THE RELATIONSHIP AMONG THREE PERCEPTUAL-MOTOR SKILLS IN CHILDREN AGED SIX YEARS REFERRED FOR OCCUPATIONAL THERAPY IN TSHWANE EAST

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DECLARATION

I, Sariza Swart, hereby declare that the work in this dissertation is my own. Acknowledgement was given to work done by others and references were included according to the requirements of the Faculty of Health Sciences at the University of Pretoria. The work in this dissertation has not been previously submitted by me at another university for degree purposes.

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EXECUTIVE SUMMARY

Purpose: The primary aim of this research study was to establish whether a relationship exists between the visual-motor integration subtest when measured with the Beery-Buktenica Developmental Test of Visual Motor Integration, 4th edition, and the copying and eye-hand coordination subtests, when measured with the Developmental Test of Visual Perception, 2nd edition. The secondary aim of this research study was to establish whether handedness and gender have an effect on the relationship between these three perceptual-motor skills.

Method: This retrospective cross-sectional study used retrospective data collected over a four-year-period, between 2009 and 2012, at a private occupational therapy practice in Tshwane East. The total sample size consisted of 106 participants that were referred for occupational therapy evaluations during the time period. The sample was divided into subgroups for grade, handedness and gender. Multivariable regression analysis was used to establish whether a relationship exists between visual-motor integration, copying and eye-hand coordination. Random-effects generalised least squares regression analysis was used to establish the effect of handedness and gender on the relationship between visual-motor integration, eye-hand coordination and copying.

Results: Results indicated reasonable agreement between the subtests of visual-motor integration and copying. Poor agreement was established between the subtests of visual-motor integration and eye-hand coordination, and the subtests of copying and eye-hand coordination. Statistically significant relationships were established between visual-motor integration, eye-hand coordination and copying for the total sample and subgroups of Grade R and Grade 1. Shared variance of 52.1% was established between the visual-motor integration and the copying subtest. The relationship between visual-motor integration and eye-hand coordination weakened for Grade 1 participants. This was also observed in the relationship between copying and eye-hand coordination. No statistically significant results were obtained for handedness and gender with regard to the relationships between visual-motor integration, eye-hand coordination and copying.

Conclusions: The results of the study indicated the importance of using all three subtests during occupational therapy evaluations. In view of the statistically significant relationships that were found to exist, the tests proved mutually supportive during occupational therapy evaluations. The negative relationship between visual-motor integration and eye-hand coordination for Grade 1 participants may be related to handwriting competency. Handedness and gender differences could not be related to the three perceptual-motor subtests.

Limitations: Firstly, the study population and study setting posed limitations toward generalisability. Secondly, the retrospective study design proved some limitations pertaining to the measurement instruments, data collection tools and re-scoring of the measurement instruments.

Recommendations: For more meaningful interpretations the study population should include children without developmental or school-related difficulties. This would aid toward better generalisability. A retrospective study design should be selected with caution.

KEYWORDS:

Perceptual-motor skills, visual-motor integration, eye-hand coordination, copying, handwriting, handedness, gender, Beery-Buktenica Developmental Test of Visual Motor Integration 4th edition, Developmental Test of Visual Perception 2nd edition.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ANNEXURES

LIST OF ABBREVIATIONS

Beery VMI-4	Beery-Buktenica Developmental Test of Visual-Motor Integration, 4th edition
COP	Copying subtest as tested with the Developmental Test of Visual Perception, 2nd edition
COP: EHC	Relationship between the copying subtest and the eye-hand coordination subtest of the Developmental Test of Visual Perception, 2nd edition
DTVP-2	Developmental Test of Visual Perception, 2nd edition
EHC	Eye-hand coordination subtest as tested with the Developmental Test of Visual Perception, 2nd edition
VMI	Visual-motor integration subtest as tested with the Beery-Buktenica Developmental Test of Visual-Motor Integration, 4th edition
VMI: EHC	Relationship between the visual-motor integration subtest of the Beery-Buktenica Developmental Test of Visual-Motor Integration-4th edition and the eye-hand coordination subtest of the Developmental Test of Visual Perception, 2nd edition
VMI: COP	Relationship between the visual-motor integration subtest of the Beery-Buktenica Developmental Test of Visual-Motor Integration-4th edition and the copying subtest of the Developmental Test of Visual Perception, 2nd edition

Chapter 1

ORIENTATION TO THE RESEARCH

1.1 INTRODUCTION

The Department of Basic Education identified handwriting as one of the weakest areas of performance in Grade 1 to Grade 9 learners in South Africa in 2013.[1] This is problematic, as 30-60% of a Grade 1 learner's time within the classroom is spent on handwriting and other fine motor tasks.[2] It poses an increased risk for children's ability to learn within the classroom environment due to the fact that handwriting is related to academic achievement.[3]

Several studies have commented on the connection between decreased perceptual-motor skills and learning difficulties such as handwriting.[4-6] Researchers identified that 7.3% of learners within the Gauteng Province Educational System can be considered to have impairments such as poor fine motor skills, which interfere with their learning abilities.[7] Additional barriers exist within rural communities, as these communities often do not have adequate access to teaching and learning materials during children's preschool years, and children then do not adequately develop school-related perceptual-motor skills.[7] The National Education Department has therefore identified the need for early detection of developmental difficulties impacting a child's success within the school environment.[7]

Occupational therapists working within the school context are concerned with the evaluation and treatment of perceptual-motor difficulties that may result in developmental difficulties within the classroom.[7,8] It is therefore vitally important for therapists to identify the underdeveloped/below average perceptual-motor skills impacting learning which may affect the child's experience of success and satisfaction within the classroom.[9] Children identified as having such difficulties could be included into an occupational therapy intervention programme, referred to experts within a multi-disciplinary team, or placed in a remedial schooling environment to address these difficulties.

Previous research has stated that standardised methods of evaluation allow for accurate diagnosis and improved interventions as long as the evaluations are conducted and interpreted by qualified therapists.[4,10] Standardised measurement tools can also assist in establishing the child's current development, his/her progress during interventions and the developing and prioritising of treatment goals.[4] A recommendation was made by the South African Education White Paper Six that standardised measurement tools should be used only when they have been proved useful in identifying learning barriers.[10] This places the responsibility on therapists to select the most appropriate measurement tools during occupational therapy evaluations.[10]

Two standardised measurement tools that are commonly used by therapists within the paediatric occupational therapy context are the Beery-Buktenica Developmental Test of Visual-Motor Integration, 4th edition (Beery VMI-4)[11] and the Developmental Test of Visual Perception, 2nd edition (DTVP-2).[12-14] Both measurement tools consist of subtests that evaluate similar aspects regarding perceptual-motor development, yet they are different in their definition and testing procedures for perceptual-motor skills. Each of these measurement tools can be used to evaluate six-year-old children and provide standardised age norm results. The Beery VMI-4 evaluates a child's visual-motor integration skills[15] and the DTVP-2 evaluates perceptual-motor skills including visual copying and eye-hand coordination skills.[16]

Handwriting is one of the areas occupational therapists address when treating children with developmental difficulties within the school environment.[17] Poor handwriting can result from any of a variety of inadequately developed perceptual-motor performance skills.[18] According to Volman, van Schendel and Jongmans,[2] there is a connection between handwriting development and the skill of visual-motor integration.[2,19] Case-Smith[20] has shed light on the importance of eye-hand coordination during the development of fine motor skills, which impact handwriting development.[20] In addition, visual copying plays an important part when acquiring the skill of writing.[21] For example, the child has to accurately observe a letter, number or symbol and copy it adequately from text or the blackboard onto paper.[21]

Visual-motor integration, copying and eye-hand coordination are perceptual-motor skills and, as stated above, are vitally important in the acquisition of handwriting. The question, therefore, arises: If these three perceptual-motor skills all contribute to handwriting development, is there a relationship between these skills when measured with standardised measurement tools?

1.2 PROBLEM STATEMENT

A research study by Richmond and Holland[10] investigating the relationship between teachers' checklists and standardised measurement tools reported that the Department of Education was challenging the use of laborious and expensive measurement instruments when evaluating children with learning difficulties.[10] The authors continued by stating that, due to decreased financial resources regarding occupational therapy services in schools, the need for an effective measurement instrument is evident in order to identify learners who would benefit from occupational therapy services.[10] This emphasises the need to investigate the relationships between the standardised measurement tools currently in use by occupational therapists in the South African context.

As stated in the introduction, both the Beery VMI-4 and the DTVP-2 are measurement tools commonly used by occupational therapists. The Beery VMI-4 has been closely associated with handwriting competency,[17,22] and occupational therapists frequently administer the Beery VMI-4 when children are referred for handwriting difficulties.[23] During a research study aimed at establishing the relationship between visual-motor integration, eye-hand coordination and the quality of handwriting, the authors reported that the copying and eye-hand coordination subtests of the DTVP-2 demonstrated significant relationships to handwriting.[19] The authors concluded that the predictive value of the Beery VMI-4 with regard to handwriting was not sufficient and that the copying and eye-hand coordination subtests of the DTVP-2 should be considered when diagnosing handwriting dysfunction.[19]

Due to the research studies mentioned above, the researcher identified the need to establish the relationships between the visual-motor integration subtest of the Beery VMI-4 and the eye-hand coordination and copying subtests of the DTVP-2. If these three subtests are related to the skill of handwriting, what is the strength and nature of the relationship between visual-motor integration, copying and eye-hand coordination?

Beery[15] compares visual-motor integration to the skill of eye-hand coordination.[15,24] However, the skill of visual-motor integration involves the accurate copying of an object with a pencil onto paper,[25] whereas eye-hand coordination consists of the skilled manipulation of the hand guided by vision.[18] When compared, both visual-motor integration and eye-hand coordination skills require visual feedback and accurate fine motor abilities to perform. In evaluations using standardised measurement tools, however, the visual-motor integration subtest consists of adequately copying geometric shapes, whereas the eye-hand coordination subtest consists of accurately tracing between designated paths.

As opposed to this, the visual-motor integration and copying subtests are more similar because both these subtests require visually observing and processing geometric shapes, and then relaying the information back onto paper with a pencil.[15,16] Therefore these subtests are more similar to each other than visual-motor integration and eye-hand coordination.

However, when measured with the measurement tools, visual-motor integration consists of drawing 27 geometrical shapes into a designated area[26] whereas copying consists of drawing 20 geometrical shapes into a smaller, more confined area.[27] Two research studies have aimed to establish the relationship of scores between visual-motor integration and copying by using the Beery VMI[15,28] and the Copying Test[29] within the South African context.[25,30] The results indicated a positive correlation between the scores of these two tests.[30] Even though these studies are outdated, similar findings could be expected when exploring the relationship between the visual-motor integration subtest of the Beery VMI-4 and the copying subtest of the DTVP-2.

In addition, the researcher questioned the effect of handedness and gender on the relationships between these three-perceptual motor skills. A number of studies[6,8,31] have found varying results in an attempt to examine the effect of gender on perceptual-motor skills, however, only limited research could be obtained regarding the effect of handedness on perceptual-motor skills. These studies will be explored in-depth in Chapter 2. No studies were found that investigated the effect of handedness and gender on the relationship between these three perceptual-motor subtests. Therefore, the effect of handedness and gender on the relationship between these three perceptual-motor subtests is still unknown, which highlights the need to explore this topic.

1.3 RESEARCH QUESTION, HYPOTHESIS, AND AIMS

1.3.1 Research question

Is there a relationship between the visual-motor integration subtest of the Beery VMI-4 and the copying subtest of the DTVP-2, the visual-motor integration subtest of the Beery VMI-4 and the eye-hand coordination subtest of the DTVP-2, and the copying subtest and eye-hand coordination subtest of the DTVP-2 in children aged six years referred for an occupational therapy evaluation? Furthermore, if a relationship were established between the three perceptual-motor skills, what role would handedness and gender play?

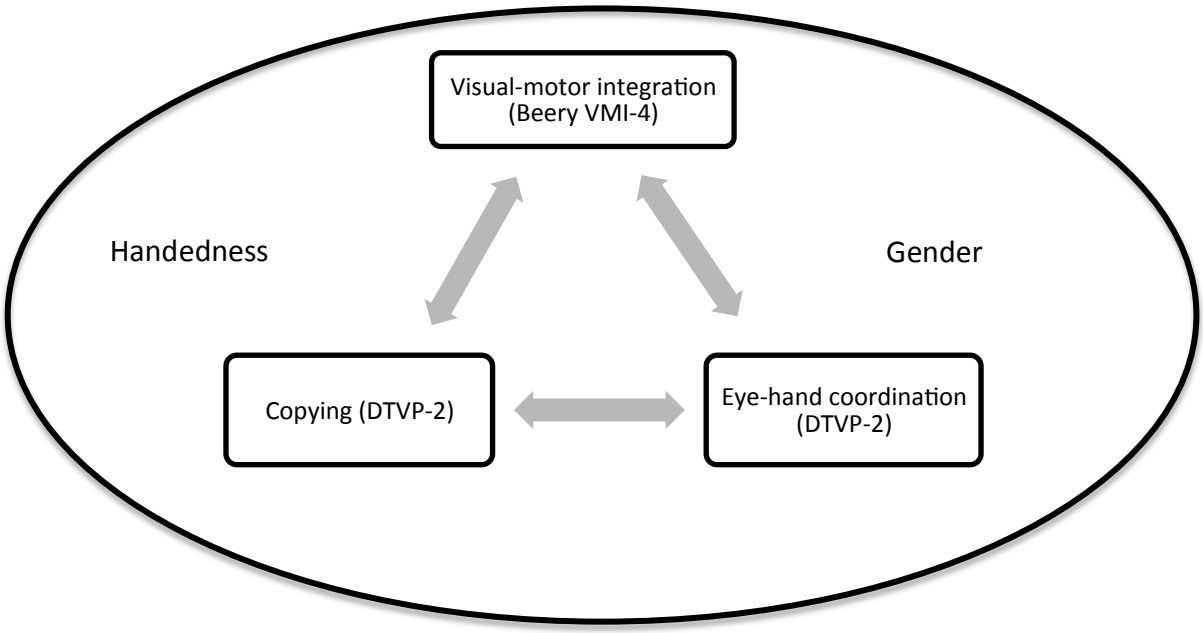

Figure 1-I: Schematic representation of the research question

1.3.2 Hypothesis and null hypothesis

1.3.2.1 Hypothesis

When measured with the Beery VMI-4 and the DTVP-2 standardised measurement instruments, a statistically significant relationship exists between the standardised scores of visual-motor integration and eye-hand coordination subtests, the standardised scores of visual-motor integration and copying subtests, and the standardised scores of copying and eye-hand coordination subtests.

1.3.2.2 Null hypothesis

When measured with the Beery VMI-4 and the DTVP-2 standardised measurement instruments, no statistically significant relationship exists between the standardised scores of visual-motor integration and eye-hand coordination subtests, the standardised scores of visual-motor integration and copying subtests, and the standardised scores of copying and eye-hand coordination subtests.

1.3.3 Aims

Primary aim: To establish whether a relationship exists between the scores of visual-motor integration and eye-hand coordination, the scores of visual-motor integration and copying, and the scores of copying and eye-hand coordination when measured with the Beery VMI-4 and the DTVP-2 standardised measurement instruments in six-year-old children referred for occupational therapy.

Secondary aim: To establish whether handedness and gender have an effect on the relationship between visual-motor integration, copying and eye-hand coordination when measured with the Beery VMI-4 and the DTVP-2 standardised measurement instruments in six-year-old children referred for occupational therapy.

1.3.4 Study objectives

To maintain goal-directed research, the following objectives were established with regard to the primary and secondary aims.

1.3.4.1 Objective 1

To establish whether a relationship exists between the visual-motor integration subtest and the eye-hand coordination subtest when measured with the Beery VMI-4 and DTVP-2.

Sub-objectives

To establish whether handedness has an effect on the relationship between the visual-motor integration subtest and the eye-hand coordination subtest.

To establish whether gender has an effect on the relationship between the visual-motor integration subtest and the eye-hand coordination subtest.

1.3.4.2 Objective 2

To establish whether a relationship exists between the visual-motor integration subtest and the copying subtest when measured with the Beery VMI-4 and DTVP-2.

Sub-objectives

To establish whether handedness has an effect on the relationship between the visual-motor integration subtest and the copying subtest.

To establish whether gender has an effect on the relationship between the visual-motor integration subtest and the copying subtest.

1.3.4.3 Objective 3

To establish whether a relationship exists between the copying subtest and the eye-hand coordination subtest when measured with the DTVP-2.

Sub-objectives

To establish whether handedness has an effect on the relationship between the copying subtest and the eye-hand coordination subtest.

To establish whether gender has an effect on the relationship between the copying subtest and the eye-hand coordination subtest.

1.4 IMPORTANCE AND BENEFITS OF THE PROPOSED STUDY

Perceptual-motor skills have a significant impact on the child's functioning within the school environment. Research has found that low perceptual-motor assessment scores are often associated with learning difficulties and poor academic achievement.[4] Studies have linked perceptual-motor skills to school-related skills such as reading, writing, and mathematics.[6,32] As stated previously, visual-motor integration, copying and eye-hand coordination are important perceptual-motor skills when entering the formal schooling system at age six,[18,33] as these skills have an influence on learning and handwriting competency.[3] Poor perceptual-motor development can therefore have a negative impact on the child's handwriting development, reading and writing competency, and mathematics ability. These factors influence the child's school performance and difficulties may result in the child experiencing low self-esteem and demotivation, which may impact the child, family, educational and social environment.[34] In establishing the relationships between the perceptual-motor skills and the effect of handedness and gender, the researcher aims to broaden knowledge with regard to school-related abilities especially within the area of handwriting development.

The present research study also aims to contribute to the aim of the National Education Department to identify learning barriers that are impacting children's school-related success.[7] The use of standardised measurement tools that are accurate, inexpensive and effective has become more important within the South African Educational System.[4] If a strong relationship exists between the visual-motor integration, copying and eye-hand coordination subtests of the Beery VMI-4 and the DTVP-2, this research could add value to occupational therapy evaluations. Assuming both subtests provide similar results, it will during occupational therapy evaluations allow therapists to select one instead of both standardised measurement tools used for this study. This will prove to be more cost-effective and less time-consuming.

If a weak relationship exists between the visual-motor integration, copying and eye-hand coordination subtests of the Beery VMI-4 and the DTVP-2, it will question the validity of the standardised measurement tools during occupational therapy evaluations, as both subtests provide valuable results with regard to different perceptual-motor abilities impacting handwriting. Furthermore, by establishing the strength of the relationship, it will assist the researcher in drawing conclusions as to whether occupational therapists have been over-testing children referred for occupational therapy or whether using both standardised measurement instruments is essential.

This research served as a descriptive study in establishing the relationships between three perceptual-motor skills in the South African context. Little research has been done regarding the relationship between the visual-motor integration, copying and eye-hand coordination subtests of the Beery VMI-4 and the DTVP-2 on a South African population. In addition, previous research studies have struggled to describe the relationship between visual-motor integration, copying and eye-hand coordination with regard to handedness and gender. This present research study aimed to investigate handedness and gender with regard to the three-perceptual-motor skills, with the intention of contributing knowledge to an otherwise mostly unexplored field.

1.5 DELIMITATIONS AND ASSUMPTIONS

1.5.1 Delimitations

This research study took place under the scope of paediatric occupational therapy. The study was designed to investigate the relationship between three perceptual-motor skills on a study sample referred for occupational therapy. The study was conducted at a private practice in Tshwane East and only included children from within government and private mainstream primary schools referred to said practice for developmental and/or school-related difficulties affecting their education.

