visual perception except for complex processes. Participants with bilateral spastic (UL and LL) had the lowest scores for complex processes

5.3.2.2 Dyskinetic Cerebral Palsy

All the scores for the dyskinetic CP group fell at -2 SD and -3 SD below the mean. Their highest score was on the form constancy subtest in basic processes. Their lowest scores were on visual discrimination in basic processes and figure-ground in complex processes. Both these subtests require the participant to focus on the very intricate details in order to either discriminate between the objects or to find the objects in very busy, distracting backgrounds. Visual impairment difficulties could contribute to these poor scores. Ipata et al. (1994) found that children with dyskinetic CP had the highest incidence of visual impairment (Ipata *et al.*. 1994). Children with dyskinetic CP also often present with dyskinetic strabismus (Ghasia et al., 2008). This could be a contributing factor to the low visual perceptual scores of the participants in this group (Table 4.8). Some of the items in the TVPS-3 have very small and intricate shapes and patterns. Poor visual acuity and difficulty controlling eye movements would cause this test to be very difficult and even affect the results.

In comparing the subtest scores of the dyskinetic group with the other CP subtypes, it was found that their scores were lower than the spastic CP subgroups in most of the tests although their overall score was higher than that of participants with unilateral spastic left CP. The finding was contradictory to Pueyo et al., (2009), who found that visuospatial abilities were more impaired in children with bilateral spastic CP than those with dyskinetic CP. The difference in the findings may have been affected by the ages of the participants in the Pueyo et al., (2009) study, which differed from the current study as their participants ages ranged from 6 years to 38 years of age. They also used different tests to assess visual perceptual and visuospatial abilities- Benton's Facial Recognition Test, and Benton's Judgment of Line Orientation Test (Benton et al., 1978) which may have assessed different aspects of visual perception to the TVPS-3. However, Stadskleiv et al*.* (2018) report lower perceptual reasoning and memory (visual recognition), (assessed on the Wechsler preschool and primary scale of intelligence, 3rd edition; and the Wechsler Intelligence Scale for Children, 4th edition) for children with akinetic CP than children with spastic CP. These later findings are congruent with the current study and a sample of children in a similar age range was used.

All the scores for participants with dyskinetic CP were higher than those of the ataxic group except for visual closure (Table 4.8).

5.3.2.3 Ataxic Cerebral Palsy

On the TVPS-3 results of the ataxic subgroup, the scores for all the subtests fell -2 SD below the mean, thus indicating visual perceptual impairment. This subgroup's highest score was on visual closure in complex processes and the lowest scores were on visual memory and form constancy in basic processes. In comparison to the other CP subtypes, the ataxic subgroup had the lowest scores for all the subtests and composites except for the visual closure subtest where they had a very similar score to the dyskinetic group.

Many children with ataxic CP have cerebellar ocular nystagmus (Ferrari and Giovanni, 2010) and this results in difficulty with scanning, tracking and focusing and could be one of the contributing reasons to the ataxic CP groups low scores on the figure-ground and visual discrimination subtests. The low scores obtained by this subgroup could also be attributed to their age distribution and the section of the school that they are in, which will be further discussed below under demographic factors.

Limited research is available on visual perceptual impairment in ataxic CP due to its rarity. The results of the current study were contradictory to Stiers *et al.*, (2002) study which concluded that children with dyskinetic and ataxic CP have less severe impairment than children with spastic diplegia, quadriplegia and hemiplegia. Stiers et al., (2002) used L94 the visual–perceptual battery, comprising six visual object recognition and two visual construction tasks and found very few of the participants (only 60 of the 96 children) (62.5%) showed no visual perceptual impairment. There were also only four participants with dyskinetic and ataxic CP in total in their study and only one had impairment on one L94 task .It is therefore difficult to compare the current study where all participants had impairments on all subtests of the TVPS-3 to the findings of Stiers *et al.*, (2002). None of the children in their study with dyskinetic and ataxic CP had vision impairments while those with spastic CP did which may also account for the difference in the results found in the current study.