1.5.2 Assumptions

The following assumptions were made with regard to the research study:

The study participants were referred by teachers, parents, remedial therapists, occupational therapists or medical professionals for an occupational therapy evaluation, due to their (the participants) experiencing developmental difficulties. The term used for a child with developmental difficulties refers to difficulty acquiring skills to the level considered as normal when compared to peers, usually caused by cognitive difficulties.[35]

It was assumed that the children used in the study did not have any physical limitations, which would be the limitation of physical movement or functioning of one or more limbs,[36] or mental retardation referring to a disorder characterised by below average intellectual functioning.[36]

Another assumption was made, namely that the Grade R participants included in the study would have been referred for an occupational therapy evaluation due to experiencing developmental difficulties, whereas the Grade 1 participants included in the study would have been referred for an occupational therapy evaluation due to experiencing developmental difficulties and/or school-related difficulties such as difficulty with handwriting.

1.6 DEFINITION OF KEY TERMS AND CLARIFICATION OF CONCEPTS

1.6.1 Relationship

Relationship is defined as "the way in which two or more people or things are connected, or the state of being connected".[37] The term therefore refers to a connection or association between two or more objects, people or concepts.

For the purpose of this research study, the term "relationship" will refer to the association between the subtests of visual-motor integration, eye-hand coordination and copying of the Beery VMI-4 and the DTVP-2.

1.6.2 Perceptual-motor skills

Visual perception is the learned ability to transfer information obtained from the environment through sight to the brain, then convert the information into meaningful and significant information. This is the process by which visual information received from the environment is interpreted and understood by the individual.[31]

Fine motor development is defined as the "proficiency in using small motor muscles for tasks such as writing, buttoning or grasping".[38] Fine motor skills consist of the coordination of muscle movements in the hand which allow the development of handwriting and drawing.[38,39]

In literature, the term perceptual-motor skills is used to refer to skills that incorporate visual perceptual abilities and fine motor abilities such as visual-motor integration, copying and eye-hand coordination.[2,40] For the purpose of this research study, the term "perceptual-motor skills" will be used.

1.6.3 Visual-motor integration

Visual-motor integration is the ability to copy with an appropriate and adequate motor response visual images of shapes, forms, pictures and letters.[41]

For the purpose of this study, "visual-motor integration" will refer to the perceptual-motor skill of visually perceiving an image and reproducing the image adequately by means of fine motor skill.

1.6.4 Eye-hand coordination

Eye-hand coordination is described as a skill where the child visually perceives an object, stationary or moving, and plans an appropriate motor response.[42,43]

For the purpose of this study, "eye-hand coordination" will refer to a perceptual-motor skill of manually tracing within a specific given area (lines on paper) while adequately tracking with the eyes in order to stay within the boundaries of the area.[18]

1.6.5 Copying

Literature refers to copying as "drawing from life where the scene is two-dimensional, a photograph, a painting, or a line drawn on paper".[44] In literature the term copying and visual-motor integration is often used interchangebly.

For the purpose of this study, "copying" will refer to the perceptual-motor skill of accurately copying visually observed geometrical shapes, letters or symbols from a picture with a pencil onto paper as evaluated by the DTVP-2 standardised measurement tool.[16]

1.6.6 Standardised measurement tool/ instrument

"A standardised test is any form of test that requires all test takers to answer the same questions in the same way, and that is scored in a standard or consistent manner, which makes it possible to compare relative performance of individual students or groups of students".[45]

For the purpose of this research study, "standardised measurement tool/ instrument" will refer to a test or assessment conducted by an occupational therapist during an occupational therapy evaluation. The tests, which consist of a standardised set of tasks and instructions, were standardised on a population or group in order to establish normative data relevant to the evaluation. The standardised measurement tools relevant to this research study are the Beery VMI-4 and the DTVP-2. Furthermore, for the purpose of this research study, the word subtest will be added when referring to the subtests of the Beery VMI-4 and the DTVP-2, namely the visual-motor integration subtest, the eye-hand coordination subtest and the copying subtest.

1.6.7 Developmental difficulty

Developmental difficulty refers to development that is slower than expected for a normally developing child. This developmental difficulty can occur temporarily or can be an indication of long-term developmental disability. According to literature the term developmental difficulty can be used until the child meets the criteria for a more appropriate diagnosis or may be disregarded if the child reaches appropriate development according to what is regarded as normal.[46]

For the purpose of this study, the term "developmental difficulty" will refer to all the children between the ages of 6 years 0 months and 6 years 11 months that were referred by a parent, teacher, medical professional or occupational therapist for an occupational therapy evaluation, due to the difficulties experienced by said children in Grade R or Grade 1.

1.6.8 Handedness

Handedness is defined as "the tendency to use either the right or the left hand more naturally than the other".[47] It refers to a child's ability to identify whether the right or left hand is the preferred hand to use during activities.

For the purpose of this research study, "handedness" will refer to each child's preferred hand of use during the completion of the standardised measurement tools as recorded by the examiner.

1.6.9 Children aged six years

For the purpose of this study, children between the ages of 6 years 0 months and 6 years 11 months will be possible research participants. This refers to every child that was between 6 years 0 months and 6 years 11 months at the time the initial occupational therapy evaluation was conducted. Children aged 5 years 11 months and 15 days or more, and children 6 years 11 months and fewer than 15 days will also be possible research participants (see Section 3.5.3).

1.6.10 Referred for occupational therapy

Referral is defined as "the act of referring someone or something for consultation, review or further action."[48]

For the purpose of this research study, all the children that participated in an initial occupational therapy evaluation will be considered as having been referred for occupational therapy, whether this referral came from a teacher, parent, psychologist, occupational therapist or medical professional.

1.6.11 Skilled occupational therapist

An occupational therapist is a therapist trained by a university in order to obtain a degree in occupational therapy. During undergraduate training the student is required to develop skills with regard to evaluation and treatment of perceptual-motor skills.

For the purpose of this research study, the term "skilled occupational therapist" will be used in order to describe the two qualified occupational therapists that conducted the occupational therapy evaluations during the period 2009 to 2012. The two occupational therapists had both been trained by a university, were registered at the Health Professionals Council of South Africa and were working within the field of paediatric occupational therapy for more than eight and ten years respectively. These therapsits can be classified as proficient and expert therapists and therefore had obtained skills in conducting occupational therapy evaluations with children.[49]

1.6.12 Tshwane East

"Tshwane" refers to a Metropolitan Municipality situated in Gauteng.[50]

The study was conducted within the region of Tshwane East, therefore children that had been referred from within the boundaries of Tshwane East were included in the study (See Annexure A).[51]

1.7 BRIEF CHAPTER OVERVIEWS

A short overview of the chapters following this one is presented below.

Chapter 2: Literature review

In Chapter 2, the researcher provides the reader with a summary of literature obtained from previous studies that have relevance to the relationship between perceptual-motor skills and handwriting, the relationship between the three perceptual-motor skills relevant to this study, as well as the effect of handedness and gender on those three perceptual-motor skills. These studies have been described and placed in context with regard to this research study.

Chapter 3: Methodology

Chapter 3 presents the reader with in-depth descriptions of the methods and procedures used during the execution of the research study. The reader will be provided with a description of the pilot study, the methods for data collection, the recording and analysing of the data as well as the ethical considerations relevant to this study.

Chapter 4: Results

Assuming that the reader has a clear understanding of the methods used during the study, the researcher provides the results and interpretations obtained during the data collection. The demographics of the sample are described and the results are presented according to the identified objectives of the study.

Chapter 5: Discussion and Conclusions

In Chapter 5, the results are discussed and explained with regard to previous literature. The reasons for the results obtained are suggested, and conclusions are drawn. Finally, the researcher explores the limitations of this research study and concludes with recommendations for future research.

Chapter 2

LITERATURE REVIEW

2.1 INTRODUCTION

As Chapter 1 consisted of the introduction, background and importance of this research study, Chapter 2 will focus on previous literature relevant to the study topic. Various national and international books, research studies and articles were reviewed in order to provide an in-depth and comprehensive review. The researcher accessed books and journals from reliable sources on the internet, the Prinshof and Main Campus Libraries of the University of Pretoria, and e-journals and health databases (PubMed and Scopus) available on the University of Pretoria website. The following keywords were used: perceptual-motor skills, visual-motor integration, eye-hand coordination, copying, handwriting, standardised assessments, and occupational therapy. In compiling the literature review, the researcher accessed books, journals and articles ranging from 1991 to 2015. The researcher is aware that, although some of the studies were published years ago, the information is still relevant to the present research study and could therefore not be omitted during the literature review.

The following literature review focuses on perceptual-motor skills and how these skills relate to learning, as well as the evaluation and treatment of these skills within the occupational therapy scope. The three perceptual-motor skills relevant to this research study will be described, namely visual-motor integration, copying and eye-hand coordination, as well as their relationship to handwriting. The importance of handedness and gender in relation to perceptual-motor skills is discussed. The background, development, validity and reliability of the Beery VMI-4 and the DTVP-2 measurement tools are presented.

2.2 NORMAL DEVELOPMENT OF THE CHILD

Development can be described as the changes in functioning that occur during the growth and maturation of the human being.[52,53] The term "child development" therefore refers to the growth that occurs through skill acquisition, whether it is emotional, social, cognitive or physical, to enable a child to transition through the stages of development.[54,55]

Perceptual-motor skill development and maturation occur during normal child development. The development of perceptual-motor skills will therefore be discussed in order to highlight the importance of these skills with regard to a child's daily activities.

2.2.1 Development of perceptual-motor skills

The human brain is the most intricate organ of the human body and undergoes dynamic changes during development.[52,56] An important aspect of brain development is the development of perceptual-motor skills. As described in Section 1.6.2, perceptual-motor skills can be divided into visual perceptual skills and fine motor skills.

Visual perceptual functioning plays an intricate part in the learning process of children.[6,8] Visual perception is a process where meaning is given to understanding and interpreting what can be visually observed, and it acts as the transitional process between visually observing a stimulus and cognition.[27] It is the process where the child extracts and organises the visual information that can be obtained from the environment[32] into meaningful interpretations in order to engage with the world. This process requires the integration of sensory information, previous experience and learning, and higher cognitive functioning.[8]

Children use their visual perceptual skills as a foundation during cognitive reasoning to adapt and control their actions by integrating the information from the environment.[41] These skills and abilities are then applied in matching and identifying colours, shapes and forms. Visual perceptual skills are therefore essential for school-related learning, and literature states that these skills are associated with learning readiness and academic achievement.[11,32,57]

Fine motor abilities refer to the skilled manipulation of objects with the hand.[33] Case-Smith[58] refers to fine motor skills as adequate eye-hand coordination and in-hand manipulation.[58] Exner[59] defines fine motor skills in terms of patterns such as reaching, grasping, releasing objects, bilateral hand use as well as manipulating objects within one's hand.[59,60] Furthermore, fine motor development is related to cognitive development, and literature states that it can be a predictor of academic achievement.[39]

Children combine fine motor skills such as drawing with visual perceptual skills in order to develop adequate perceptual-motor abilities needed for handwriting.[41] The combination of these skills is essential to learning within the formal schooling environment.

2.2.2 Occupational therapy and perceptual-motor skills

Occupational therapists use a client-centred approach.[27] Therapists identify various problem areas with regard to perceptual-motor skills, the relationship between these skills, and the effect these skills have on the child's occupations.[18,61] Occupational therapists treat children with special needs to assist their learning in school.[8] Therapists therefore perform holistic and thorough evaluations, in order to ensure that therapy is accurate and individualised.[8,62]

Therapists use standardised measurement tools to assist in identifying any perceptual-motor skill delays so that intervention can be specific to a child's needs. Within paediatric occupational therapy practices the Beery VMI-4 as well as the DTVP-2 are widely used.[8,12,27,57,63] These standardised measurement tools provide quantifiable information on the development of a child's perceptual-motor skills, and can act as an indicator of the child's learning abilities when entering primary school.[8] These tools also assist occupational therapists when treating perceptual-motor skill delays affecting a child's functioning within the school setting.

Several research studies have shown the benefits of occupational therapy intervention when addressing perceptual-motor skill delays.[32,41,57,63] Dankert, Davies and Gavin[41] investigated the effect of occupational therapy on visual-motor integration abilities. The researchers identified children with and without developmental delays and provided occupational therapy intervention for eight months. These children's performance was then compared to a control group's performance on the Beery VMI-4. The researchers reported significant improvement in the participants' performance after occupational therapy intervention. The study also found that participants with developmental delays who received occupational therapy intervention demonstrated improvement in their visual-motor integration skills that exceeded typically developing peers.[41]

Within the South African context, many children that enter the formal schooling system have never been part of a preschool programme or were never involved in a school readiness programme (Grade R).[40] These programmes focus on the development of perceptual-motor skills in preperation for formal education. Children that have not attended a school readiness programme may not have adequately developed perceptual-motor skills. According to Pienaar,[40] this may account for the high referral of Grade 1 learners to occupational therapy. Pienaar, Barhorst and Twisk[40] conducted a study in the North West Province of South Africa and examined the relationship between academic performance and perceptual-motor skills, and reported that high percentages of the South African study population had below average visual perceptual skills.[40]

Ercan, Ahmetoglu and Aral[64] found that culture and socio-economic status are related to visual perceptual development and learning.[64] This may be one of the factors influencing the high frequency of referrals to occupational therapy in South Africa, as the country is a developing country, and has a wide variety of children from different cultures and socio-economic statuses entering formal schooling each year. This emphasises the importance of occupational therapy for children that are referred due to developmental or school-related difficulties. Occupational therapists can therefore evaluate these children and ensure that problem areas are addressed during occupational therapy interventions.

2.3 PERCEPTUAL-MOTOR SKILLS

2.3.1 Visual-motor integration

As defined in Section 1.6.3, "Visual-motor integration can be described as the integration of visual, perceptual and motor skills, and is the ability to integrate visual processing abilities and fine motor abilities".[31] Visual-motor integration, therefore, is the skill of organising visual information from the environment into finer hand movements, and conveying the information onto paper.[2,11,65]

The skill of visual-motor integration plays a role in school-related learning, and studies have demonstrated a connection between visual-motor integration and academic achievement.[11,32,66,67] Taylor and Kulp[68] reported that visual-motor integration ability and ratings of math, reading, spelling and writing ability were significantly related.[68] Occupational therapy intervention programmes include the treatment of visual-motor integration as part of the treatment of perceptual-motor skills. In Section 2.2.2 the researcher discussed the benefits of occupational therapy intervention for children with developmental difficulties. This was highlighted by the significant effect of occupational therapy intervention on visual-motor integration skills.[41]

Similar results were reported when Ratzon, Efraim and Bart[69] evaluated the effectiveness of intervention on the visual-motor skills of Grade 1 learners from low socioeconomic communities. The study was based on providing short-term intervention for writing skills, which included 12 sessions of 45 minutes once a week. A significant increase in the participants' standardised scores of the DTVP-2 after intervention was established.[69]

A research study by Coetzee and Du Plessis[31] on a South African sample found that 22.9% of the research population scored below and far below average for visual-motor integration when tested with the Beery VMI-4.[31] This indicates that visual-motor integration was a poorly developed skill in these children. It therefore places valuable emphasis on the accurate evaluation and treatment of visual-motor integration as a perceptual-motor skill, as it has an essential role to play in the child's development of school-related skills[25,66] and experience of success at school.[64]

Lotz, Loxton and Naidoo[6] investigated the visual-motor integration functioning in 339 South African children from Grade 1 to Grade 4.[6] The majority of the sample population consisted of children from lower socioeconomic families. The researchers administered the Beery VMI-4 along with the Goodenough-Harris Drawing Test.[6] The findings were similar to Coetzee and Du Plessis's[31] findings, indicating that the study sample's visual-motor integration skills were 16 months below their chronological age. They also found that the learners had decreased visual-motor integration when beginning formal education. It was concluded from the study that socioeconomic status has an effect on visual-motor integration skills, causing decreased visual-motor integration functioning in children from low socioeconomic communities upon entering school. However, the researchers found that the children's visual-motor integration skills improved during their early school years, when treatment was received.[6]

The discussion in this section highlights the importance of visual-motor integration skills. The studies by Coetzee and Du Plessis[31] and Lotz, Loxton and Naidoo[6] emphasised the need to focus on visual-motor integration skills within the South African context, contributing to the importance of this research topic.

2.3.2 Eye-hand coordination

Occupational therapists treating preschool children with motor impairments frequently focus on perceptual-motor skills, especially eye-hand coordination.[58] Eye-hand coordination is described in Section 1.6.4 as a fine motor skill[15,58] which consists of coordinated hand movements guided by visual and sensory-motor feedback to produce fluent writing.[33,70] It refers to the ability to produce hand actions in a goal-directed manner.[70] Eye-hand coordination as a result plays an integral part in school-related learning such as handwriting, as a child needs to be able to visually guide his/her arm, hand and fingers to provide coordinated movements.[71] This, in turn, produces accurately formed letters.[33]

Research studies have highlighted the importance of eye-hand coordination in handwriting. One research study[33] described handwriting as consisting of finely graded movements during the manipulation of a pencil in order to produce a letter or symbol within the confines of a line. Therefore the coordinated movements and adequate feedback between the eye and hand produce legible handwriting.[33] This emphasises the importance of eye-hand coordination, as handwriting plays a significant part in the academic tasks of a child.[72,73] According to research,[43] tracing and drawing make use of two different kinds of eye-hand coordination abilities. Tracing depends on external visual cues to monitor the pencil movement in relation to the line being traced. Drawing on the other hand utilizes internal cues such as memory. The aim of this research study was to shed light on the interaction between the eye and hand during tracing and drawing tasks. The researchers found that the eye-hand interactions occurring during these tasks were similar.[43]

When considering standardised measurement tools with regard to perceptual-motor skills, the eye-hand coordination subtest of the DTVP-2 consists of tracing within the confines of lines and paths, whereas the visual-motor integration subtest of the Beery VMI-4 and the copying subtest of the DTVP-2 incorporate drawing abilities. Limited research could be obtained regarding eye-hand coordination as evaluated by the DTVP-2. Furthermore, limited research exists pertaining to eye-hand coordination within the South African context. This places emphasis on the need to broaden research regarding eye-hand coordination using standardised measurement tools available to therapists.

2.3.3 Copying

Copying is a perceptual-motor subtest of the DTVP-2 that consists of copying shapes.[16] This subtest therefore incorporates the skill of visual-motor integration and therefore plays an important role as a child starts to write letters. This perceptual-motor skill becomes refined once the child starts to imitate shapes through vertical strokes of the pencil. The ability to draw horizontal strokes will develop later, after which the development of circular patterns will emerge. This is followed by the copying of crosses, squares and triangles, which indicates writing readiness in the child.[2]

The significance of copying was noted when research established that children with good copying abilities during preschool were reported to have better reading, writing, spelling and mathematic abilities during formal schooling.[66] A research study on fine motor skills and executive functioning found that copying was strongly related to reading performance.[66] The researchers also found that children with good copying skills were able to perform classroom tasks faster, which supported the finding of increased reading skills during preschool.[66] Limited research has been done on the task of copying. Research has also failed to establish the relationship between the task of visual copying and other perceptual-motor skills, especially with regard to copying as a subtest of the DTVP-2 and how it relates to visual-motor integration and eye-hand coordination.