Although vision impairments were not assessed as part of the current study and cannot be commented on, other demographic factors which may impact on visual perceptual scores are discussed below.

5.4 Difference in visual perception according to demographic factors

5.4.1 Gender

There was a significant difference (p = 0.031) in the basic processes scores of male and female participants, with males scoring higher than females. There were no significant differences between sequencing and complex processes scores. Stadskleiv et al*.* (2018) also found higher cognitive scores for males with CP in their study, but the gender difference was not significant.

Smith *et al.*. (2018) completed a study where they looked at the considerations when assessing South African children using standardised visual perception tests using the Developmental Test of Visual Perception 2nd Edition. In their study, males and females had similar scores on all the subtests of the DTVP-2 except the figure-ground subtest which had a significant difference (p=0.03), with females scoring higher than males (Smith *et al.*. 2018). Although the tests are considered to be gender free in certain circumstances, it appears that there may be differences between genders in South African children, but other studies did not consider this variable so comparisons cannot be made (Harris, 2017)(Visser et al., 2017).

5.4.2 Age

No significant differences for age were found in this study for basic processes, sequencing and complex processes scores. A trend in the scores was however noticed in all the index scores, that younger participants appeared to have slightly higher scores than older participants. This could be attributed to younger children having more exposure to therapy at the school which considers visual perceptual impairments. This also could be due to the higher functioning children in the academic stream of the school moving to other schools at the age of 13 for grade 8 to 12, resulting in the older age band being made up of lower functioning adolescents in the modified stream. Stadskleiv et al*.* (2018) confirmed in their study on neuropsychological profiles of children with CP, that older children and adolescents had a lower average performance on standardised tests than younger age groups attending rehabilitation at a hospital. Again, it is possible that only older participants with more deficits were retained in the programme.

5.4.3 Gross Motor Function Classification System – Expanded and Revised

As part of the demographic questionnaire (Appendix A) there was a question regarding the GMFCS level of the participant. Even though this was not a factor that affected the inclusion of the participant, there was no significant differences in the visual perceptual scores of the different GMFCS levels. The GMFCS level 4 participants scored the highest in the basic processes composite scores and the scores of the GMFCS level 3 participants were highest in the sequencing composite scores. These results correlate with the research completed by Hamid et al. (2016) where they found that the severity of gross motor functioning does not directly impact on the visual perceptual skills of children with CP (Hamid *et al.*. 2016). When comparing the visual perceptual scores of the participants with different subtypes of CP and their GMFCS level in Figure 4.13. it is evident that the GMFCS level did not impact on the visual perceptual scores.

Differences in visual deficits however could have an effect and these need to be considered when completing visual perceptual assessments.

5.5 Limitations of the study

Limitations of this study are visual, intellectual functioning of the participants as well as diverse culture and language. The vision of the participants was not assessed and therefore the extent that vision affected the visual perceptual scores of the participants was unable to be clarified. The participants were all assumed to have no more than mild intellectual impairment due to attending Forest Town School. Most of them are not English first language which may impact on the results of the test.

5.5.1 Visual Impairment

Numerous studies have found that 50-80% of children with CP have visual acuity problems with approximately 22% who present with visual cerebral impairment having low vision (Ferrari and Giovanni, 2010) (Schenk and McIntosh, 2010) (Schenk-Rootlieb et al., 1992). Participants in the current study were included if they did not present with known severe visual deficits. Visual impairment was taken into consideration to a very small degree in this research as the assessment book was placed in front of the participants and glasses were worn. But the acuity and eye movements of the participants were not considered. Therefore, a comparison between their visual impairment and their visual perceptual scores could not be made.

Although it has been suggested that these visual impairments may influence visual perception in children with CP the results for visual perceptual skills of the current study have been considered in relation to the reported visual impairment by subtype in the literature and this did not appear to be an interfering variable in the current study.