2.3.4 The link between visual-motor integration, copying and eye-hand coordination

The relationship between visual-motor integration, copying and eye-hand coordination is not clearly defined in literature, as stated in the previous sections. Some international studies, however, have established a link between visual-motor integration and eye-hand coordination.[19,74]

According to Coen-Cagli[74] regarding visual-motor integration and eye-hand coordination during a complex drawing task, the researchers found that increased attention was needed for adequate eye control when drawing complex pictures, which imposed limitations on eye-hand coordination.[74] The researchers shed light on the interaction between visual-motor integration and eye-hand coordination by stating that when complex pictures were drawn, decreased eye-hand coordination occurred, due to increased focus on eye control. Therefore the more complicated the visual-motor integration task, the less eye-hand coordination occurred.[74] This study suggested a negative relationship between visual-motor integration and eye-hand coordination.[74] The researchers concluded by stating that there was a strong relationship between visual-motor integration and eye movements during drawing tasks.[74]

One study related directly to the present research topic. Idoni, Taub and Harris[75] compared the visual-motor integration subtest of the Beery VMI-4 and the eye-hand coordination subtest of the DTVP-2 in children aged between seven and eleven years, and established a statistically significant relationship between the two subtests. The researchers concluded that although a statistically significant relationship was established, the tests could not be seen as interchangeable.[75] Similar results would therefore be expected for the current research study.

Coetzee[31] conducted a research study within the South African context and the results demonstrated a strong relationship between visual-motor integration and eye-hand coordination.[31] The researchers aimed to establish whether the visual-motor integration, visual perception and motor coordination subtests of the Beery VMI-4 correlated in Grade 1 learners. A meaningful relationship was established between the visual-motor integration subtest and the motor coordination subtest of the Beery VMI-4. The motor coordination subtest of the Beery VMI-4 is similar to the eye-hand coordination subtest of the DTVP-2, which involves drawing within specifically designated paths. According to the research study, visual-motor integration requires adequate eye-hand coordination in order to develop.[31] Similar results were reported by Pienaar, Barhorst and Twisk[40] when they established that academic performance and visual-motor integration, visual perception and eye-hand coordination correlated strongly within the South African context.[40]

Tchalenko[44] has attempted to establish the link between the skills of eye-hand coordination and copying,[44] and therefore investigated eye-hand interactions during the copying of complex lines such as the outlines of a head or human profile. According to these researchers, visual information is transferred to the brain and then integrated by the brain into a motor program which can be referred to as visual motor mapping. However, they stated that limited research exists regarding eye-hand interactions during copying.[44] Volman[2] has also drawn a connection between visual-motor integration and visual copying, by recognising the relationship between visual-motor integration and the skill of copying letters and symbols.[2]

Dunn, Loxton and Naidoo[25] researched the correlation between the results of the Beery VMI-4 and the South African Copying Test,[29] establishing a correlation of 0.75.[25] However, studies have failed to comment on the nature and strength of a relationship between the visual-motor integration subtest and the copying subtest of the Beery VMI-4 and the DTVP-2, respectively. In addition, several studies have aimed to determine the relationship between visual-motor integration and eye-hand coordination, reporting different results.

This emphasises the need to investigate the nature and strength of the relationship between the visual-motor integration subtest, the eye-hand coordination subtest and the copying subtest when using the Beery VMI-4 and the DTVP-2 standardised measurement instruments.

2.4 PERCEPTUAL-MOTOR SKILLS AND HANDWRITING DEVELOPMENT

2.4.1 The development of handwriting

Willingham[76] described the motor control processes in acquiring a motor skill such as handwriting.[76] According to him, a child goes through four stages to adequately learn a new motor skill, namely (1) identifying and selecting an appropriate goal of action that suits the required task; (2) learning the appropriate motor response through undergoing a perceptual-motor integration process; (3) a sequencing process in which the correct order of the motor response is learned; and lastly (4) a dynamic process that retains the new pattern of muscle activity.[76]

Various abilities form the foundation for handwriting to develop. These consist of motor, sensory, postural and perceptual abilities.[17] Thus factors such as postural muscle tone and proximal stability, pencil grasp and in-hand manipulation, and perceptual-motor abilities all form part of handwriting acquisition.[72] Handwriting develops with early scribbles and increases in purpose until the child is able to produce patterns that form shapes and letters.[2] Pre-writing skills are established during preschool before the child enters the formal schooling environment[77] and consists of the child's ability to draw by experimenting with different patterns while using a functional pencil grasp and adjusting his/her sitting posture accordingly.[77] Children are therefore ready for formal handwriting if these pre-writing abilities have been accomplished.[77]

Handwriting acquisition takes time. It is a complex process and is only mastered after several years of instruction.[65] Overvelde and Hulstijn[78] attempted, on a sample of Grade 2 and Grade 3 learners, to establish the development and maturation of handwriting during the early grades. These researchers' findings correlated with other research studies,[78] stating that the quality of handwriting improved in Grade 1 but stabilised during the remaining primary school years. The researchers also concluded that handwriting quality has decreased over the past two decades, the cause being uncertain.[78]

Handwriting difficulties are frequently found amongst young children and are especially common amongst children aged six to seven years.[33] This could be due to the high demand of increased fine motor activity during formal schooling. One study reported that 46% of the preschool child's day consists of fine motor activities, whereas 42% of these fine motor activities are predominantly pencil and paper tasks.[66,79] Other sources have reported varying percentages of 30-60% of time spent on fine motor activities during primary school, with writing as the main activity.[2,33] Skilful handwriting has also been identified as essential for later academic performance[2,3,66] and inadequate handwriting usually has a negative impact on the child's self-esteem.[2,3,63] From the information provided above it is evident that handwriting is a very important developmental skill.

The following section will therefore highlight the connection between handwriting and the three perceptual-motor skills, namely visual-motor integration, eye-hand coordination and copying.

2.4.2 Visual-motor integration, eye-hand coordination, copying and handwriting development

Handwriting is a complex skill consisting of many perceptual-motor skills. Handwriting skills as well as the components underlying the development of adequate handwriting (pre-writing skills) have therefore been widely considered by occupational therapists due to an increase in referrals of children with handwriting difficulties.[13,22,33] The treatment of handwriting difficulties is important for occupational therapy intervention within the school setting,[33] and research has proven handwriting intervention to be effective.[2,69]

Handwriting is described as a complex functional skill that every young school-aged child has to acquire.[2,17,63,71] Researchers have attempted to understand handwriting in terms of the various underlying perceptual-motor skills. According to Volman[2], perceptual-motor skills such as visual-motor integration, copying, and eye-hand coordination form part of and are required for adequate and sufficient engagement in handwriting.[2] Other sources have also confirmed this by stating that various components namely eye-hand coordination, visual-motor integration, planning and attention abilities are all involved in handwriting.[2,33,71] Evidence therefore suggests that handwriting difficulties can be related to deficits in perceptual-motor functioning.[2]

Several studies have attempted to connect handwriting with perceptual-motor skills.[2,19,22] Studies on American, Norwegian and Chinese primary school children emphasised this connection by reporting that handwriting legibility was indicated by visual-motor integration.[33] Similar results were obtained on Dutch primary school children during a research study to investigate the relationship between handwriting and visual-motor integration. These researchers established that handwriting quality and accuracy could be accurately estimated by visual-motor integration abilities.[2,71] Therefore, visual-motor integration was identified as an essential skill in connection with handwriting.[19]

Eye-hand coordination and copying have also been connected to handwriting development. Uysal and Aki's[80] study on handwriting and students with poor vision found that visual-motor integration, the skill to copy letters, and eye-hand coordination were necessary skills for proficient handwriting development.[80] Similar findings were reported by Kaiser[19] in a research study on visual-motor integration, eye-hand coordination and the connection to handwriting.[19] The researchers stated that visual-motor integration has been widely researched regarding quality of handwriting, but less focus has been placed on the influence of eye-hand coordination.[19] During the research study above the researchers noted that eye-hand coordination relating to visual-motor integration predicted handwriting proficiency.[19] They concluded by reporting that visual-motor integration and eye-hand coordination both have an influence on handwriting difficulties and should be considered when children are referred for occupational therapy.[19] The research study also highlighted the valuable contribution of the skill of copying in handwriting.[2,19] The study confirmed the notion that the copying subtest from the DTVP-2 has a significant relation to handwriting.[19] This research study therefore established a relationship between the visual copying and eye-hand coordination subtests of the DTVP-2 when considering handwriting, and relates directly to the present research study. Bara and Gentaz[65] found similar results when exploring the contribution of visual-motor integration and eye-hand coordination skills to handwriting acquisition.[65] They found that tracing during an eye-hand coordination test was strongly associated with handwriting, and concluded that visual-motor integration and eye-hand coordination have a role to play in handwriting development and acquisition.[65]

Although literature has established links between handwriting and perceptual-motor skills, limited research exists on the relationship between visual-motor integration, copying and eye-hand coordination within the South African population. As discussed above, visual-motor integration, copying and eye-hand coordination can each be presumed to be connected to handwriting, however, this three-way relationship and the nature thereof has not been proven. It was therefore of benefit to investigate the relationship between visual-motor integration, copying and eye-hand coordination in this present study in order to enhance the effectiveness of evaluation and treatment of handwriting difficulties.

2.5 GENDER AND PERCEPTUAL-MOTOR SKILLS

Limited research could be obtained regarding the effect of gender on perceptual-motor skills, though differences between boys and girls have been noted in relation to visual-motor integration. A study by Singh et al.[81] stated that boys scored higher than girls in visual-motor integration skills when evaluating a group of 100 Indian children.[81] Similar results were reported nationally by Lotz, Loxton and Naidoo[6] while examining the visual-motor integration functioning in a South African sample. The findings demonstrated that boys scored significantly higher on the Beery VMI-4 than girls.[6] This was confirmed by Coetzee's[31] South African study in the Free State on a group of nine-year-old children, where boys obtained significantly better scores as compared to girls.[31]

These findings, however, were contradictory to previous research in other countries[6] and the researcher's clinical experience. More boys are referred for occupational therapy than girls, and more boys require therapy as compared to girls. According to Volman, Van Schendel and Jongmans,[2] handwriting difficulties are more frequently observed in boys.[2] This was confirmed by Tseng and Murray,[82] stating that the ratio for poor handwriting in boys to girls was five to one.[82] Studies by Berninger[83] have also reported gender differences when examining writing skills of boys and girls diagnosed with dyslexia. These studies reported lower performance in handwriting skills in primary school boys.[83] Volman, Van Schendel and Jongmans,[2] and Berninger[83] found that, as compared to girls, the boys' writing problems were more severe.[2,83] In this researcher's experience girls tend to apply more time and effort to drawing tasks and focus more on detail, whereas boys tend to dislike drawing and handwriting tasks.

A study by Vlachos[9] examining the relationship between handedness and drawing confirmed the researcher's experience, stating that fine motor development matures earlier in girls.[9] Similar findings were reported by Cheung[8] in Hong Kong who conducted a study to establish whether gender has an influence on the perceptual-motor development of children. The researchers used the DTVP-2 to examine 289 children aged between six and seven years. Their findings reported that the girls performed better in the copying subtest, due to their being more cautious and taking their time during the copying test.[8]

Due to the differences in research methods and findings of previous research studies concerning the relationship between gender and perceptual-motor development, there was uncertainty regarding gender performance when testing perceptual-motor skills in the course of this research study. It therefore had to be explored whether boys or girls would score better on the visual-motor integration, copying and eye-hand coordination subtests of the Beery VMI-4 and the DTVP-2.

2.6 HANDEDNESS AND PERCEPTUAL-MOTOR SKILLS

Literature states that more or less 90% of the population is right-handed, however, studies on handedness have shown variations across cultures.[84,85] A survey of 12 000 subjects from 17 countries reported that 2.5-12.8% of the population used their left hand for writing tasks. An internet study conducted by the BBC reported that 7-11.8% of the general population in the UK is left-handed.[86] Furthermore, 10% of the population in Australia is left-handed.[87] No statistics regarding handedness could be obtained for the South African population, and therefore the researcher assumed, from the statistics stated above, that approximately 10% of the South African population could be considered as left-handed.

Handedness starts to develop very early in a child's life, and it is believed that genetics and environmental influences contribute mostly towards the establishment of hand preference.[88] Hand preference can be detected as early as six months of age[88] but it is generally believed to emerge at age three, and may be fully established at seven years.[88]

Little research could be obtained regarding the effect of handedness on perceptual-motor skills such as visual-motor integration, copying and eye-hand coordination. One study commented on this by stating that handedness has not been correctly defined in literature.[89] Some studies have viewed handedness as having selected a consistent dominant hand for tasks, where other studies have done research on the differences between left- and right-hand dominant children. What the researchers did state, however, was that handedness is in part genetically determined but also influenced by culture.[89]

Left-handed children are at risk for inconsistent hand preference due to growing up in a right-hand dominant world.[89] This may impact the development of visual-motor integration, copying and eye-hand coordination skills in left-handed children. During a research study, girls with inconsistent hand preference scored lower than those with established hand preference.[89] The researchers concluded that it was vitally important to establish a consistent hand preference.[89]

Literature has commented on the difference between drawings by left- and right-handed participants due to hemispheric specialisation, stating that there were differences in lateralisation of the brain between left- and right-hand dominant individuals.[86] Holtzen observed improved gross visual-motor integration in left-handed individuals.[90] However, a research study examining the impact of gender and handedness on the development of visual-motor integration reported poorer drawing performance in left-handed children.[89]

Differences between hand dominance and writing and reading abilities have also been reported. Gedutiene[91] reported an increase in writing errors such as spelling mistakes made by left-handed participants, as compared to right-handed participants.[91] They concluded by stating that right-handed participants use both perceptual and phonological strategies during reading and writing, as compared to left-handed participants. The results indicated that children who are left-handed have an increased susceptibility for reading and writing difficulties.[91]

In a study by Schmidt et al.[84] to examine the effect of handedness using the Grooved Pegboard Test, a test that evaluates eye-hand coordination, researchers found no difference between left- and right-handed participants.[84] Another study examined the differences in gross motor eye-hand coordination with regard to handedness in international handball players, and reported similar findings. No differences relating to handedness and eye-hand coordination were found.[90] Furthermore, researchers examined drawing performance in left- and right-handed school aged children. No difference between the developmental level representational drawings of left- and right-handed children was reported.[9]

As stated in Section 2.4.2, perceptual-motor skills relate to handwriting. Furthermore, the visual-motor integration, eye-hand coordination and copying subtests of the Beery VMI-4 and the DTVP-2 incorporate drawing abilities. As a result of the differences reported by previous studies, it was therefore of interest to examine whether the visual-motor integration, copying and eye-hand coordination subtests' scores differred between left- and right-handed children in the present research study. The effect of handedness was uncertain, and therefore of value to investigate during this research study.

2.7 AGE AND PERCEPTUAL-MOTOR SKILLS

Age has a role to play in the development of perceptual-motor skills. In a study by Cheung et al.[8] to establish whether gender, grade and age impacted children's visual-perceptual performance, the researchers found significant grade differences between Grade 1 and Grade 2 learners on the copying subtest but not on the eye-hand coordination subtest of the DTVP-2.[8] According to literature, visual-motor integration skills are important skills in preparing children for writing.[31] Visual-motor integration therefore has a necessary role to play in a child's success in a pre-academic and an academic setting. Dankert, Davies and Gavin[41] conducted a research study to determine the success and value of intervention on visual-motor integration skills with regard to preschool children, and stated that various studies[92,93] have been conducted on preschool and school-aged children, respectively.[41] These studies, however, did not compare Grade R and Grade 1 learners.

Literature states that there are differences in children's skill development in the first years of primary school.[22] Children in Grade R tend to develop visual-motor integration skills by refining their fine motor skills and visual perceptual abilities as part of obtaining pre-writing skills, in order to prepare them for handwriting in Grade 1.[22] However, children in Grade 1 daily use their visual-motor integration skills to participate in handwriting tasks.[2,22,33,66] Children in Grade 1 therefore have more experience in school-related tasks such as handwriting,[23] which may have an impact on their visual-motor integration, copying and eye-hand coordination skills.

Children between the ages of 6 years 0 months and 6 years 11 months can either be in Grade R or Grade 1, depending on their date of birth. For instance, if the child's birthday falls in the first half of the year, the child may turn six while in Grade 1. From the information above it was evident at the onset of the present research study that a Grade R participant's skills would differ from a Grade 1 participant's skills, and that it was therefore important to make a distinction between Grade R and Grade 1 participants for the purpose of this study.

2.8 STANDARDISED MEASUREMENT TOOLS

Standardised measurement tools provide increased accuracy for diagnosis of perceptual-motor skills causing learning difficulties as well as aid therapists in implementing intervention strategies that are correct.[4] Standardised measurement tools assist therapists in establishing the child's development, measuring his/her progress during therapy and identifying therapy goals.[4] The development, properties, validity and reliability of the following standardised measurement instruments are discussed with relevance to the study.

2.8.1 Beery-Buktenica Test of Visual-Motor Integration, 4th edition (Beery VMI-4)

2.8.1.1 Background

The Beery-Buktenica Developmental Test of Visual-Motor Integration (Beery VMI)[15,28] is a standardised, norm-referenced test.[15,63] The test was first developed in 1967, with its 4th revised edition having been published in 1997.[15,63] The Beery VMI-4 assesses visual-motor integration ability or skill through the copying of geometric shapes based on age appropriate developmental skills.[11] The test has the ability to distinguish between reduced and normal perceptual-motor abilities.[11,24]

The Beery VMI-4 is used internationally,[26] and the developers of this measurement tool suggest that it is free of cultural bias.[15,40] The test can be administered by various professionals such as occupational therapists, educational staff and psychologists.[63] It can be used for diagnosing medical, neurological or academic difficulties;[15] as a tool for determining the success of interventions with regards to visual-motor integration; and also for research purposes.[63,94] The value of the Beery VMI-4 as a measurement tool has long been realised, as this test is widely used amongst therapists.[63]

The Beery VMI-4 has three subtests consisting of visual-motor integration, visual perception and motor coordination. The two supplemental tests, visual perception and motor coordination, were developed to assist practitioners in differentiating between visual perceptual and motor coordination difficulties that contribute to visual-motor integration.[24] The visual perception subtest assesses the child's visual perceptual abilities. The motor coordination subtest focuses mainly on the child's fine motor and coordination abilities.[11] For the purpose of this research study, only the visual-motor integration subtest was used, and not the supplemental tests of visual perception and motor coordination as well.

The Beery VMI-4 can be used in various ways in its full or shortened form, during individual evaluations or as a group screening tool.[11,15,94] The visual-motor integration subtest assesses the individual's ability to copy developmentally sequential geometric forms using a pencil on paper. The tasks involve copying 27 forms in the response booklet.[15,31,94]

Administration instructions were developed in order to be easily understood by all ages.[15] The instructions, outlined in the test manual, are given by the examiner, after which he/she observes the individual's responses.[94] The first three items are practice items, where the child has the opportunity to copy a vertical line, a horizontal line and a circle drawn by the examiner. Items 4-27 are geometrical shapes that increase in complexity and difficulty.[15]

The description of the items in the response booklet is as follows:[15,95]

Item no.	Item	Item no.	Item	Item no.	Item
1.	Vertical line (imitated copy)	2.	Horizontal line (imitated copy)	3.	Circle (imitated copy)
4.	Vertical line (copy the design)	5.	Horizontal line (copy the design)	6.	Circle (copy the design)
7.	Vertical-horizontal cross (copy the design)	8.	Right oblique line (copy the design)	9.	Square (copy the design)
10.	Left oblique line (copy the design)	11.	Oblique cross (copy the design)	12.	Triangle (copy the design)
13.	Open square and circle (copy the design)	14.	Three-line cross (copy the design)	15.	Directional arrows (copy the design)
16.	Two dimensional rings (copy the design)	17.	Six-circle triangle (copy the design)	18.	Circle and tilted square (copy the design)
19.	Vertical diamond (copy the design)	20.	Tilted triangles (copy the design)	21.	Eight-dot circle (copy the design)
22.	Wertheimer's hexagons (copy the design)	23.	Horizontal diamond (copy the design)	24.	Three dimensional rings (copy the design)
25.	Necker cube (copy the design)	26.	Tapered box (copy the design)	27.	Three-dimensional star (copy the design)

Table 2-1: Items of the Beery VMI-4

The Beery VMI-4 has a clinically objective scoring system.[11,63] The scoring guidelines are provided in the manual, as well as examples for correct and incorrect responses. The examiner carefully analises the responses, however, the manual states that if in doubt, the examiner should score the response as correct. A score of zero is given to incorrect responses and a score of one is given to correct responses.[15] The examiner discontinues scoring after three successive incorrect responses.[15] The raw score is determined by counting all the correct responses. Raw scores can be converted to standard scores, percentiles and age equivalents by using the conversion tables in the manual.[15]

2.8.1.2 Reliability and validity

The Beery VMI-4 manual provides evidence of validity and reliability.[15] According to the manual, inter-rater reliability correlations are 0.94 for the visual-motor integration subtest. The content validity was strongly supported and the test's concurrent validity was established by correlating the scores between the Beery VMI-4 and various other standardised measurement instruments, namely The Bender Gestalt Test (r= 0.29-0.93, median r= 0.56);[26] The Wide Range Achievement Visual-Motor Assessment Drawing Test (r= 0.52);[26] and The Developmental Test of Visual Perception 2nd edition (DTVP-2) copying subtest (r= 0.75), position in space subtest (r= 0.62) and eye-hand coordination subtest (r= 0.65).[15]

The test construct validity was demonstrated through the following measures:[15]

- Visual-motor integration scores increase with age;
- Visual-motor integration measures integration of visual perceptual and motor coordination skills;
- Visual-motor integration is related to academic achievement and intelligence test scores.

Studies have looked at the validity of older and newer editions of the Beery VMI. In a study to evaluate the construct validity of the Beery VMI-5 by using the Rasch Measurement Model, the findings supported the clinical use of the Beery VMI-5. They found that potential gender bias with regard to task nine existed, and reported the possibility of some items containing the same level of difficulty as opposed to an increase in difficulty.[26] This needs to be considered when using the Beery VMI-4, as the task items have not been changed between these two versions.

2.8.1.3 Additional research

Wuang[96] have also examined the measurement properties of the Beery VMI-4 by using the Rasch Analysis in children aged four to twelve years with intellectual disabilities.[96] The researchers found that some items demonstrated a misfit to the Rasch model and therefore had to be eliminated. They further established that nine items accurately measured mild perceptual-motor impairment and demonstrated a reliability of 0.91 in children with intellectual disabilities. This adapted version of the initial Beery VMI-4 was able to identify mild, moderate and severe intellectual disabilities as compared to the ability of the initial version of the Beery VMI-4.[96]

A study to examine the discriminant validity of the Beery VMI-4 in children with poor handwriting stated that the Beery VMI-4 cannot be used to identify or diagnose handwriting dysfunction.[63] According to the researchers, the Beery VMI-4 failed to recognise 66% of the children identified as having handwriting difficulties. However, the study showed that children from four to six years with poor handwriting did obtain significantly lower scores on the Beery VMI-4.[63] This study shows that, although the Beery VMI-4 cannot be used to diagnose handwriting problems, children with handwriting difficulties usually present with visual-motor integration problems.[63]

The Beery VMI-4 is related to academic achievement, and the results of the test will correlate moderately well with academic achievement test scores as demonstrated in the test manual.[15] A research study by Sortor[32] relating academic achievement to the results of the Beery VMI-4 subtests demonstrated differences between children with good and poor math and reading abilities. However, the study population scored below the expected norms. One of the reasons provided by the researchers was that the study population presented poor pencil grasp during the completion of the test.[32] Therefore it should be considered that fine motor ability, especially with regard to pencil grip, may impact the score for the visual-motor integration subtest.

Little is known about the Beery VMI-4 with regard to the South African population. Dunn, Loxton and Naidoo[25] however, attempted to evaluate the relationship between the scores of the Beery VMI-4 and the South African standardised Copying Test.[25] In the study the researchers used a multi-ethnic preschool sample consisting of coloured, black and white children within a semi-rural environment. Findings reported that concurrent validity existed between the two standardised tests, which in turn enhanced the suitability of using the Beery VMI-4 on a South African population. Both tests also demonstrated differences by race and socio-economic status.[25]

2.8.2 Developmental Test of Visual Perception, 2nd Edition

2.8.2.1 Background

The Developmental Test of Visual Perception (DTVP)[16] is a standardised test,[27] originally developed by Marianne Frostig in 1966.[57] A revised version, the Developmental Test of Visual Perception, 2nd edition, was published by Hammill, Pearson and Voress in 1993.[12,16] The DTVP-2 was developed as a psychometrically sound measurement tool.[12,27]

It is described as a comprehensive test to evaluate perceptual-motor abilities, and it takes 30-60 minutes to complete the full evaluation.[8,12,27] The DTVP-2 was standardised on 1972 children aged between four and ten years of age in the United States, selected with regard to racial status, background, gender, geographic area, handedness and age. There were equal numbers of boys and girls in the study sample, and 3% of the sample consisted of children with disabilities.[12,57]

The DTVP-2 consists of eight interrelated subtests,[12,57] namely eye-hand coordination, position in space, copying, figure ground, spatial relations, visual closure, visual motor speed and form constancy.[8,27,57] These subtests are divided into two groups. The position in space, figure ground, visual closure and form constancy subtests are categorised as motor reduced visual perception, whereas the eye-hand coordination, copying, spatial relations and visual motor speed subtests are categorised as visual-motor integration. By combining the standard scores of all eight subtests, a general visual perception quotient can be established.[5,57] The subtest performance scores alone can be used to generate assumptions or speculations, but should not be used to act as diagnoses or for clinical interpretations.[12] Scoring of the DTVP-2 consists of recording raw scores, which in turn can be converted into standard scores, percentiles and age equivalents.[8,16,57,16,84] For the purpose of this research study only the eye-hand coordination and copying subtests will be used.

When completing the eye-hand coordination subtest, the child draws within four paths involving angles and curves, and it increases in difficulty by becoming narrower. The paths are divided into segments and intervals and scoring is reliant upon whether the child refrained from lifting his/her pencil, or how far the child extended beyond the initial gray boundary and into the segments. The child scores four points for staying within the gray boundary, and one point is deducted for each of the four boundaries crossed. The child scores zero for a segment, if the child lifts his/her hand during the drawing task. The eye-hand coordination subtest requires the child to apply abilities such as manual agility, eye-hand coordination precision, visual perceptual abilties and adequate pencil grasp and manipulation.[16,27]

The copying subtest requires the child to copy in the test booklet 20 geometric figures that are similar to the Beery VMI-4. The child is able to score zero, one or two depending on the accuracy of copying the shape as described in the manual. After a series of three incorrect responses the subtest is discontinued. Each geometric shape is progressively more difficult than the previous one.[16,27]

2.8.2.2 Reliability and validity

Concurrent validity was established by examining the correlation between the DTVP-2, the Motor-Free Visual Perceptual Test and the Beery VMI-3rd edition (Beery VMI-3) on a sample of 49 neurologically impaired children. The correlation between the subtests was as follows:[12,16]

- Motor-Free Visual-Perceptual Test (r= 0.78)
- Beery VMI-3 (r= 0.87)

This demonstrated a strong correlation between the DTVP-2 and the Beery VMI-3.

As described in the examiner's manual, the DTVP-2 is said to have good content validity.[16] Construct validity was established through identifying the underlying concepts, developing theories, and verifying those theories.[12] It was found that the test had significant age differentiation, which supports the developmental characteristics of the test. It was also established that inter-relationship between subtests existed, and subtests had the ability to measure different visual perceptual abilities.[12] The test was also found to measure different abilities than intelligence and achievement tests.[12] Furthermore, high discriminant validity was found to exist between normally developing children and neurologically impaired children.[12,57]

Researchers conducted a study to establish the discriminant validity of the DTVP-2 for children that present with learning disabilities as diagnosed by a psychologist, and the results supported the use of the DTVP-2. The researchers found lower scores on all the subtests for children identified with learning disabilities, as compared to the scores of the normative sample. The study also concluded that visual perceptual abilities and learning difficulties were related.[12]

The reliability of the test was measured for internal consistency on a sample of 100 children, using yearly intervals. The reliability of each subtest was established, ranging from 0.83 to 0.93. Each subtest, except the copying subtest, had a reliability of more than 0.80.[12] In a research study that examined the validity and reliability of the DTVP-2, the researchers found that the DTVP-2 had an overall high level of internal consistency.[62] The test-retest reliability was evaluated on a sample of 88 children, using two-weekly intervals. Test-retest reliability ranged from 0.80 to 0.92 and inter-scorer reliability ranged between 0.92 and 0.99.[12] The DTVP-2 was also examined for content sampling error and time sampling error and was found to have adequate levels of reliability.[16,57]

Brown[62] examined the validity and reliability of the DTVP-2 when compared with the Beery VMI-6th edition (Beery VMI-6) and the Test of Visual Perceptual Skills 3rd edition (TVPS-3). The researchers concluded that positive correlations existed between the scores of these three tests, which indicated good convergent validity of the DTVP-2. The study was conducted within an Australian context, and it was found that reasonable convergent validity and internal consistency was evident in a cross-cultural setting.[62]

Occupational therapists frequently use the DTVP-2 as a screening tool for visual perceptual difficulties.[62] Therefore therapists in the United States, England and even South Africa still use the DTVP-2 regularly.[12] Studies have, however, questioned the reliability, validity and standardization procedures of the test. It has been stated that the test should be used with caution in countries such as South Africa, due to the unavailability of norms for children in South Africa.[12]

2.9 CONCLUSION

In conclusion, occupational therapists play an integral part in assisting children that experience developmental and/or school-related difficulties to reach their potential. This includes intervention relating to visual-motor integration, eye-hand coordination, copying and many more perceptual-motor skills. The topic of visual-motor integration, as well as its connection to handwriting, has been researched internationally. Research studies have been conducted nationally and internationally to establish a relationship between visual-motor integration, copying and eye-hand coordination. These studies, however, have not established the relationship between the visual-motor integration, eye-hand coordination and copying subtests of the Beery VMI-4 and the DTVP-2. Studies have also failed to describe the effect of handedness and gender on the relationship between these subtests.

From the literature reviewed and discussed in this chapter, the researcher felt confident that a positive relationship would be established between the three perceptual-motor skills identified for this research study. In addition, the researcher was able to establish that various studies have confirmed the validity and reliability of the Beery VMI-4 and the DTVP-2, which increases the validity and reliability of the measurement tools identified for this research study. However, the researcher was unable to conclude the effect of handedness and gender on the relationship between the three perceptual-motor skills, due to the limited number of research studies available.

Chapter 3 will focus on the methods pertaining to the execution of this research study. In addition, this chapter discusses the ethical considerations pertaining to the research study.

Chapter 3

METHOD

3.1 INTRODUCTION

This chapter aims to provide the reader with an understanding of the methods used to execute the research study. Firstly, the researcher provides the reader with a review of the purpose of the study. This is followed by in-depth discussions of the research design and methodology. The researcher discusses the pilot study, data collection process, data management and data analysis. Lastly, the ethical and legal considerations are provided followed by a conclusion.

3.2 REVIEW OF THE AIMS OF THE RESEARCH STUDY

The primary aim of this research study was to establish the nature and strength of the relationship between the visual-motor integration subtest when measured with the Beery VMI-4 and the eye-hand coordination and copying subtests when measured with the DTVP-2. The secondary aim of the research study was to establish whether handedness and gender have an effect on these relationships. The study objectives with the sub-objectives, as described in Chapter 1, are presented below.

3.3 REVIEW OF THE STUDY OBJECTIVES

3.3.1 Objective 1

To establish whether a relationship exists between the visual-motor integration subtest and the eye-hand coordination subtest when measured with the Beery VMI-4 and DTVP-2.

Sub-objectives

To establish whether handedness has an effect on the relationship between the visual-motor integration subtest and the eye-hand coordination subtest.

To establish whether gender has an effect on the relationship between the visual-motor integration subtest and the eye-hand coordination subtest.

3.3.2 Objective 2

To establish whether a relationship exists between the visual-motor integration subtest and the copying subtest when measured with the Beery VMI-4 and DTVP-2.

Sub-objectives

To establish whether handedness has an effect on the relationship between the visual-motor integration subtest and the copying subtest.

To establish whether gender has an effect on the relationship between the visual-motor integration subtest and the copying subtest.

3.3.3 Objective 3

To establish whether a relationship exists between the copying subtest and the eye-hand coordination subtest when measured with the DTVP-2.

Sub-objectives

To establish whether handedness has an effect on the relationship between the copying subtest and the eye-hand coordination subtest.

To establish whether gender has an effect on the relationship between the copying subtest and the eye-hand coordination subtest.

3.4 DESCRIPTION OF THE STUDY DESIGN

In order to establish the relationship between the visual-motor integration, eye-hand coordination and copying subtests, the researcher made use of a retrospective cross-sectional study design to collect and analyse the data. This study design allowed the researcher to examine the strength of the relationship between the visual-motor integration, eye-hand coordination and copying subtests by analysing a large sample of retrospective data.[97] This consisted of recording the standardised scores of the Beery VMI-4 and the DTVP-2, obtained between 2009 and 2012 from a group of participants between the ages of 6 years 0 months and 6 years 11 months.

The advantages of using a cross-sectional study design are that it is effective when examining age-related trends,[97] and can be conducted within a short time period. This study design is also effective for descriptive analysis to establish the relationships between the identified subtests.[98] One advantage of using retrospective data was that the researcher had access to a large sample with little to no change in the testing methods.

One disadvantage of a cross-sectional study design is that the design could be susceptible to recall bias.[98] The researcher aimed to eliminate this by using the data that was recorded in the participant files on the day of their initial evaluation and stored within the private practice.

3.5 METHODOLOGY

This section describes the methodology used to conduct the research study. The identified study setting and sampling method to obtain the sample size are discussed. Furthermore, information is provided on the measurement tools and how they were implemented during the data collection process. Lastly, the measures implemented to ensure quality control will be provided.

3.5.1 Study setting

The study was conducted at a paediatric occupational therapy private practice within the boundaries of Tshwane East (see Annexure A). The study setting was determined by convenience to the researcher, as the researcher was allowed access to the storage data pertaining to occupational therapy evaluations conducted at the said practice.

The paediatric practice specialised in evaluating and treating children referred for occupational therapy due to developmental or school-related difficulties affecting their functioning. The private practice received referrals from teachers in private and public schools, parents, psychologists, occupational therapists and medical professionals within Tshwane East.

3.5.2 Study population

The study population consisted of children aged 6 years 0 months to 6 years 11 months that were referred for developmental or school-related difficulties and evaluated using the Beery VMI-4 and the DTVP-2 by the identified occupational therapy private practice between 2009 and 2012.

3.5.3 Sampling method

All the children between the ages of 6 years 0 months and 6 years 11 months who were evaluated by the occupational therapy private practice using the Beery VMI-4 and the DTVP-2, in the time period 2009 to 2012 were possible research participants. From this population the study sample was derived by identifying each 6 year 0 month to 6 year 11 month old child that attended an initial occupational therapy evaluation and met the following inclusion criteria.

3.5.3.1 Inclusion criteria

- Children between the ages of 6 years 0 months and 6 years 11 months at the time of the initial occupational therapy evaluation were included in the research study. The age group was determined by the researcher to be the age group that would benefit most from the research; as it is at that age that children engage 30-60% of their school day in writing tasks,[2,66] which incorporates perceptual-motor skills such as visual-motor integration, copying and eye-hand coordination.

- The study only included children within the boundaries of Tshwane East, therefore excluding children that were evaluated by the practice from other areas outside the boundaries of Tshwane East (see Annexure A).

- The children included in the research study were children that participated in an initial occupational therapy evaluation at the practice, and had not been evaluated previously by another occupational therapist as reported by the parents in the patient background form.

- Only children that were evaluated by the two skilled occupational therapists were included in the research study (see Section 1.6.11)

- Only children that completed both the Beery VMI-4 and the DTVP-2 were included in the research study.

- During scoring of the standardised measurement instruments the test standardisation made provision for children close to their next birthday or month e.g. children aged 5 years 11 months. The test manual stated that if the child was 5 years 11 months and more than 15 days, their age was converted to 6 years 0 months. These children were then included in the study population.

3.5.3.2 Exclusion criteria

- The study excluded children younger or older than the identified age group on the date of the evaluation.

- The study excluded children diagnosed by a paediatrician or neurologist with the following conditions, prior to attending the initial evaluation. These terms were not included in the initial terminology, as these terms did not directly relate to the research study:

Autism Spectrum Disorder

"Defined as a psychiatric disorder of childhood, with an onset before the age of 2½ years. It is marked by severe difficulties in communicating and forming relationships with other people, in developing language, and in using abstract concepts; repetitive and limited patterns of behaviour; and obsessive resistance to tiny changes in familiar surroundings. Autistic children find it hard to understand how other people feel, and so tend to remain isolated even into adult life. About 50% have learning disabilities, but some are very intelligent and may even be gifted in specific areas. Autism and similar developmental disorders, including Asperger's syndrome and Rett's syndrome, are known as autistic spectrum disorders." [99]

Cerebral Palsy

"Defined as a disorder of movement and/or posture as a result of non-progressive but permanent damage to the developing brain. This damage may occur before, during, or immediately after delivery and has many causes, including an inadequate supply of oxygen to the brain, low levels of glucose in the blood, and infection. It is often associated with other problems, such as learning difficulties, hearing difficulties, poor speech, poor balance, and epilepsy." [100]

Epilepsy

"Defined as a disorder of brain function characterized by recurrent seizures that have a sudden onset." [101]

Physical abnormalities

Physical abnormalities refer to any congenital physical condition that may affect the child's use of his upper limbs e.g. amelia, ectrodactyly, brachydactyly and syndactyly.

Attention Deficit Disorder/ Attention Deficit Hyperactivity Disorder

"Defined as a mental disorder, usually of children, characterized by a grossly excessive level of activity and a marked impairment of the ability to attend. The behaviour may be predominantly hyperactive-impulsive, predominantly inattentive, or combined. Learning is impaired as a result, and behaviour can be disruptive and may be defiant or aggressive." [102]

- The study excluded children taking medication such as Ritalin™ and Concerta™ as prescribed by a doctor to enhance concentration abilities, or any of the other medication prescribed for concentration difficulties[103] (see Annexure B). This, however, did not include enhancements such as vitamins and minerals or medication that could be obtained from over the counter e.g. Keen mind™, EyeQ™, ADDvance™, etc.

- The study excluded children that were evaluated by any other occupational therapist (other than the two skilled occupational therapists identified for the study, to increase the reliability of the study) at the private practice within the time frame of 2009 to 2012. There were instances where one of the skilled occupational therapists conducted evaluations in conjunction with another occupational therapist at the practice. These evaluations were discarded.

- As stated under inclusion criteria, during scoring of the standardised measurement tools the test standardisation made provision for children close to the next birthday or month e.g. children aged 6 years 11 months. The test manual stated that if the child was 6 years 11 months and more than 15 days, their age was converted to 7 years 0 months. These children were excluded from the study population.

3.5.3.3 Sampling procedures

The children's files were removed from storage, and the researcher examined each file with regard to the inclusion and exclusion criteria. All the children that met the inclusion criteria formed part of the total sample. The total sample was then divided into subgroups for grade, handedness and gender.

The researcher decided to make a distinction between children between the ages of 6 years 0 months and 6 years 11 months that were in Grade R, and those that were in Grade 1. The Grade R participants that fell within the relevant age group had not had formal schooling experience and may have presented with developmental difficulties rather than school-related difficulties. They also had less exposure to pencil and paper tasks as compared to Grade 1 6-year-old children. The Grade 1 participants that fell within the identified age group may have been referred due to experiencing more school-related difficulties, and they may have had more experience with paper and pencil tasks which would influence their scoring of the measurement instruments.