5.5.2 Intellectual functioning of the participants

The study took place at Forest Town School which is an LSEN school. The school caters for learners with mild intellectual impairment. The school does not accept learners with more severe intellectual impairment. Within the school, the intellectual level of the children does however vary. IQ tests were not completed on the participants of the study. The criteria for the study was that the child attends Forest Town School and was therefore assumed to have no more than a mild intellectual impairment. However, the intellectual level of the students was not established and may have differed for the participants in the study. This could have had an impact on the results of the study.

5.5.3 Sample size

The sample in this study had different number of participants in each CP subtype and the small number of participants in some groups may have affected the results. However, the number did reflect the prevalence of CP subtypes and the number of participants seen in other studies (Ego et al., 2015)(Stadskleiv et al., 2018)(Stiers et al., 2002).

5.5.4 Language

Forest Town School's language of medium is English, however most of the participants' are not English first language. The TVPS-3 instructions are standardised on an American, English speaking population and therefore the language is not appropriate for the intended population group. This language barrier served as a limitation in this study and the TVPS-3 instructions need to be revised in order to make them more relevant to a South African population in future studies.

5.6 Summary

Ninety-two and a half percent of participants in this population were found to have visual perceptual impairment. This could be attributed to them all attending a special needs school and having a learning disability. In comparison to a mainstream South African population and a South African LSEN school population without CP, the scores of the participants in this study were significantly lower.

In this study, all the subtypes of CP were found to have visual perceptual deficit, however the extent of their deficits differed. The CP subtypes with the highest overall scores on the TVPS-3 were the spastic unilateral right subtype, spastic bilateral (LL and UL) subtype and the spastic bilateral (LL) subtype. The participants with dyskinetic and spastic unilateral left subtype achieved lower scores with the lowest overall scores overall achieved by the ataxic subtype

Significant differences were found in two of the subtests of the TVPS-3 which included visual discrimination (p=0.03) and figure-ground (p=0.03). There was also a significant difference in the basic processes composite scores (p=0.002). The highest scoring CP subtype was the right spastic unilateral and the lowest was the ataxic group.

The right spastic unilateral CP subgroup achieved higher scores on all the subtest than the left spastic unilateral CP group. This correlates with previous studies and can be attributed to the area of the brain affected and its specific function.

The spastic bilateral (LL) CP group scored higher than the spastic bilateral (LL and UL) group in the visual discrimination, visual memory, figure-ground and visual closure subtests. The spastic bilateral (LL & UL) CP subgroup had higher scores on the spatial relationships, form constancy and sequential memory subtests (Table 4.8). These results indicate that the extent of physical dysfunction does not necessarily impact on the visual perceptual scores of the participants with CP which is supported by research completed by Hamid et al. (2016).

In comparing the subtest scores of the dyskinetic group with the other CP subtypes, it was found that their scores were lower than the spastic CP subgroups in most of the tests but higher than the ataxic group which is controversial with a number of authors reporting that children with dyskinetic CP had fewer VPI’s than those with spastic CP.

However, more recent findings reported by Stadskleiv et al*.* (2018) are similar to the current study and seem to apply to children attending CP clinics or special education.

In comparison to the other CP subtypes, the ataxic subgroup had the lowest scores for all the subtests and composites except for the visual closure subtest where they scored slightly higher than the dyskinetic group. These results are contradictory to Stiers *et al.*, (2002) study which concluded that children with ataxic CP have less severe impairment than children with spastic diplegia, quadriplegia and hemiplegia, although their study was on higher functioning children. Limited research is available on visual perceptual impairment in ataxic CP due to its rarity.

In comparing the composite scores of the different demographics of the participants it was found that there was a significant difference ($p = 0.031$) in the basic processes scores of male and female participants with males scoring higher than females. There were no significant differences between the composite scores for age and GMFCS level.

CHAPTER 6: CONCLUSION

6.1 Introduction

This chapter presents the conclusions drawn from the study regarding visual perception in children with CP as well as recommendations for future studies.