The researcher intended to use stratified random sampling to ensure proportional representation of left-handed participants and girl participants in the study sample.[104,105] As discussed in Section 2.6, left-handed children are in the minority as compared to right-handed children. The discussion in Section 2.5 highlighted the high referral of boys to occupational therapy as compared to girls. The researcher expected to enrol fewer left-handed participants and fewer girl participants and therefore aimed to include 30% left-handed and 30% girl participants within the total sample. This was, however, not achieved. After consultation with the statistician, the reseacher and the statistician decided that stratified random sampling would not be implemented, and the total population of left- and right-handed participants and boy and girl participants were included in the study. Figure 3-I demonstrates the total sample divided into the three subgroups.

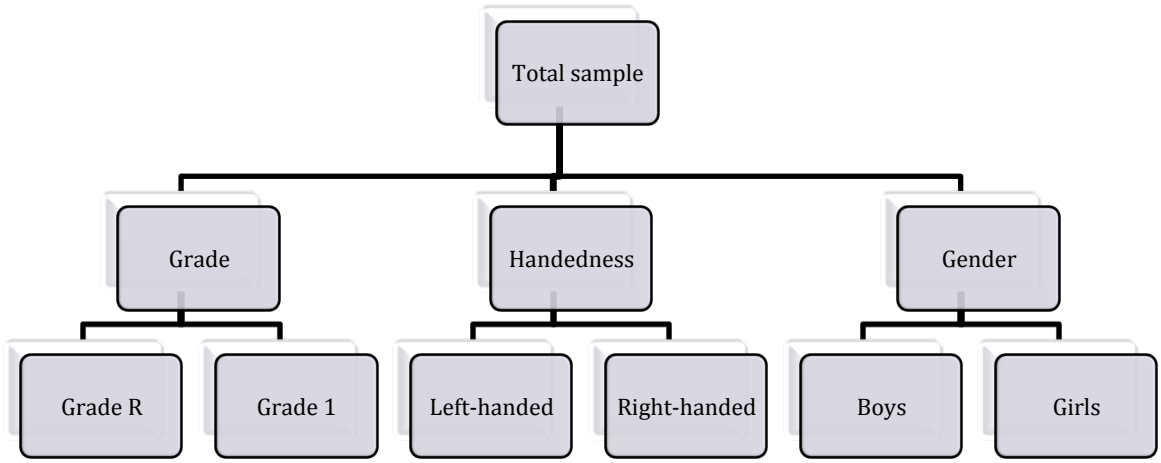

Figure 3-I: Schematic representation of the sampling procedure

3.5.4 Sample size

Initially, as calculated by the statistician based on the number of variables in the study, a sample size of 30-45 participants was required, i.e. 10-15 participants per covariate. However, a sample of more than 100 participants was obtainable (163 participants). The researcher therefore aimed to enrol more than 100 participants. This large sample size intended to account for the difference in variation between the outcome measures.

3.5.5 Data collection tools

The researcher aimed to use two data collection tools, namely the patient background information form and the evaluation summary form obtained in the participants' files. These data collection tools were developed by the occupational therapists working within the private practice to record data obtained during the occupational therapy evaluations.

3.5.5.1 Patient background information form

The patient background information form was completed by the parent of the child that was referred to the practice for an initial occupational therapy evaluation. The form contained information regarding the child's name and surname, date of birth, age, the mother's pregnancy and the child's neonatal condition, milestone development, preschool years, school and grade, and reason for referral (see Annexure C). The researcher only recorded information regarding the participant's date of birth, age, preschool years and grade from this form.

3.5.5.2 Evaluation summary form

The skilled occupational therapists that conducted the occupational therapy evaluation completed the evaluation summary form, which contained information from the measurement instruments and observations made by the therapist, i.e. the child's handedness, the child's behaviour during the evaluation, whether the child used medication for concentration difficulties etc. The raw scores of the Beery VMI-4 and the DTVP-2 (as described in Section 2.8) were transcribed onto this form by the occupational therapist (see Annexure D).

The Beery VMI-4 and the DTVP-2 were indirect measurement instruments. These instruments were administered by the two skilled occupational therapists during the occupational therapy evaluations from 2009 to 2012. Both are standardised measurement instruments that provide normative data with regard to perceptual-motor development (see Section 2.8)

3.5.5.3 Beery-Buktenica Developmental Test of Visual-Motor Integration-4th edition (Refer to Section 2.8.1)

The visual-motor integration subtest of the Beery VMI-4 was the first test to be administered, and took more or less 10 minutes to complete. The child was asked to copy a set of 27 geometrical shapes that were arranged according to complexity. The booklet was placed in front of the child, and instructions were given to copy the shapes in the top box, into the bottom box by using the pencil provided.

The skilled occupational therapist scored each shape according to a set of scoring guidelines and examples outlined in the manual. For the copied visual-motor integration shapes, scoring consisted of various measurements of lines and angles that were applied to establish a score. The manual, however, states that if the examiner is in doubt, the item should always be scored as passed, providing the child with the benefit of the doubt. The child was then allocated with a raw score.

A standard score, percentile, age equivalent and z-score could be calculated from the raw scores by using the test manual. The researcher converted the raw score into a standard score by using the test manual and calculated the z-score by using the following equation:

z-score = (Standard score – 100) / 15.

3.5.5.4 Developmental Test of Visual Perception-2nd edition (DTVP-2)

(Refer to Section 2.8.2)

The DTVP-2 consists of eight subtests, all of which were completed by the children and of which only two were analysed in the research study. The eye-hand coordination subtest and the copying subtest were completed with a pencil in a booklet that was placed in front of the child.

During the completion of the eye-hand coordination subtest, instructions were given to the child to draw a continuous line within designated grey paths. The child was provided with the opportunity to practise in a grey path provided in the response booklet. During this practise opportunity the therapist could ensure that the child understood the instructions for the completion of the task.

During the completion of the copying subtest, the child was instructed to copy 20 geometric figures, each underneath its corresponding example. The child had to start copying the figures in the top left corner and work from left to right and top to bottom. The skilled occupational therapist observed the child's copying ability and discontinued the copying after the child made three consecutive mistakes.

The skilled occupational therapist then scored each subtest according to scoring guidelines provided in the test manual. The child was then allocated a raw score for the eye-hand coordination subtest and the copying subtest that could be converted into a standardised score, percentile, age equivalent and z-score by means of normative tables. The researcher converted the raw score into a standard score by using the test manual and then calculated a z-score by using the following equation: z-score = (Standard score – 10) / 3.

3.5.6 Quality control

The standardised measurement tools used in the study have been researched and are widely used by therapists to obtain normative data during evaluations (refer to Section 2.8). The Beery VMI-4 is stated to be free of cultural bias.[15] This confirmed the use of this measurement tool within a South-African context.

To ensure external validity[97,105] with regard to generalisation from the study sample to the study population, a representative sample pertaining to handedness and gender was included in the study.

3.5.6.1 Reliability of data collection tools

To establish the reliability of the data collection tools, the researcher had to evaluate the quality and consistency of the data obtained from these tools.[97,106] Two skilled occupational therapists conducted all the initial occupational therapy evaluations from 2009 to 2012. This increased the stability and consistency of the results obtained during the initial occupational therapy evaluations. This also ensured that the researcher did not have any influence on the results obtained.[105]

The same data collection tools, namely the patient background information form and the assessment summary form, were used by the occupational therapy private practice for all the evaluations from 2009 to 2012. This increased the stability and consistency of the results obtained.[105]

To ensure inter-rater reliability of the results, a randomly selected sample of ten evaluations was re-scored during the pilot study by an external rater, to establish whether the results obtained were consistent when scored by another therapist. If the results differed between the raw scores of any of the three subtests in more than four of the evaluations, all the evaluations would have to be re-scored. The external rater had to be an expert within the field of paediatric occupational therapy; therefore he/she had to comply with specific criteria identified by the researcher. According to research, the external rater's level of education and experience as well as his/her knowledge of the factors that are being evaluated, have an influence on ratings.[107] It has been verified that an expert has more refined abilities and developed cognitive schemas for the factors that are being evaluated than an inexperienced person.[107]

To ensure accurate results, the external rater had to be an occupational therapist with a minimum of five years experience within the field of paediatric occupational therapy. This would ensure that the external rater was an expert within the field of conducting and scoring evaluations using the Beery VMI-4 and the DTVP-2.

In order to establish test-retest reliability for the measurement instruments, both instruments had to be administered on the same sample on two different occasions.[106] As the researcher was using retrospective data from participant files, test-retest reliability could not be established. However, both the Beery VMI-4 and the DTVP-2 have been evaluated for test-retest reliability by using two-week intervals, and was found to have adequate test-retest reliability (refer to Section 2.8).

From the information above, it was concluded that the data collection tools and indirect measurement instruments had good stability, consistency and test-retest reliability.

3.5.6.2 Validity of measurement tools

To measure the validity of the research data collection tools, the researcher had to establish whether the tools measured exactly what they were intended to measure.[97] Prior to commencement of the research study, the following measures were implemented by the occupational therapy private practice to ensure that the occupational therapy evaluations conducted at the practice were of good quality. These measures contributed to the validity of the measurement tools.

Construct validity refers to how well the patient's background information form reflected the background information needed for the study, and how well the assessment summary form reflected the scores for the visual-motor integration, copying and eye-hand coordination subtests.[106]

The patient background information form provided personal background regarding the child's age, date of birth, preschool years and school (in the case of Grade 1 participants). The evaluation summary form provided the initial scores and the re-marked scores of the visual-motor integration, copying and eye-hand coordination subtests, as well as the participant's handedness.

Furthermore, the data collection tools had at the time been used by the occupational therapy private practice for more than ten years. It could therefore be assumed that the occupational therapists at the private practice considered these tools to provide accurate and correct information. The measurement instruments, therefore, had face and content validity. [105,106]

The patient background information form provided the researcher with personal information about the participant as reported by the parent. The evaluation summary form provided the researcher with information reported by the occupational therapist during the initial occupational therapy evaluation. These two resources were combined in order to provide the researcher with more in-depth information.

Concurrent validity is described as the ability of the measurement tool to distinguish between groups.[106] The Beery VMI-4 and the DTVP-2 standardised instruments were tested for validity during the standardisation procedures. (Refer to Section 2.8) The DTVP-2 has also been reported to have discriminant validity for children with learning disabilities.[12] The study population consisted of children referred for an occupational therapy evaluation due to developmental or school-related difficulties. It was therefore concluded that the DTVP-2 had discriminant validity for the study population.

From the above information it was concluded that the measurement tools had established construct validity.

A pilot study was conducted prior to commencement of the data collection process, as part of the quality control measures.[105] The purpose of the pilot study was to evaluate and adapt the methodology that would be used in the study. This was done through obtaining an estimate for the study sample size, studying the data in the participant files, re-scoring by the external rater and evaluating the data capturing procedures. The statistician then reviewed the data in order to establish whether it was sufficient. The pilot study will henceforth be discussed in full.

3.5.7 Results of the pilot study

3.5.7.1 Estimated study sample size

Prior to the pilot study, the researcher and statistician decided that a sample of 100 participants was sufficient for the research study. The researcher therefore needed to establish the estimated population size of 6 year 0 month to 6 year 11 month old children that attended an initial occupational therapy evaluation at the practice in order to determine whether the identified sample size was attainable. Recording the number of evaluations conducted by the two skilled occupational therapists on 6 year 0 month to 6 year 11 month old children from the practice diaries provided the researcher with a population estimate. An estimated population of 163 participants was established.

3.5.7.2 Testing the data collection procedures

Prior to the pilot study, the researcher intended to use participant files from 2002 to 2012. Three participant files for each year from 2002 to 2012 were studied during the pilot study, in order to record relevant evaluation information from the files onto the spreadsheet. One participant from every period of four months who met the inclusion criteria was included in the pilot study, i.e. one participant from January to April, one from May to August, and one from September to December. This added up to 27 participants.

The following information was recorded:

- Identification number as allocated by the researcher
- Age (year and month)
- Date of birth
- Handedness (L/R)
- Gender (M/F)
- Current grade (Grade R/ Grade 1)
- Whether the child attended nursery school or Grade R
- Standard score for each individual subtest (visual-motor integration, copying, eye-hand coordination)
- Z-score for each individual subtest (visual-motor integration, copying, eye-hand coordination)

During the studying of the participant files it was found that the occupational therapy practice used two different editions of the Beery VMI. From 2002 to 2008 the Beery VMI 3rd edition (Beery VMI-3) was used, and from 2009 to 2012 the practice used the Beery VMI-4. The scoring of the Beery VMI-3 differs from the scoring of the Beery VMI-4, and after consultation with the research supervisors and statistician it was decided to only use the participant files from 2009 to 2012.

3.5.7.3 Re-scoring by the external rater

As stated in Section 3.5.6.1, as part of the quality control process an external rater would re-score ten evaluations in order to determine whether the same raw score was obtained if scored by an expert. If the results of the raw scores of any of the three subtests differed in more than four of the evaluations, all the evaluations would have to be re-scored.

As the external rater's calculated raw scores differed from the raw scores obtained by the two skilled occupational therapists on more than four of the subtests, the researcher was required to re-score all the subtests in the study sample during the data collection process.

3.5.7.4 Review of the data by the statistician

The information obtained from the 27 participant files was reviewed by the statistician in order to determine whether the estimated sample size of the study was sufficient, or whether adjustments had to be made to include an adequate sample of Grade R and Grade 1 participants, left-handed and right-handed participants, and boys and girls. The statistician also had to establish whether the data obtained from the participant files was sufficient and complete for statistical analysis. The information was found to be sufficient and adequate by the statistician.

3.5.7.5 Adjustments to the initial research study

After completion of the pilot study, the following adjustments were made to the research study. The researcher submitted an amendment to the Research Ethics Committee to change the study dates from 2002-2012 to 2009-2012, so that only participants that had completed the Beery VMI-4 would be included in the research study. The implications of this amendment included adjustments to the sample size as well as to the percentage of left-handed and girl participants included in the total sample. This amendment was approved in January 2015. (Refer to Section 3.8)

3.6 DATA COLLECTION

The data collection process was administered in the three phases described below.

3.6.1 Phase 1: Sampling and participant identification

Once ethical clearance had been obtained, the researcher was allowed to access the patient files. During the pilot study an estimated population of 163 participants was established. The researcher administered the sampling procedures described in Section 3.5.3 to obtain the total sample of participants. The estimated population included evaluations that did not fit the inclusion criteria. Those evaluations were discarded.

3.6.2 Phase 2: Allocation of identification numbers and re-scoring

After the study sample had been identified, the researcher could allocate an identification number from 1-117 to each participant file. During this phase, the researcher found that another therapist/university student had worked in conjunction with the skilled occupational therapists and had conducted one or more of the participant evaluations. These participants were also removed from the study sample and therefore the final sample consisted of 106 participants.

The researcher re-scored the visual-motor integration subtests, copying subtests and eye-hand coordination subtests of the entire sample, using the test manuals for both standardized measurement tools. The raw scores obtained for each subtest was recorded in the participant files.

3.6.3 Phase 3: Capturing of the data

A data capturing spreadsheet with the following headings was developed in Microsoft Excel:

- ID (participant identification number)
- Date of evaluation
- Age (year and month)
- Date of birth
- Handedness
- Gender
- Grade R/Grade 1
- Grade R attendance
- Beery edition
- Raw visual-motor integration
- Raw eye-hand coordination
- Raw copying
- Standard score visual-motor integration
- Standard score eye-hand coordination
- Standard score copying
- Z-score visual-motor integration
- Z-score eye-hand coordination
- Z-score copying

The researcher transferred the relevant data from the patient background information form and the evaluation summary form onto the spreadsheet. The following information was collected from the patient background information form: each child's age, date of birth, gender, whether a Grade R participant or Grade 1 participant, and preschool attendance i.e. whether the child attended Grade R. Although the researcher re-scored all the participants' subtests and did not use the raw scores on the evaluation summary form, information such as whether the participant was on medication and the participant's handedness was still obtained from the evaluation summary form. Furthermore, the calculated raw scores from the measurement instruments were recorded onto the spreadsheet, together with the calculated standard score and z-score of each subtest. The information in each participant file was compared to the corresponding data on the spreadsheet to monitor for accuracy or mistakes.

3.7 DATA MANAGEMENT AND ANALYSIS

The section below provides the reader with information pertaining to data management and analysis. The variables are described in terms of the independent, dependent and confounding variables relevant to the research study. The data analysis procedures as well as the statistical consideration are provided.

3.7.1 Variables

The variables measured in the research study were as follows:

3.7.1.1 Independent variables

The independent variables for this research study were each participant's age, handedness and gender.

3.7.1.2 Dependent variables

The dependent variables for this research study were each participant's standardised score and z-score for each subtest that had been conducted, namely visual-motor integration, eye-hand coordination and copying.

3.7.1.3 Confounding variables

One of the confounding variables for this research study was the study setting. Only participants from within the boundaries of Tshwane East were included in the research study (see Annexure A).

The time of day each child was evaluated, and his/her physical and emotional state may have had an effect on the outcome of the test results. Early in the morning children are usually more alert and better able to focus and sustain attention. Children who were evaluated later in the day may have been tired and might have had more difficulty in sustaining their attention. These factors, however, could not have been avoided or controlled in this research study as it was a retrospective study.

The skilled occupational therapists may have gained more expertise and experience in conducting evaluations during the period of 2009 to 2012. This may have had an effect on the evaluation scoring and results obtained. As this research study used retrospective data, this factor could not be controlled or monitored by the researcher.

Data analysis was performed by the statistician as described below.

3.7.2 Statistical consideration

Of primary importance in the retrospective cross-sectional study was to establish the relationship between the standardised score of the visual-motor integration subtest from the Beery VMI-4 and the standardised scores of the copying and eye-hand coordination subtests from the DTVP-2.

Of secondary importance in the retrospective cross-sectional study was to establish the effect of gender and handedness on the relationship between the the visual-motor integration subtest from the Beery VMI-4 and the copying and eye-hand coordination subtests of the DTVP-2.

3.7.3 Data analysis

The statistics pertaining to the study sample was analysed by establishing the mean age for the total sample, establishing the percentage of each group within the total sample, providing the data pertaining to the Grade R attendance as well as establishing the distribution of gender and handedness across grades. The data was then analysed by establishing the effect of grade, handedness and gender on each subtest through two-sample t-tests.

The results pertaining to the first, second and third objectives were analysed according to the said objectives. The levels of agreement between the mean z-scores of the visual-motor integration and the eye-hand coordination subtests, the visual-motor integration and the copying subtests, and the copying and eye-hand coordination subtests were established through intraclass correlation coefficient (ICC). The term “agreement” refers to the inherent capibility of the two subtests to measure similar skills or abilities. The level of agreement was considered significant if the ICC >0.5, in view of the norm for excellent agreement being 0.9. In addition, the Pearson correlation coefficient was implemented to establish the relationship between the mean z-scores of the three subtests. The relationship was considered significant if the Pearson rho correlation coefficient was below the p=0.05 level and highly significant if the coefficient was below p= 0.01.

The results pertaining to the sub-objectives were analysed according to the said sub-objectives. The effect of handedness and gender was established for the relationship between visual-motor integration and eye-hand coordination (VMI: EHC), visual-motor integration and copying (VMI: COP), and copying and eye-hand coordination (COP: EHC) through random-effects generalised least squares regression analysis. The association was considered significant if the Pearson rho correlation coefficient was below the p=0.05 level and highly significant if the coefficient was below the p=0.01 level.

The statistical values for the level of agreement and relationship between the subtests will be described accordingly:

	Values	Description
Level of agreement	Excellent	The level of agreement is considered excellent if the ICC =0.9
	Reasonable	The level of agreement is considered reasonable if the ICC> 0.5
	Poor	The level of agreement is considered poor if the ICC<0.5
Relationship	Highly significant	The relationship is considered highly significant if p=0.01
	Significant	The relationship is considered significant if p=0.05
	Weak	The relationship is considered weak if the p>0.05

Table 3-1: Statistical values and descriptions

Lastly, the variation in visual-motor integration that could be explained by the variation in eye-hand coordination, copying, handedness and gender was established through multivariable regression analysis. For each of the outcome measures, i.e. z-scores, the multivariable regression between the z-score for visual-motor integration and the z-score for eye-hand coordination, the z-score for copying, handedness and gender was fit. The coefficient of determination (R^2*100%) was assessed for fit.

The regression coefficients were interpreted in order to understand the association between the covariates and visual-motor integration. The data summary included mean and standard deviation for the individual outcomes by test. The testing was done at the 0.05 level of significance (see Annexure E).

3.8 ETHICAL AND LEGAL CONSIDERATIONS

All reasonable attempts were made to counteract potential harm during the research study.

3.8.1 Permission to conduct the research study, ethical clearance and informed consent

Provisional permission to conduct the study was granted by the occupational therapy private practice. This consisted of permission granted by the occupational therapy practice prior to ethical clearance, allowing the researcher assurance that the study could commence once ethical clearance was received. (See Annexure F)

Ethical clearance was granted by the University of Pretoria Ethics Committee (see Annexure G). Amendments were submitted after the pilot study was conducted, as described in Section 3.5.7, whereafter ethical clearance for amendments was received (see Annexure H).

The research study only commenced once written informed consent was obtained from the occupational therapy private practice (see Annexure I). This was initiated once ethical clearance had been granted by the University of Pretoria Ethics Committee. This allowed the researcher to access patient files and analyse the data obtained from 2009 to 2012.

3.8.2 Key values of Helsinki and good clinical practice

The following key values, principles of Helsinki and good clinical practice were adhered to:

3.8.2.1 Social responsibility

The researcher aimed to consider the needs and problems of the local and national communities in which the research study was conducted, and attempted to address and contribute to the needs and problems of the community.[108]

3.8.2.2 The principle of justice

The principle of justice was adhered to by considering the statement "give everyone their due".[108] This refers to fair and just treatment of each research participant and the relevant institutions, namely the private practice and the University of Pretoria involved in the research study. The study population was identified because the participants were directly related to the study problem.[105]

3.8.2.3 The principle of benevolence

The researcher aspired to protect all participants and institutions participating in the research study from discomfort or harm.[108] The research study consisted of using retrospective data, thereby potentially nullifying the possibility of risk or harm to participants and the occupational therapy private practice.[97] Confidentiality was ensured, as all results were reported anonymously by providing each participant with an identification number as allocated by the researcher. Furthermore, no intervention measures were implemented.

3.8.2.4 The principle of respect for the individual

The researcher accepted that it was her duty to recognise the autonomy of each individual that partook in the research study. This included the occupational therapy private practice where the study was conducted. The researcher acknowledged that the occupational therapy private practice had the right to decide whether or not to participate in the research study. This included the right of the private practice to withdraw from the research study, to refuse to provide information and to ask for clarification if the purpose or methods of the research study were unclear.[105]

3.8.2.5 The principle of professionalism

The researcher aimed to protect the integrity, quality and accountability of the research study.[108] The researcher conducted the research study in a professional manner when communicating with the occupational therapy private practice in person, over the telephone or via email. The researcher also collected and captured data in a secure manner by ensuring that the participant files were protected, observed and stored in a professional manner.

3.8.2.6 Refraining from discrimination

The researcher did not discriminate on the grounds of race or gender, or financial or socio-economic status.[108]

3.8.2.7 Scientific honesty and other responsibilities

The researcher demonstrated respect for the scientific society by protecting the integrity of the scientific information and knowledge obtained through the study, therefore no fabrication or falsifying of information occurred. Only a true reflection of what was conducted in the research study was reported. The researcher undertook not to manipulate data. Data was reported correctly and accurately as found in the participant files. The researcher undertook to present her own work and to refrain from plagiarism by accurately referencing information obtained from other sources.[105]

3.8.3 Other Ethical Considerations

The participant files were kept safe at the occupational therapy private practice, and were only removed from the storeroom by the researcher when the participant subtests were re-scored and when data was recorded onto the spreadsheet. The participant files were placed in a container for safekeeping once information had been recorded and the data collection process was complete.

The participant files will be stored safely by the occupational therapy private practice for a period of 15 years after finalisation of the study. A copy of the data collection spreadsheet will be kept at the occupational therapy department for 15 years after finalisation of the study.

No photocopies of participant files were made and the information obtained during this research study was used for research purposes only. The pilot study and main research study were administered once approval from the University of Pretoria Ethics Committee had been received. The informed consent documents for the proposed study can be found in Annexure I.

3.9 CONCLUSION

This chapter discussed the study design implemented to achieve the identified aims and objectives of the research study. The study setting, study population as well as the sampling method were presented. The researcher explored relevant information in the pilot study and implemented the proposed changes after the pilot study had been conducted by making amendments to the final research study.

The data collection phases and data analysis methods were provided. Lastly, the ethical considerations during the planning and execution of the study were provided. The next chapter will present the research results with interpretations as they relate to the identified research objectives.

Chapter 4

Results and Interpretations

4.1 INTRODUCTION

The aim of this research chapter is to summarise the data pertaining to the research study and present it to the reader. The data was analysed according to the aims and objectives of the research study, therefore this chapter will convey the results according to the objectives stated in Chapter 1 and Chapter 3 (refer to Section 1.3.4 or Section 3.3).

Descriptive statistics as well as correlation and regression statistics were used to analyse and describe the data. Firstly, the statistics pertaining to the study sample are discussed. Thereafter the results of the effect of the independent variables on each individual subtest, namely grade, handedness and gender are provided. The researcher aimed to establish the relationship between visual-motor integration (VMI), eye-hand coordination (EHC) and copying (COP) for the total sample as well as the sample divided into Grade R and Grade 1 participants. In addition, the effect of handedness and gender was established for the relationships between VMI, COP and EHC. Lastly, the percentage of variation in VMI that can be explained by the EHC, the COP, handedness and gender is described, and the researcher concludes the results and interpretations of this chapter.

Note that abbreviations will be used for terms such as the visual-motor integration subtest of the Beery VMI-4 (VMI), the copying subtest of the DTVP-2 (COP) and the eye-hand coordination subtest of the DTVP-2 (EHC). The relationship between these subtests will be abbreviated as follows (VMI: EHC); (VMI: COP); (COP: EHC). (Refer to the abbreviations table.)

4.2 STATISTICS PERTAINING TO THE STUDY SAMPLE

A total sample of 106 participants was enrolled in the study. This sample comprised participants between the ages of 6 years 0 months and 6 years 11 months with developmental or school-related difficulties and who were evaluated at the occupational therapy private practice during 2009 and 2012. The mean age for the total sample was 6 years 4 months, of which the mean age for boys were 6 years 3 months and the mean age for girls 6 years 4 months.

The participants were either in Grade R or Grade 1, depending on their age and date of birth. The participants were also classified as either left- or right-handed, and as boys or girls. Each participant therefore formed part of three groups namely grade, handedness and gender. Within these groups the participants were divided into their relevant subgroup, i.e for grade the participants were either placed in the Grade R or Grade 1 subgroup, right- or left-handed subgroup, and boy or girl subgroup. Therefore, each group consisted of 106 participants divided into one of two of each subgroup. The subgroup composition is presented in Table 4-1.

Group	Subgroup	Number (out of 106 participants)	Percentage of overall sample
Grade:	Grade R	62	58.49 %
	Grade 1	44	41.51 %
Handedness:	Right-handed	87	82.08 %
	Left-handed	19	17.92 %
Gender:	Boys	77	72.64 %
	Girls	29	27.36 %

Table 4-1: Composition of sample according to the subgroups

As seen in Table 4-1, Grade R participants comprised 58.49% (n=62) and Grade 1 participants comprised 41.51% (n=44) of the total sample. The subgroup for handedness included 82.08% (n=87) right-handed participants and 17.92% (n=19) left-handed participants. It was concluded that the 18% left-handed participants were still proportionately representational to the general population (see Section 2.6).[84,85] The subgroup for gender consisted of 72.64% (n=77) boy participants, whereas girls were 27.36% (n= 29) of the total sample. The 27% girl participants were also viewed as sufficiently and proportionately representational by the researcher and statistician, as the ratio of poor handwriting between boys and girls is five to one.[82]

4.2.1 Statistics pertaining to Grade R attendance

During the data collection process the researcher recorded data pertaining to each participant's preschool years, i.e whether participants had attended a nursery school prior to Grade 1, in order to establish the percentage of participants that had received preparation with regard to the formal schooling environment. Table 4-2 provides the statistics pertaining to the participants' Grade R attendance.

Subgroup	Schooling environment	Number (n)	Percentage within subgroups	Percentage within the total sample
Grade R	Playgroup/Daycare	2	3.23%	1.89%
	Nursery school	60	96.77%	56.6%
Grade 1	Playgroup/ Daycare	5	11.36%	4.72%
	Nursery school	39	88.64%	36.79%
	Total	106	100%	100%

Table 4-2: Sample according to the schooling environment

It can be observed that, as compared to the Grade 1 subgroup, 16.98% more Grade R learners were referred for developmental difficulties during the period of 2009 to 2012. In addition, 3.23% (n=2) of the Grade R participants were not attending formal Grade R schooling, but only attended daycare during their preschool year. It was also noted that 96.77% (n=60) of the Grade R participants were enrolled in preschools with a formal Grade R curriculum. Out of the 44 Grade 1 participants 11.36% (n=5) had not attended formal Grade R schooling, but had been enrolled in a playgroup/daycare during their preschool years. A total of 88.64% (n=39) of the Grade 1 subgroup had attended Grade R as preparation before enrolling in Grade 1. Note that one Grade R participant participating in the research study was repeating Grade R.

4.2.2 Distribution of gender and handedness across grades

The distribution of handedness and gender across Grade R and Grade 1 participants is presented in Figure 4-I below. Note that 9.43% (n=10) of the total of 17.92% (n=19) left-handed participants were boys from the Grade R sample. It is also observed that Grade R boys were referred for occupational therapy evaluations more than Grade R girl participants, encompassing 45.28% of the total sample.

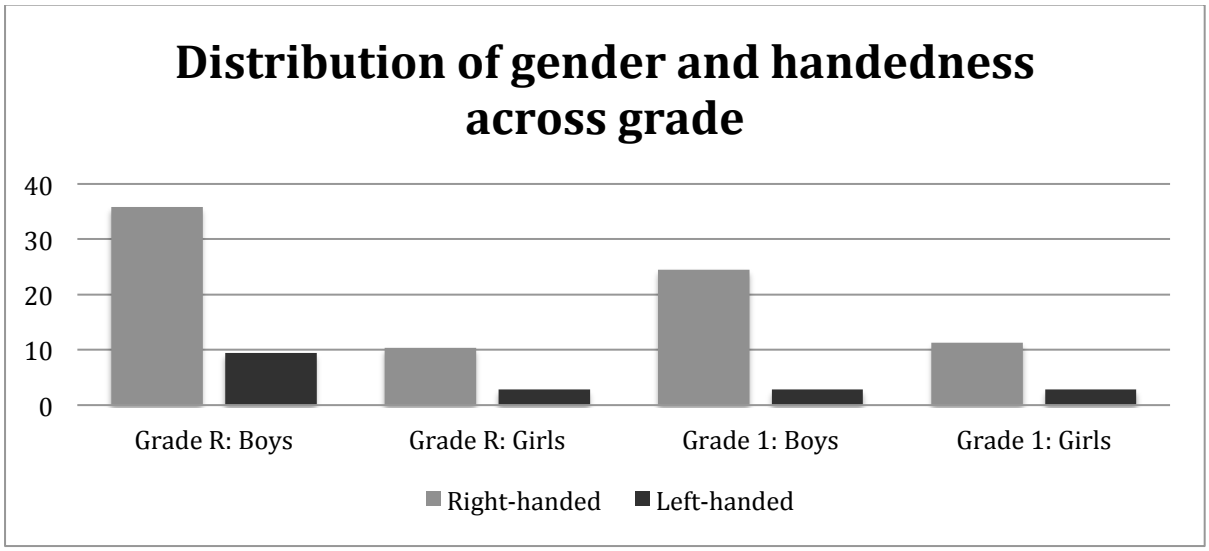

Figure 4-I: Distribution of handedness and gender across grade

In Figure 4-I it can be seen that the distribution of gender and handedness across Grade R and Grade 1 participants varied. The Grade R right-handed boy participants formed most of the sample, i.e. 35.85% (n=38) of the total sample. The second largest percentage consisted of right-handed Grade 1 boy participants at 24.53% (n=26). Grade 1 right-handed girl participants formed the third largest subgroup with a total of 11.32% (n=12). For the left-handed boy and girl categories all subgroups were equal in percentage, consisting of 2.83% (n=3), except for left-handed Grade R boy participants consisting of 9.43% (n=10) of the total sample.

4.3 RESULTS AND FINDINGS

The results and findings are presented below.

4.3.1 Results of the effect of grade, handedness and gender with regard to each subtest

4.3.1.1 Grade, handedness and gender with regard to the VMI

The researcher and statistician used two-sample t-tests with equal variances in order to establish whether grade, handedness or gender had an effect on the scoring of VMI prior to establishing the relationship between the VMI and the COP or EHC. The results are presented in Table 4-3.

Group	Subgroup	Number (n)	Mean	Standard deviation	95% confidence interval		p- value
Grade:	Grade R	62	-0.434	0.974	-0.682	-0.187	0.015
	Grade 1	44	0.005	0.787	-0.235	0.244	
	Difference	106	-0.439		-0.791	-0.087	
Handedness:	Right-handed	87	-0.205	0.944	-0.407	-0.004	0.266
	Left-handed	19	-0.467	0.808	-0.856	-0.077	
	Difference	106	0.252		-0.202	0.724	
Gender:	Boys	77	-0.259	0.974	-0.480	-0.038	0.904
	Girls	29	-0.235	0.786	-0.533	0.064	
	Difference	106	-0.024		-0.425	0.376	

Table 4-3: Effect of grade, handedness and gender on the VMI

4.3.1.1.1 Grade

As seen in Table 4-3, Grade R participants obtained a mean z-score of -0.434 whereas Grade 1 participants scored a mean z-score of 0.005 with a mean difference of -0.439. It can therefore be concluded that, with regard to the VMI, Grade 1 participants scored significantly higher than Grade R participants. Furthermore, a statistically significant p=0.015 difference between Grade R and Grade 1 participants was obtained on the VMI.

4.3.1.1.2 Handedness

As seen in Table 4-3, a slight mean z-score difference of 0.252 between right- and left-handed participants can be observed for the VMI. It can also be observed that right-handed participants scored slightly higher on the VMI as compared to left-handed participants. This does not reflect a statistically significant difference, and therefore with regard to the VMI no significant difference could be observed between right- and left-handed participants (p=0.266).

4.3.1.1.3 Gender

Table 4-3 reports that boys scored a mean z-score of -0.259 whereas girls scored a mean z-score of -0.235; therefore boys and girls scored relatively similar for the VMI reflecting a mean difference of -0.024. It can therefore be established that gender did not have a statistically significant effect on the scoring of the VMI (p=0.904).

4.3.1.2 Grade, handedness and gender with regards to the EHC

The results obtained for EHC in each group were analysed using two-sample t-tests with equal variances similar to those in Section 4.3.1.1. The results are displayed in Table 4-4.

Group	Subgroup	Number (n)	Mean	Standard deviation	95% confidence interval		p- value
Grade:	Grade R	62	-0.280	0.732	-0.466	-0.094	0.1002
	Grade 1	44	-0.046	0.692	-0.256	0.165	
	Difference	106	-0.234		-0.514	0.046	
Handedness:	Right-handed	87	-0.234	0.721	-0.387	-0.080	0.118
	Left-handed	19	0.053	0.696	-0.283	0.388	
	Difference	106	-0.286		-0.646	0.073	
Gender:	Boys	77	-0.229	0.697	-0.388	-0.071	0.276
	Girls	29	-0.058	0.782	-0.355	0.240	
	Difference	106	-0.172		-0.483	0.140	

Table 4-4: Effect of grade, handedness and gender on the EHC

4.3.1.2.1 Grade

As seen in Table 4-4, a slight mean difference of -0.234 can be observed in the z-scores of Grade R and Grade 1 participants for the EHC. Grade R participants scored a mean z-score of -0.280, whereas Grade 1 participants scored a mean z-score of -0.046. This demonstrates that Grade R and Grade 1 participants obtained relatively similar results during the EHC. Based on this observation, it can be concluded that no significant difference exists between Grade R and Grade 1 participants (p=0.1002).

4.3.1.2.2 Handedness

Table 4-4 shows a slight mean difference of -0.286 in the z-scores of right- and left-handed participants for the EHC. Right-handed participants scored a mean of -0.234 whereas left-handed participants scored a mean of 0.053. This demonstrates that right- and left-handed participants obtained relatively similar results during EHC. It can therefore be concluded that no significant difference exists between the scores for right- and left-handed participants during the EHC (p=0.118).

4.3.1.2.3 Gender

In Table 4-4, a slight mean difference of -0.172 can be observed in the z-scores of boy and girl participants for the EHC. Boy participants scored a mean z-score of -0.229, whereas girl participants scored a mean z-score of -0.058. This demonstrates that boy and girl participants obtained relatively similar results during the EHC. It can therefore be established that, during the completion of the EHC, boys and girls reflected little difference in their scores for the test (p=0.276)

4.3.1.3 Grade, handedness and gender with regards to the COP

Similar to Section 4.3.1.1, the results pertaining to grade, handedness and gender with regards to the COP were analysed with two-sample t-tests of equal variances, and are displayed in Table 4-5.

Group	Subgroup	Number	Mean	Standard deviation	95% confidence interval		p-value
Grade:	Grade R	62	-0.091	0.759	-0.284	0.101	0.0002
	Grade 1	44	0.508	0.805	0.263	0.752	
	Difference	106	-0.599		-0.903	-0.295	
Handedness:	Right-handed	87	0.226	0.881	0.038	0.414	0.067
	Left-handed	19	-0.158	0.421	-0.360	0.045	
	Difference	106	0.384		-0.028	0.796	
Gender:	Boys	77	0.095	0.807	-0.088	0.278	0.212
	Girls	29	0.321	0.880	-0.013	0.656	
	Difference	106	-0.023		-0.584	0.131	

Table 4-5: Effect of grade, handedness and gender on the COP

4.3.1.3.1 Grade

As seen in Table 4-5, a mean difference of -0.599 can be observed in the z-scores of the COP between Grade R and Grade 1 participants. Grade R participants scored a mean z-score of -0.091 whereas Grade 1 participants scored a mean z-score of 0.508. With regard to the COP, Grade 1 participants scored significantly higher than Grade R participants.

The p-value of 0.002 reflects that a statistically significant difference exists between Grade R and Grade 1 with regards to the COP. Therefore it can be concluded that grade has a significant effect on the COP.

4.3.1.3.2 Handedness

Table 4-5 displays a mean difference of 0.384 in the z-scores of right- and left-handed participants for the COP. Right-handed participants scored a mean z-score of 0.226 whereas left-handed participants scored a mean z-score of -0.158. This demonstrates that left-handed participants scored slightly lower on the COP as compared to right-handed participants. This, however, does not indicate a statistically significant difference (p= 0.067). It can therefore be concluded that, in respect of the COP, no significant difference exists between right- and left-handed participants.