6.2 Summary

This study aimed to describe the differences between the specific VPI's in children with different subtypes of CP attending a school for learners with special educational needs (LSEN) in Johannesburg. The TVPS-3 was administered on six different CP groups (spastic unilateral right CP, spastic unilateral left CP, spastic bilateral (LL) CP, spastic bilateral (LL and UL) CP, athetoid CP and ataxic CP) between the ages of 4 years and 18 years 11 months at Forest Town LSEN school. The subtest and composite scores from the TVPS-3 of the different subtypes of CP were compared as well as the demographic factors which included age, gender and GMFCS level.

The results in this study found that learners with all subtypes of CP have VPI. The spastic unilateral (right) CP groups had the highest overall scores and the ataxic group had the lowest scores. The different subtypes of CP showed different trends in VPI. There was a significant difference in the visual discrimination and figure-ground subtest scores as well as the composite basic processes scores between the different subtypes of CP as well as between males and females. Participants with unilateral spastic CP had more impairment in sequential memory and spatial components while the participants with bilateral spastic CP had greater impairments in visual decimation related components. No significant differences are found between different ages and GMFCS levels.

6.3 Recommendations

6.3.1 Recommendations for clinical practice

The results of this study have implications for future clinical practice with children with CP in an LSEN school in South Africa. Due to the findings that almost all the children with CP have VPI, practitioners working with children with CP need to be aware of these impairments and provide appropriate accommodations or compensations for these impairments not only when working on VP skills, but also in day to day life, as they have a major impact on function and ADL's.

The trends that were found in this study can assist with the grouping of CP subtypes in therapy. The extent of VPI of the different subtypes of CP were identified and therefore in this setting children can be grouped accordingly. This should however be done with caution and individual treatment for children should still be administered where possible.

This study will be published in a peer reviewed journal.

6.3.2 Recommendations for further research

Further research is required when considering VPI in children with CP in a South African context. It is recommended that future studies on VPI in children with CP, be completed on a larger population and in a variety of different schools in order to further validate these results. Qualitative studies could further identify the way in which OT's could design interventions to address the VPI's found in this study.

Future research that takes visual impairment into consideration when assessing VPI in children with CP would be beneficial. Thus a comparison between the extent of visual impairment and VP scores could be compared to determine the impact that vision has on VP scores.

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Appendix A - Demographic Questionnaire:

To be kept separate

Code ________________

Name of Child____

Date of Birth of Child:____

Gender: ____

Diagnosis:____

GMFCS Level: ____

School:____

Grade:____

Does the child receive Occupational Therapy:_________________________________

How long has the child been receiving Occupational Therapy:___________________

When was the child diagnosed:____

Appendix B Test of Visual Perceptual Skills 3rd Ed Scoresheet

TEST OF VISUAL PERCEPTUAL SKILLS
3RD EDITION

TVPS 3

Code : ____________________ ____________

Age : ____________________ Examiner: ____________________

;: ____

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

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

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

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

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TVPS-3 subtests do not have basals.

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

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

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

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

SUBTEST 1: Discrimination

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

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

SUBTEST 2: Memory

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

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

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

SUBTEST 3: Spatial Relations

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

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

Appendix C Ethical Clearance Letter

R14/49 Ms S Berelowitz

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M170817

NAME: (Principal Investigator)	Ms S Berelowitz
DEPARTMENT:	School of Therapeutic Sciences Department of Occupational Therapy Medical School
PROJECT TITLE:	Visual perceptual deficits in different types of cerebral palsy
DATE CONSIDERED:	25/08/2017
DECISION:	Approved conditionally
CONDITIONS:	Letters of permission from the principals of the three schools involved must be submitted to the HREC (Med) Secretariat before the study begins
SUPERVISOR:	Dr D Franzsen
APPROVED BY:	Professor PE Cleaton-Jones, Chairperson, HREC (Medical)
DATE OF APPROVAL:	27/10/2017

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 3rd floor, Phillip V Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.
I/We fully understand the conditions under which I am/we are authorised 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 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 **August** and will therefore be due in the month of **August** 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 D Permission Gauteng Education Department