4.3.1.3.3 Gender

Table 4-5 indicates a mean difference of -0.023 in the z-scores of boy and girl participants for the COP. Boy participants scored a mean z-score of 0.095 whereas girl participants scored a mean z-score of 0.321. This demonstrates that girl participants obtained slightly better scores as compared to boy participants during the completion of the COP. This, however, does not reflect a statistically significant difference (p=0.212), and it can be concluded that no significant difference exists between the z-scores of the COP for boy and girl participants.

4.3.2 Results pertaining to Objective 1: The visual-motor integration and eye-hand coordination subtests

The researcher and statistician established the levels of agreement between the subtests in order to investigate the interchangeability of the subtests. This was done to determine whether therapists are over-testing by using both subtests during occupational therapy evaluations. After having established the levels of agreement, the relationship between the subtests was established for the total sample as well as the sample when divided into the Grade R and Grade 1 subgroups. Lastly, the effect of handedness and gender on the established relationship was investigated and reported.

4.3.2.1 The level of agreement between the visual-motor integration and the eye-hand coordination subtests

The researcher intended to establish the level of agreement between the z-scores obtained by the participants for the VMI and EHC by assessing the intraclass correlation coefficient (ICC). A random effects maximum likelihood regression model was implemented using the z-scores of the total sample as obtained from the VMI and EHC subtests, to determine an ICC value of 0.371, reflecting poor agreement in view of the norm for excellent agreement being 0.9. Note that when adjusted for hand, gender and grade, the ICC=0.360.

4.3.2.2 Relationship between the visual-motor integration and the eye-hand coordination subtests for the total sample and subgroups of Grade R and Grade 1

The relationship between the VMI and the EHC of each participant is represented on the scatterplot in Figure 4-II (Pearson r=0.385; p<0.001).

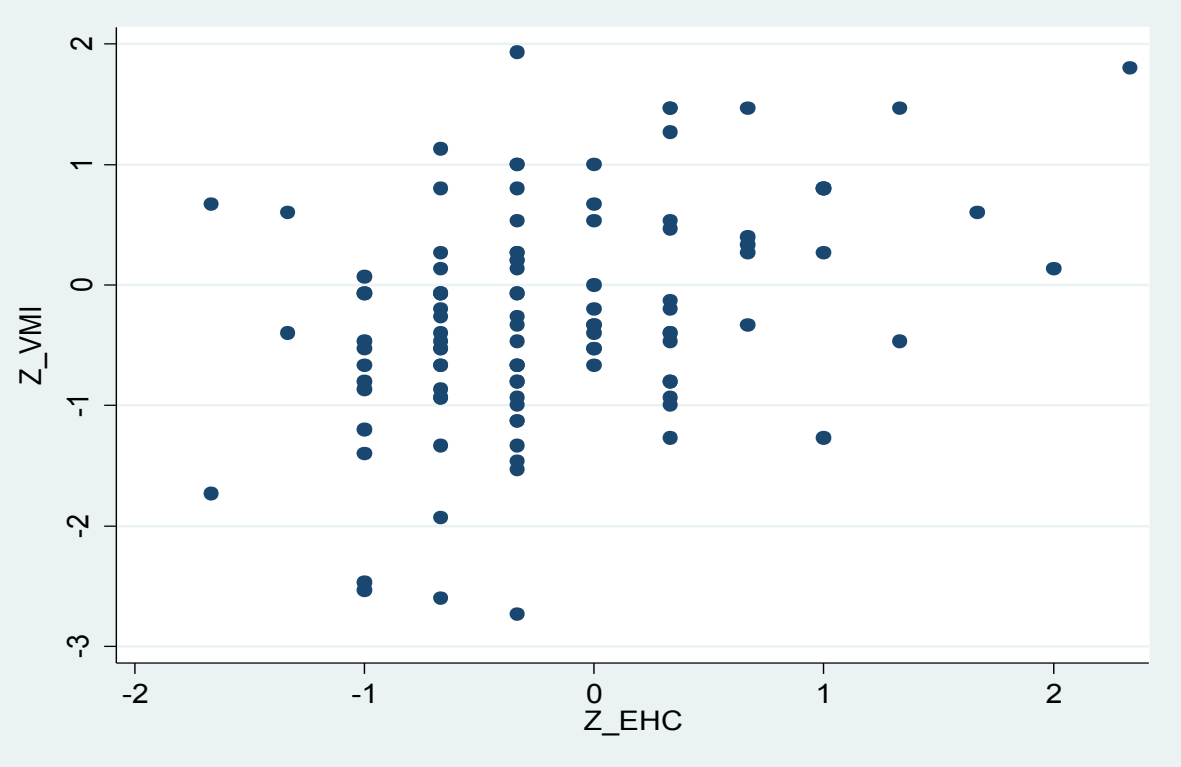

Figure 4-II: Scatterplot demonstrating the relationship between the VMI and the EHC

The sample was divided into two subgroups, namely Grade R and Grade 1, to investigate whether a difference could be observed in the relationship of VMI: EHC in Grade R and Grade 1 participants, as illustrated in Table 4-6.

Group: Grade	Number (n)	Pearson r	p-value
Grade R	62	r= 0.410	p= 0.001*
Grade 1	44	r= 0.274	p= 0.072
Total population	106	r= 0.385	p< 0.001*
* indicating a statistically significant relationship			

Table 4-6: Relationship between the VMI: EHC across Grade R and Grade 1

The Pearson correlation coefficient (r=0.385; p<0.001) demonstrates that a highly significant relationship between the VMI: EHC exists for the total sample.

In addition, when the sample is divided into the two grade subgroups, the Grade R participants demonstrated a highly significant relationship between the VMI: EHC (r=0.410; p=0.001). The Grade 1 participants demonstrated a weak relationship between the VMI: EHC (r=0.274; p=0.072).

It can therefore be concluded that, although a weak ICC was established between the VMI and the EHC, a relationship for the total sample still exists between the VMI: EHC. On closer examination, it is evident that the Grade R participants contributed significantly to the observed relationship between the VMI: EHC.

4.3.2.3 Effect of handedness and gender on the relationship between the visual-motor integration and eye-hand coordination subtests

VMI:EHC	Coefficient	Standard error	z- score	p- value	95% confidence interval	
Handedness	0.051	0.172	0.29	0.769	-0.287	0.388
Gender	0.049	0.149	0.33	0.741	-0.242	0.340
Constant	-0.379	0.098	-3.86	0.000	-0.571	-0.186

Table 4-7: Effect of handedness and gender on the VMI: EHC

Table 4-7 demonstrates the effect of the independent variables on the established relationship between the VMI: EHC. The table above reflects a p-value of 0.769 for handedness and a p-value of 0.741 for gender. Handedness and gender are weakly related to the relationship between the VMI and the EHC.

4.3.2.4 Summary

Upon examining the ICC between the VMI and the EHC, poor agreement was established. The relationship between the VMI: EHC (Pearson r=0.385; p<0,001) indicates that a significant relationship exists between the VMI: EHC for the total sample. This relationship was significant for the Grade R sample (r=0.410; p=0.001), but weak for the Grade 1 sample (r=0.274; p=0.072). It can therefore be concluded that a relationship between the VMI: EHC exists in respect of Grade R participants, but this established relationship decreases when participants are exposed to formal schooling i.e. Grade 1. Furthermore, when examining the effect of handedness and gender on the VMI: EHC, it was established that handedness and gender demonstrated a poor effect on the relationship between the VMI: EHC.

4.3.3 Results pertaining to Objective 2: The visual-motor integration and copying subtests

The statistical analysis procedures implemented for Objective 2 were similar to the procedures explained in Section 4.3.2.

4.3.3.1 The level of agreement between the visual-motor integration and the copying subtests

The researcher aimed to establish the level of agreement between the z-scores obtained by the participants for the VMI and the COP by assessing the intraclass correlation coefficient (ICC). A random effects maximum likelihood regression model was implemented using the z-scores obtained from the VMI and COP subtests of the total sample, to determine an ICC value of 0.617, reflecting reasonable agreement in view of the norm for excellent agreement being 0.9.

The ICC of 0.617 demonstrates that the VMI and the COP show reasonable agreement. The ICC of 0.617 is, however, not adequate in view of an ICC=0.9 which by convention depicts excellent agreement. Note that when adjusted for hand, gender and grade, the ICC=0.590.

4.3.3.2 Relationship between the visual-motor integration and the copying subtests for the total sample and subgroups of Grade R and Grade 1

The relationship between each participant's VMI and COP scores is represented on the scatterplot in Figure 4-III (Pearson r=0.71; p<0.001).

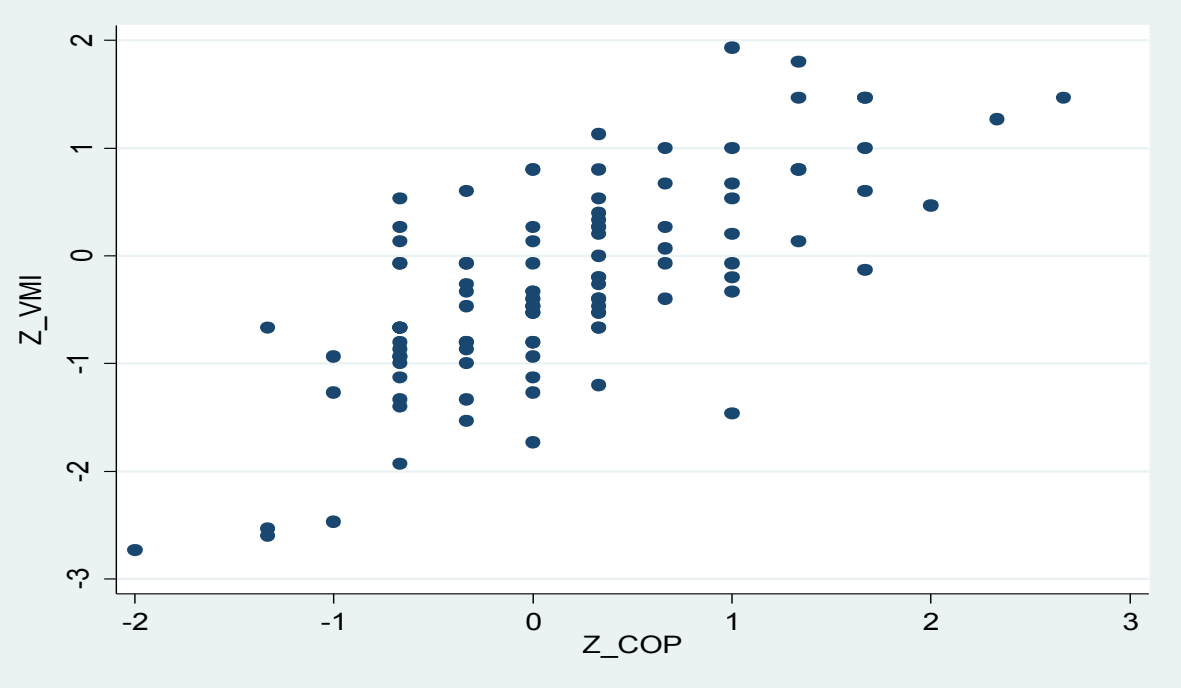

Figure 4-III: Scatterplot demonstrating the relationship between the VMI and the COP

The sample of 106 participants was divided into two subgroups, namely Grade R and Grade 1, to investigate whether a difference could be observed in the relationship between the VMI and the COP in Grade R and Grade 1 participants, as illustrated in Table 4-8.

Group: Grade	Number (N)	Pearson r	p-value
Grade R	62	r= 0.719	p< 0.001*
Grade 1	44	r= 0.656	p< 0.001*
Total sample	106	r= 0.71	p< 0.001*
* indicating a statistically significant relationship			

Table 4-8: Relationship between the VMI: COP across Grade R and Grade 1

The Pearson correlation coefficient (r=0.71; p<0.001) indicates a significant relationship between the VMI and the COP for the total sample. When dividing the sample into Grade R and Grade 1 participants, both groups reflected a significant relationship between the VMI and the COP (p<0.001). It can therefore be concluded that a significant relationship exists between the standardised measurement tools of the VMI and the COP for the total sample, as well as in Grade R and Grade 1 participants, respectively.

4.3.3.3 Effect of handedness and gender on the relationship between the visual-motor integration and copying subtests

VMI: COP	Coefficient	Standard error	z-score	p-value	95% confidence interval	
Handedness	-0.267	0.197	-1.35	0.176	-0.652	0.119
Gender	0.066	0.170	0.39	0.696	-0.267	0.340
Constant	-0.222	0.112	-1.98	0.048	-0.442	-0.002

Table 4-9: Effect of handedness and gender on the VMI: COP

From the results in Table 4-9, it is evident that handedness (p=0.176) and gender (p=0.696) had a weak effect on the relationship between the VMI: COP.

4.3.3.4 Summary

The results and findings indicate reasonable agreement for the ICC between the VMI and the COP. It was evident that the relationship was significant for Grade R and Grade 1 participants ($p<0.001$). It can therefore be concluded that the relationship between VMI: COP remains significant from Grade R to Grade 1. Furthermore, it was established that handedness and gender demonstrate a weak relationship to the VMI: COP.

4.3.4 Results pertaining to Objective 3: The copying and eye-hand coordination subtests

The statistical analysis procedures implemented for Objective 3 were similar to the procedures explained in Section 4.3.2.

4.3.4.1 The level of agreement between the copying and eye-hand coordination subtests

Similar to the establishing of levels of agreement in Section 4.3.2 and Section 4.3.3, the researcher intended in this section to establish the level of agreement between the components of the COP and EHC by assessing the intraclass correlation coefficient (ICC). A random effects maximum likelihood regression model was implemented using the z-scores of the total sample obtained from the COP and EHC standardised measurement tools, to determine an ICC value of 0.340. The ICC of 0.340 demonstrates poor agreement between the COP and the EHC and is not adequate in view of an ICC=0.9, which by convention depicts excellent agreement. Note that when adjusted for hand, gender and grade, the ICC=0.306.

4.3.4.2 Relationship between the copying and the eye-hand coordination subtests for the total sample and subgroups of Grade R and Grade 1

The relationship between the COP and the EHC of each participant is represented on the scatterplot in Figure 4-IV (Pearson r=0.409; p<0.001).

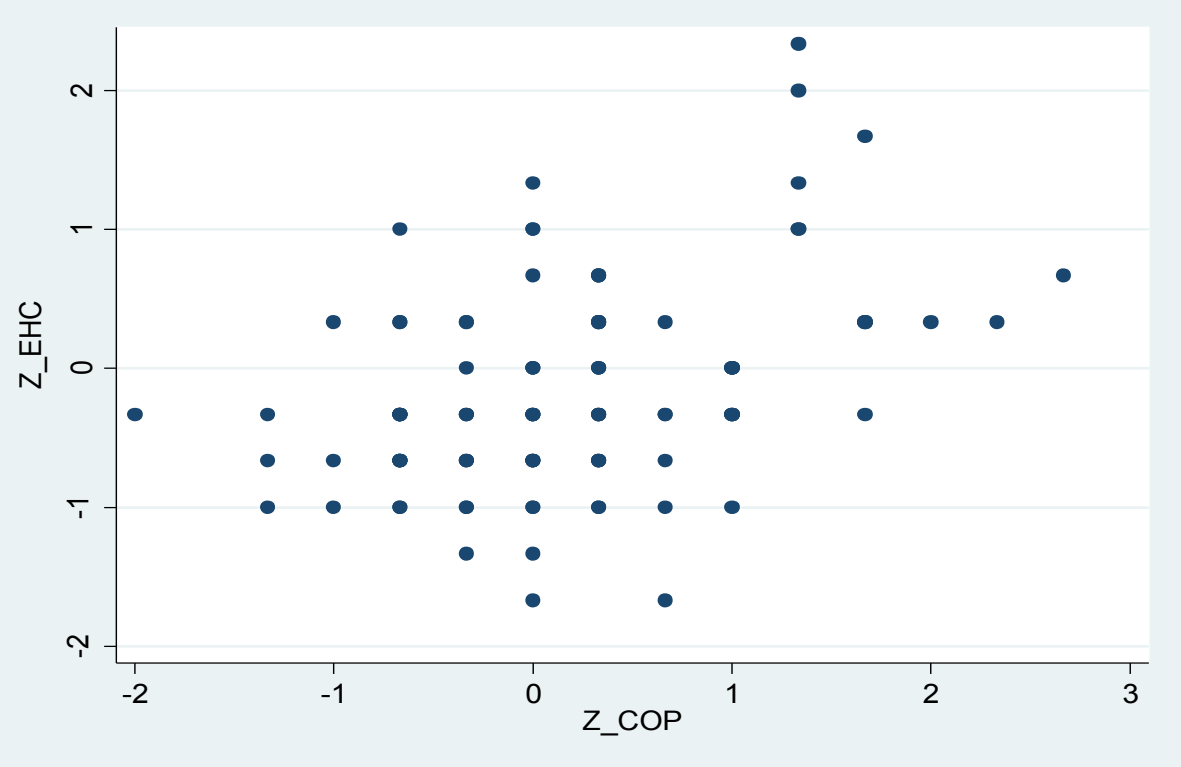

Figure 4-IV: Scatterplot demonstrating the relationship between the EHC and the COP

The sample was divided into two subgroups, namely Grade R and Grade 1, to investigate whether a difference could be observed in the relationship between the COP and the EHC in Grade R and Grade 1 participants, as illustrated in Table 4-10.

Group: Grade	Number (n)	Pearson r	p-value
Grade R	62	r= 0.373	p= 0.003*
Grade 1	44	r= 0.395	p= 0.008*
Total sample	106	r= 0.409	p< 0.001*
* indicating a statistically significant relationship			

Table 4-10: Relationship between the COP: EHC across Grade R and Grade 1

The Pearson correlation coefficient (r=0.409; p<0.001) indicates that a relationship exists between the COP and the EHC of the total sample.

When examining the relationship between the COP and the EHC for the two subgroups of Grade R and Grade 1, the Grade R participants demonstrated a slightly more significant relationship between the subgroups (r=0.373; p=0.003) as compared to Grade 1 participants (r=0.395; p=0.008).

4.3.4.3 Effect of independent variables on the relationship between the copying and eye-hand coordination subtests

COP: EHC	Coefficient	Standard error	z-score	p-value	95% confidence interval	
Handedness	-0.008	0.159	-0.05	0.961	-0.319	0.303
Gender	0.143	0.137	1.04	0.296	-0.126	0.412
Constant	-0.216	0.091	-2.38	0.017	-0.394	-0.038

Table 4-11: Effect of handedness and gender on the COP: EHC

The effect of the independent variables on the relationship between the COP: EHC is weak. Upon closer examination it is evident that handedness (p=0.961) and gender (p=0.296) had a weak influence on the established relationship between the COP: EHC.

4.3.4.4 Summary

The ICC between the COP and the EHC indicated a poor level of agreement. However, a statistically significant relationship was established (Pearson r=0.409; p<0.001) for the total sample. This relationship between the COP: EHC remained significant for the Grade R (r=0.373; p=0.003) and Grade 1 sample (r=0.395; p=0.008), respectively. In addition, handedness and gender did not indicate a significant effect on the relationship between the COP: EHC.

4.3.5 The effect of eye-hand coordination, copying, handedness and gender on visual-motor integration

A multivariable regression analysis was conducted to establish the percentage of variation in the VMI that can be explained by the variation in the EHC, the COP, handedness and gender, respectively. The researcher and statistician aimed to establish whether the COP, the EHC, handedness or gender could account for the scores obtained on the VMI. This was done through multivariable regression analyses, i.e modelling VMI **α** f (COP, EHC, Handedness, Gender).