GAUTENG PROVINCE

Department: Education

REPUBLIC OF SOUTH AFRICA

8/4/4/1/2

GDE RESEARCH APPROVAL LETTER

Date:	**26 September 2017**
Validity of Research Approval:	**05 February 2018 – 28 September 2018** **2017/276**
Name of Researcher:	**Berelowitz S.P**
Address of Researcher:	**25 Troon Road**
	Emmarentia
	2195
Telephone Number:	**011 646 1239 079 498 0463**
Email address:	**sharnaberelowitz@gmail.com**
Research Topic:	**Visual perceptual deficits in different types of cerebral palsy**
Number and type of schools:	**4 LSEN Schools.**
District/s/HO	**Johannesburg South, Johannesburg Central and Johannesburg West**

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.

2017/09/27

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: 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 outlines 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

....

Ms Faith Tshabalala
CES: Education Research and Knowledge Management

DATE: 2017/09/27

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 E - Permission from Principals and HOD Occupational Therapy at Schools

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**

Research Permission Letter

Forest Town School

Corner Rannoch

and New Forest Road

Forest Town

Dear Sir, Madam

Study Title: *Visual Perceptual Deficits in Different Types of Cerebral Palsy*

My name is Sharna Berelowitz. I am conducting a research study as part of the requirements of a Master's Degree at the University of Witwatersrand. I am doing research on visual perceptual impairments in children with different types of Cerebral Palsy. The aim of this research is to determine the specific visual perceptual impairments in children with different subtypes of CP attending a school for learners with special needs (LSEN) in Johannesburg. The specific visual perceptual impairments in children ages 6-12 years with different subtypes of CP will be determined using the Test of Visual Perceptual Skills-3 (TVPS3). A comparison will be done to compare the scores of the test with the subtypes of CP which include bilateral spasticity (diplegia and quadriplegia); unilateral spasticity (left or right); dyskinetic and ataxic (Morris, 2007).

I would like to ask for your permission to complete my research on some of the learners at your school. Your school has been chosen as it is an LSEN school for children with Mild Intellectual Impairment with children with CP. The children who meet the criteria will need to be assessed during school time. The assessment takes about 20-30 minutes. All assessment information will be given to the learner's OT with the parents' consent in case further treatment is required in the identified areas.

Participant Requirements

To take part in the research, the participant must have a diagnosis of Cerebral Palsy, be between the ages of 6-12 years, in a grade R – grade 3 class. The participant must also have attended Occupational Therapy for at least 6 months. A demographic questionnaire will need to be completed by the parent or guardian. The TVPS-3 is an assessment in which the participant is shown a picture with either 4 or 5 options and is required to point to the correct answer. The test takes about 20-30 minutes to complete. The test will be completed at the child's school during school time.

Participant's Rights

Participation in this study is voluntary and therefore there is no consequence for non-participation. Participants and parents/ legal guardians have the right to ask any questions and refuse to answer any questions. They may withdraw your consent at any time without consequence. Any data in that instance will be discarded. The child's identity will be protected and not published in and reports, confidentiality will be maintained throughout the process. The demographic questionnaires will be stored securely. The results of the study might be published in reports or journal articles however this will not include any information, which could identify any of the participants.

Participant's Risks

Participant's safety is important; therefore, every measure will be taken to ensure that information is kept strictly confidential. The person conducting the assessment is SACE accredited and therefore is able to be alone with the participant during the process. Participants will be allowed a break if required. No assessments will take place during participant's school break times. Results from the assessment will be given to the participant's treating occupational therapist, with the parents/legal guardian's permission in case a problem is found and treatment is required in this area.

Benefits of the study

This study aims to identify specific trends in the visual perceptual impairments in children with different subtypes of Cerebral Palsy. The results will assist with the assessment, treatment and grouping of these children in the future with regards to visual perceptual impairment.

Complaints

For any ethical concerns please contact the chairperson of the Human Research Ethics Committee at the University of Witwatersrand, Prof P Cleaton-Jones at peter.cleaton-jones@wits.ac.za Contact details for the administrative offices: Ms. Z Ndlovu/ Mr Rhulani Mkansi/ Mr Lebo Moeng, Tel: 011 717 2700/2656/1234/1252, or email: Zanele.ndlovu@wits.ac.za; Rhulani.mkansi@wits.ac.za; Lebo.moeng@wits.ac.za

Research Approval

This project has been approved by the Human Ethics Research Committee.

If you have any questions about the research or would like further information about the project please contact me, Sharna Berelowitz, 362187@students.wits.ac.za

Thank you for taking the time to consider helping with this research.

Sharna Berelowitz (Occupational Therapist)

Signed Consent from Principal and HOD

I, RONALDA LUCAS (Principal) and Lynndall Ewen (Head of Department of Occupational Therapy) give Sharna Berelowitz permission to complete her research on the learners at Forest Town School that meet the requirements for her research. I have read and understand the information and letter above.

Signed

Principal

HOD

Appendix F - Information Sheet Parents

Study Title: ***Visual Perceptual Deficits in Different Types of Cerebral Palsy***

Good Day Parent/Legal Guardian

My name is Sharna Berelowitz. I am conducting a research study as part of the requirements of a Masters Degree at the University of Witwatersrand I am doing research on visual perceptual impairments in children with different types of Cerebral Palsy (CP). The aim of this research is to determine the specific visual perceptual impairments in children with different subtypes of CP attending a school for learners with special needs (LSEN) in Johannesburg. The specific visual perceptual impairments in children ages 6-12 years with different subtypes of CP will be determined using the Test of Visual Perceptual Skills-3 (TVPS3). A comparison will be done to compare the scores of the test with the subtypes of CP which include bilateral spasticity (diplegia and quadriplegia); unilateral spasticity (left or right); dyskinetic and ataxic (Morris, 2007).

I would like to ask for your permission to include your child in a research study.

Participant Requirements
To take part in the research. your child should have a diagnosis of CP. be between the ages of 6-12 years. in a grade R – grade 3 class. Your child must also have attended Occupational Therapy for at least 6 months. I will ask you to complete a demographic questionnaire. Your child will be assessed by matching pictures on a test called the TVPS-3. This is an assessment in which your child is shown a picture with either 4 or 5 options and is required to point to the correct answer. The test takes about 20-30 minutes to complete. The test will be completed at the child's school at a time convenient to you and the school.

Participant's Rights
Participation in this study is voluntary and therefore there is no consequence for non-participation. You have the right to ask any questions and refuse to answer any questions. Your child will be asked to agree verbally to take part in the study and will not be included if they refuse. There is neither payment nor cost for participating in this study.

You may withdraw your consent at any time without consequence. Any data in that instance will be discarded. Your child's identity will be protected and not published in and reports. confidentiality will be maintained throughout the process. The demographic questionnaires will be stored securely. The results of the study may be published in reports or journal articles however this will not include any information. which could identify any of the participants.

Participant's Risks
Your child's safety is important; therefore. I will make sure that information is kept confidential and not shared with anybody. At a government school. children must always be supervised by a person that is accredited with the South African Council for Educators (SACE). This will apply in the study as the person completing the assessment with the child will be SACE accredited. Your child will be allowed a break if he/she needs one. No assessments will take place during school break times. Results from the assessment will be given to your child's treating occupational therapist. with your permission in case a problem is found and treatment is required in this area.

Benefits of the study
This study aims to identify specific trends in the visual perceptual impairments in children with different subtypes of CP. The results will assist with the assessment. treatment and grouping of these children in the future with regards to visual perceptual impairment.

Research Approval
This project has been approved by the Human Ethics Research Committee (Medical) of the University of the Witwatersrand. Johannesburg. 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.

Participant Contacts
If you have any questions about the research. or would like further information about the project. please contact me. Sharna Berelowitz. on 079 498 0463 or 362187@students.wits.ac.za. or my supervisor. Dr Denise Franzsen. on 011 717 3701 or Denise.Franszen@wits.ac.za.

For any ethical concerns please contact the chairperson of the Human Research Ethics Committee at the University of Witwatersrand. Professor P Cleaton-Jones on 011 717 2301 or at Peter.Cleaton-Jones1@wits.ac.za. Contact details for the administrative offices: Ms. Z Ndlovu/ Mr Rhulani Mkansi/ Mr Lebo Moeng. Tel: 011 717 2700/2656/1234/1252. or email: Zanele.ndlovu@wits.ac.za; Rhulani.mkansi@wits.ac.za; Lebo.moeng@wits.ac.za

If you allow your child to participate in this research please complete the informed consent document and return it to your child's OT.

Thank you for taking the time to consider helping with this research.

Sharna Berelowitz
Occupational Therapist

Appendix G Informed Consent Parents

This form acknowledges that I have read the Information Letter about the research into “Visual Perceptual Deficits in Different Types of Cerebral Palsy”.

1. I have had sufficient time to read and understand the information. I have been given the opportunity to question the research and my questions have been answered to my satisfaction. If any further questions arise. I feel comfortable that I can contact the researcher during business hours.
2. I am aware that the research requires me to complete a demographical questionnaire and that my child will be required to complete the TVPS-3 assessment which will last approximately 20-30 minutes.
3. I understand that the information I give will be kept confidential and my identity will be protected. I am aware that the results of the research project may be published in reports or journals but confidentiality will be maintained at all times.
4. I agree that my child’s assessment results will be given to their treating Occupational Therapist in case treatment of these areas are required.
5. I have been made aware that I can withdraw from further participation in the project at any time and that I do not need to give any explanation or justification. There will be no penalty if I choose to withdraw consent.
6. I agree that my child can participate in the research.

Parent/Guardians Name: ________________

Parent/Guardian Signature: ______________

Child’s Name: _______________________ Date: ________________________

Agreement to share results

I agree that my child’s assessment results will be given to their treating Occupational Therapist in case treatment of these areas are required.

Parent/Guardians Name: ________________

Parent/Guardian Signature: ______________

Child’s Name: _______________________ Date: ________________________

Appendix H Verbal/Written Assent Children

Hi

My name is Sharna. I would like to see how well you can match pictures in this book. This is not a test and getting the right and wrong answers does not affect your school marks in any way. This is to help us see if you need help with matching shapes and pictures when reading or writing. You can say no if you want to.

- Participants Signature (if able to do so)__________________________
- Witness ____________________________________
- Date _______________________________________

Appendix I Plagiarism Form

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

FACULTY OF HEALTH SCIENCES

PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

I ____ (Student number: _________________) am a student

registered for the degree of ____________________________________ in the academic year _______.

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.
- I have included as an appendix a report from "Turnitin" (or other approved plagiarism detection) software indicating the level of plagiarism in my research document.

Signature: _________________________ Date: ________________________

1

Appendix J Turn it in Report

VISUAL PERCEPTUAL DEFICITS IN DIFFERENT TYPES OF CEREBRAL PALSY

ORIGINALITY REPORT

13%	9%	10%	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	edu.eacd.org Internet Source	1%
2	Adriano Ferrari, Giovanni Cioni. "The Spastic Forms of Cerebral Palsy", Springer Nature, 2010 Publication	1%
3	espace.library.uq.edu.au Internet Source	<1%
4	wiredspace.wits.ac.za Internet Source	<1%
5	Peter Stiers. "Visual–perceptual impairment in a random sample of children with cerebral palsy", Developmental Medicine & Child Neurology, 06/2002 Publication	<1%
6	edoc.pub Internet Source	<1%
7	aspe.hhs.gov Internet Source	<1%
8	minerva-access.unimelb.edu.au Internet Source	<1%
9	"Handbook of Growth and Growth Monitoring in Health and Disease", Springer Nature, 2012	<1%