4.3.5.1 Results for the total sample

VMI	Coefficient	Standard error	p- value	95% confidence interval		Coefficient of determination
EHC	0.154	0.0998	0.127	-0.044	0.352	0.521 (52.1%)
COP	0.745	0.088	<0.001*	0.572	0.919	
Handedness	-0.10	0.173	0.953	-0.354	0.334	
Gender	-0.171	0.143	0.237	-0.455	0.114	
Constant	-0.293	0.087	0.001	-0.466	-0.120	
* indicating a statistically significant relationship						

Table 4-12: Variation of the VMI that can be explained by the variation in the EHC, the COP, handedness and gender for the total sample

The overall fit was significant ($p<0.001$) with a coefficient of determination equal to 0.521 as illustrated in Table 4-12. This demonstrates that 52.1% of the variation in VMI can be attributed to combined variables of the EHC, the COP, handedness and gender. This is a reasonable relationship. Furthermore, the COP contributed significantly to this relationship ($p<0.001$). It can therefore be concluded that the COP contributed predominantly to the percentage of variance in the VMI, whereas the other factors, namely the EHC, handedness and gender, had little to no influence on the VMI.

4.3.5.2 Results for the sample divided into Grade R and Grade 1

The total sample was then divided into two subgroups, namely Grade R and Grade 1, to establish whether the percentage of variation fluctuated between Grade R and Grade 1 participants. A multivariable regression analysis was conducted to examine the percentage of variation in the EHC, the COP, handedness and gender on the VMI for the two groups, as illustrated in Table 4-13.

VMI		Coefficient	Standard error	p- value	95% confidence interval		Coefficient of determination
Grade R	EHC	0.214	0.133	0.112	-0.051	0.479	0.542 (54.2%)
	COP	0.856	0.127	<0.001*	0.602	1.110	
	Handedness	0.088	0.218	0.688	-0.348	0.524	
	Gender	-0.046	0.215	0.833	-0.476	0.385	
	Constant	-0.305	0.120	0.014	-0.544	-0.065	
Grade 1	EHC	0.040	0.151	0.792	-0.266	0.346	0.5 (50%)
	COP	0.586	0.130	<0.001*	0.323	0.850	
	Handedness	-0.211	0.288	0.468	-0.793	0.372	
	Gender	-0.391	0.189	0.045*	-0.773	-0.008	
	Constant	-0.129	0.139	0.360	-0.411	0.153	
* indicating a statistically significant relationship or excellent agreement							

Table 4-13: Variation in the VMI that can be explained by the variation in the EHC, the COP, handedness and gender across Grade R and Grade 1

The Grade R participants demonstrated a reasonable variation with a coefficient of determination=0.542, which indicates that 54.2% of the variation in the VMI can be explained by the variation in the EHC, the COP, handedness and gender. The COP contributed significantly to the variation ($p<0.001$), which demonstrates that the VMI and the COP are significantly associated. The EHC ($p=0.112$), handedness ($p=0.688$) and gender ($p=0.833$) reflected a weak relationship. It can be concluded that the COP contributed significantly to the 0.542 coefficient of determination for Grade R participants.

Furthermore, the Grade 1 participants also demonstrated reasonable variation with a coefficient of determination equal to 0.5. The COP displayed a significant contribution to the variation ($p<0.001$), which demonstrates that the VMI and the COP are significantly associated for Grade 1 participants. Gender ($p=0.045$) also demonstrated a significant relationship to the VMI for Grade 1 participants. The EHC ($p=0.792$) and handedness ($p=0.468$) did not reflect a significant percentage of variation and therefore are not significantly associated to the VMI. This indicates that, for the Grade 1 participants, the COP and gender contributed significantly to the percentage of variation in the VMI.

4.3.5.3 Summary

The researcher aimed to establish the percentage of variation in VMI that could be explained by the variation in the EHC, the COP, handedness and gender. The overall fit was significant ($p<0.001$), and a coefficient of determination of 0.521 was established. Therefore a reasonable relationship was established. The COP contributed significantly to this relationship ($p<0.001$). When dividing the total sample into Grade R and Grade 1 subgroups, it was established that Grade R demonstrated a reasonable relationship with 54.2% of the variation in the VMI that could be explained by the variation in the EHC, the COP, handedness and gender. Upon closer examination, the variation could mainly be attributed to the COP with $p<0.001$. Similar results were obtained for the Grade 1 sample, where 50% of the variance in the VMI can be explained mainly by the variation in the COP ($p<0.001$) and gender ($p=0.045$).

4.4 CONCLUSION

To conclude this chapter, the statistics pertaining to the study sample were presented. Statistics pertaining to the Grade R attendance of the study sample, as well as the distribution of gender and handedness across grade were provided. The results of the study were presented according to the research objectives. Some significant correlation coefficients were calculated, relating directly to the research objectives of the study.

In Chapter 5 these results and interpretations will be explored in greater detail and possible explanations will be provided for the findings presented in this chapter.

Chapter 5

DISCUSSION, RECOMMENDATIONS AND CONCLUSIONS

5.1 INTRODUCTION

The previous chapter presented the findings of the study according to the research objectives and sub-objectives. This chapter will focus on discussing the results obtained and providing possible explanations for the results of this research study. This will enable the researcher to hypothesise some results and draw conclusions from the results and findings of the research study. The limitations of this study will be discussed and the possibilities and recommendations for future research studies will be provided. Finally, the researcher will reflect on whether the study proved effective in meeting the research aims.

5.2 DISCUSSION OF THE STUDY SAMPLE

As stated in Section 4.2, the sample consisted of 106 participants, each referred for an occupational therapy evaluation during the period of 2009 to 2012. The total sample was grouped according to grade, handedness and gender.

5.2.1 Composition of the sample according to grade

As seen in Table 4-1 (p81), 58.49% (n=62) of the total sample were in Grade R and 41.51% (n=44) were in Grade 1. From the observed percentages, it is evident that more Grade R children were referred for occupational therapy evaluations during the time period and were included in the research, as compared to Grade 1 participants. Previous research commented on the high referral of Grade 1 learners for occupational therapy[40] due to many children not having access to a preschool programme to prepare them for Grade 1. However, as reported in Table 4-2 (p82), all the participants in the research study attended some form of schooling in Grade R, whether it was daycare (6.6%) or a nursery school (93.4%). It can therefore be established that the participants in the sample would have been identified if they had presented with a developmental difficulty in Grade R. This may explain the higher percentage of referrals in Grade R as compared to Grade 1 participants.

5.2.1.1 Results pertaining to grade and the perceptual-motor subtests

With regard to the subgroups' scoring on the individual subtests, it was interesting to note that the Grade 1 subgroup scored higher than the Grade R subgroup for both the VMI and the COP, as demonstrated in Table 4-3 (p85) and Table 4-5 (p89). These results verify previous findings by several researchers regarding visual-motor integration. Authors have acknowledged that visual-motor integration may still be a developing skill during Grade R, whereas it may be an established skill in Grade 1 due to the increase in time spent writing.[2,22,66] The results indicate that Grade R participants found the VMI and the COP more challenging, and therefore may not yet have established the skills of visual-motor integration and copying. It is however important to note that the mean z-scores for the Grade R and Grade 1 participants were still within the normal range.

Relatively similar scores were obtained for the EHC for both the Grade R and Grade 1 subgroups, as seen in Table 4-4 (p87). In the researcher's opinion, these findings may indicate that both subgroups found the EHC subtest to be equally challenging, regardless of handwriting proficiency.

5.2.2 Composition of the sample according to handedness

The left-handed participants encompassed 17.92% of the total sample. Literature[84-87] reveals that 10% of the general population is left-handed. Therefore, from the composition of the sample and when considering the percentage of left-handed children from the general population, it can be established that more left-handed children were referred for occupational therapy evaluations. One reason for this may be that left-handed participants present with more developmental and school-related difficulties, e.g. handwriting challenges, due to growing up in a right-hand dominant environment.[87]

5.2.2.1 Results pertaining to handedness and the perceptual-motor subtests

Right-handed participants obtained higher scores on the VMI and the COP when compared to left-handed participants, as demonstrated in Table 4-3 (p85) and Table 4-5 (p89). These results agree with findings by Gedutiene[91] noting that left-handed children are at risk for reading and writing difficulties.[91] However, it is interesting to note that left-handed and right-handed participants obtained relatively similar scores during the EHC. These results are similar to findings by Awamleh[90] stating that no differences were observed between handedness and eye-hand coordination.[90] It is important to note that although right-handed participants scored higher than left-handed participants on the VMI and COP, both subgroups' mean z-scores were still within the normal range.

From the results discussed in Section 5.2.1 and this current section regarding eye-hand coordination, it can be observed that eye-hand coordination is a consistently scored skill when considering handedness and grade. One reason for the consistent scoring of eye-hand coordination across grades can be that eye-hand coordination is a skill that is practised regularly during Grade R. The researcher hypothesises that the participants in Grade R were exposed to eye-hand coordination tasks similar to those in the eye-hand coordination subtest (drawing within the confines of paths) in preparation for Grade 1. This explains the consistent scoring of this skill among the Grade 1 participants, as they had had exposure to similar eye-hand coordination tasks prior to the evaluation date. Similar reasoning can be applied to the consistent scoring of eye-hand coordination between left- and right-handed participants. If participants had been exposed to similar eye-hand coordination tasks during Grade R, left-handed participants would have had equal opportunity to master the skill of eye-hand coordination as compared to right-handed participants.

5.2.3 Composition of the sample according to gender

For the total sample of 106 participants, 72.64% (n=77) participants were boys. This indicates that more boys were referred for occupational therapy evaluations as compared to girls during the time period between 2009 and 2012. This may indicate that boys struggle more with developmental and school-related skills. This is similar to the researcher's clinical experience where more boys attend occupational therapy evaluations and more boys participate in occupational therapy programmes as compared to girls. This was confirmed by previous studies stating that more boys present with handwriting difficulties as compared to girls.[2,82]

It was also noted that more left-handed Grade R boys (9.43%) were referred for occupational therapy evaluations during the study period as compared to left-handed Grade R girls (2.83%) and left-handed Grade 1 boys (2.83%) and girls (2.83%).

This may indicate that Grade R boys who are left-handed experience more difficulty with developmental and school-related skills. The researcher's opinion correlates with Cameron[66] in that the high referral of Grade R boys could be due to teachers noticing fine motor skill deficiencies due to the increase in time spent on fine motor tasks in preparation for formal schooling.[66]

5.2.3.1 Results pertaining to gender and the perceptual-motor subtests

The VMI, COP and EHC subtest scores yielded interesting results relating to gender. Relatively similar scores were obtained for all three of the perceptual-motor subtests for boys and girls, demonstrating no significant differences between boys and girls on any of the three perceptual-motor subtests. This supports findings by Coetzee and Du Plessis[31] indicating that no statistically significant differences were observed with regard to visual-motor integration and gender. Similar findings were also reported by Ercan, Ahmetoglu and Aral,[64] where the researchers found that boys and girls obtained relatively similar scores for the Beery VMI-5 visual-motor integration and motor coordination subtests (eye-hand coordination). These findings are, however, contradictory to findings reported by Singh et al,[81] Lotz, Loxton and Naidoo,[6] and Tseng and Murray,[82] where gender differences were observed for visual-motor integration and handwriting skills. The findings in the present research study suggest that gender does not have an impact on scores obtained for the subtests of visual-motor integration, eye-hand coordination and copying. Therapists should therefore be cautious when interpreting perceptual-motor test scores with regard to gender differences.

5.3 DISCUSSION OF THE RESULTS IN TERMS OF THE OBJECTIVES AS THEY RELATE TO THE PRIMARY AND SECONDARY AIMS

The primary aim of the study was *to establish whether a relationship exists between the standardised scores of visual-motor integration and eye-hand coordination, the standardised scores of visual-motor integration and copying, and the standardised scores of copying and eye-hand coordination when measured with the Beery VMI-4 and the DTVP-2 measurement instruments in 6-year-old children referred for occupational therapy.*

The secondary aim of the study was *to establish whether handedness and gender have an effect on the relationship between visual-motor integration, copying and eye-hand coordination when measured with the Beery VMI-4 and the DTVP-2 standardised measurement tools in 6-year-old children referred for occupational therapy.*

The sample was divided into Grade R and Grade 1 participants. The results relating to the objectives will therefore be discussed for the total sample, as well as for the subgroups of Grade R and Grade 1.

5.3.1 Discussion of Objective 1: The visual-motor integration and eye-hand coordination subtests

The results of the research relating to the first objective were reported and interpreted in Section 4.3.2. The sub-objectives in establishing such a relationship are restated and discussed below, i.e. the level of agreement between the VMI and the EHC; the relationship between the VMI: EHC for the total sample as well as the subgroups of Grade R and Grade 1; and the effect of handedness and gender on the established relationship between the VMI: EHC.

5.3.1.1 Level of agreement between the VMI and the EHC

As reported in Section 4.3.2.1, a poor level of agreement in terms of the VMI and EHC subtests was established. The term "agreement" refers to the inherent capibility of the two subtests to measure similar skills or abilities. This indicates that the VMI and EHC subtests contain little inherent similarity. A reason for the weak ICC between the VMI subtest and the EHC subtest may be that these tests differ greatly in their administration, the nature of the activities or tasks, and their scoring.

The VMI required the participants to copy geometrical shapes within a designated area, for which a score of 0 or 1 could be obtained. The EHC required participants to trace continuous lines within designated paths, for which scores of between 0 and 4 could be obtained (see Section 2.8.2). It can also be reasoned that the tasks in the EHC subtest are less challenging than the tasks of the VMI subtest due to the nature of the activities within the subtests. For example, the EHC subtest provides the child with visual cues in the form of boundaries to assist in directing the child's tracing. The VMI subtest does not provide such cues, therefore the child has to reproduce the provided shape by relying on many more perceptual-motor skills.[75]

Authors, however, have used eye-hand coordination as a term to describe visual-motor integration,[24] but when assessed in a standardised manner, the VMI and EHC subtests demonstrated poor similarity. These subtests are therefore not interchangeable and provide different results pertaining to the individual's skills and abilities. The poor agreement between these two subtests demonstrates that the VMI and the EHC measure different abilities. Similar findings were reported by Idoni, Taub and Harris[75] in their comparison of the VMI and EHC subtests. The researchers concluded by stating that, although the performance of the participants correlated on the two subtests, the tests cannot be used interchangebly. They stated that the two tests measure different aspects of visual perceptual and visual-motor integration abilities.

The researcher agrees with their statement that visual-motor integration and eye-hand coordination cannot be seen as similar abilities and that the term eye-hand coordination should therefore not be used to descibe the skill of visual-motor integration. Furthermore, the researcher agrees that the EHC subtest cannot be used as a substitute for the VMI subtest. This confirms the necessity for the use of both tests during occupational therapy evaluations, which contributes to the significance of this study. It can therefore be concluded that therapists are not over-testing by using both subtests during occupational therapy evaluations as these tests demonstrate poor agreement. Idoni, Taub and Harris[75] argued that a strong agreement between the two tests is not desirable. They stated that the notable differences between the VMI and EHC subtests currently allow therapists to evaluate many perceptual-motor abilities and therefore provides a broader view of the child's abilities and skills.

5.3.1.2 Relationship between VMI and EHC for the total sample

Although a weak level of agreement in terms of the VMI and EHC was established, in Section 4.3.2.2 the researcher reports that a significant relationship was established for the VMI: EHC. This demonstrates that although the VMI and the EHC contain little inherent similarity in their standardised testing, the subtests still demonstrate a statistically significant relationship with each other. Therefore, it is likely that if the participant had had good visual-motor integration, he/she would have had good eye-hand coordination as well.

Idoni, Taub and Harris[75] also established a statistically significant relationship between the VMI and EHC in participants aged between seven and eleven years. Furthermore, Coetzee and Du Plessis[31] established a meaningful relationship between visual-motor integration and motor coordination using the Beery VMI-4 subtests of visual-motor integration and motor coordination.[31] The motor coordination subtest of the Beery VMI-4 is similar to the eye-hand coordination subtest of the DTVP-2. Both subtests require the child to use visual tracking and control to draw within the confines of paths.

Kaiser, Albaret and Doudin[19] compared these two subtests and discussed the slight differences between the motor coordination subtest of the Beery VMI-4 and the eye-hand coordination subtest of the DTVP-2 i.e. although both require the child to trace within the confines of a path, the eye-hand coordination subtest paths are smaller, the complexity of the forms differ, and lastly the width of the tracing space varies between the two subtests.[19] Although there are slight differences, both tests still evaluate eye-hand coordination.

The statistically significant relationship between VMI: EHC place valuable emphasis on these two perceptual-motor skills as complimentary to each other. These findings are similar to statements by Weil and Cunningham-Amundson,[17] stating that visual-motor integration requires adequate eye-hand coordination to develop.[17] The skill of eye-hand coordination therefore forms the basis for adequate visual-motor integration. If the child has mastered the skill of eye-hand coordination, which is the ability to manually trace within a specific given area while adequately tracking with his/her eyes in order to stay within the boundaries of the area, he/she would be better equipped to reproduce the geometrical shapes within the visual-motor integration subtest. The researcher therefore concludes that visual-motor integration is a complex skill which would prove difficult to implement without adequate eye-hand coordination.

In light of the finding regarding the statistically significant relationship between the VMI: EHC and the discussion regarding the similarities between the eye-hand coordination subtest of the DTVP-2 and the motor coordination subtest of the Beery VMI-4, the researcher concludes that using the motor coordination subtest of the Beery VMI-4 instead of using the eye-hand coordination subtest of the DTVP-2 might be another option for therapists. Many therapists may prefer to use the motor coordination subtest of the Beery VMI-4 along with the visual-motor coordination subtest of the Beery VMI-4 during evaluations. Coetzee and Du Plessis's[31] research findings support this notion. It is the researcher's opinion that the importance lies with the combination of skills evaluated i.e. visual-motor integration and eye-hand coordination, rather than using the specific measurement tools used in this research study.

5.3.1.3 Relationship between visual-motor integration and eye-hand coordination in Grade R and Grade 1 participants

The sample was divided into two subgroups for Grade R and Grade 1 participants as indicated in Table 4-6 (p93). A significant relationship between the VMI: EHC was established for Grade R participants. Grade 1 participants reflected a weak relationship between the VMI: EHC. These findings demonstrate that the Grade R participants obtained relatively similar scores for both the VMI and the EHC; whereas the Grade 1 participants did not reflect similar scores. Cheung, Poon, Leung and Wong[8] reported that no significant difference was found for eye-hand coordination in Grade 1 and Grade 2 participants.[8] Furthermore, findings by Karlsdottir and Stefansson[109] indicated that the connection between the results of the Beery VMI-4 and handwriting proficiency decreased with age.[109]

In view of the findings demonstrated in Table 4-6 and reported in previous research, it could be stated that when considering the relationship between the VMI: EHC, a significant difference is observed between Grade R and Grade 1 participants. The researcher hypothesises that the decline in the strength of the relationship between the VMI: EHC may extrapolate in higher grades, similar to findings by Cheung, Poon, Leung and Wong.[8]

One reason for the decline in the relationship between the VMI: EHC for the Grade 1 sample could be that participants had improved handwriting. Literature has commented on the increase in time spent on paper and pencil tasks during formal schooling,[2,33] which inherently increases the participants' handwriting ability. The researcher hypothesises that handwriting is still a developing skill for Grade R participants, whereas Grade 1 participants have had more exposure to handwriting tasks. Research has connected handwriting proficiency to visual-motor integration,[2,71] and Coen-Cagli and Corragio[74] have reported a negative relationship between visual-motor integration and eye-hand coordination when the complexity of the written task increased.[74] Furthermore, studies have noted that visual-motor integration is a developing skill for Grade R children, whereas it is an established skill for Grade 1 children.[2,22,33,66]

The researcher therefore agrees with Coen-Cagli and Corragio's findings regarding a negative relationship between visual-motor integration and eye-hand coordination. This opens up the possibility that less eye-hand coordination occurs once the visual-motor integration skill is established and handwriting ability becomes automated. These are, however, only speculations and suggestions, and cannot be confirmed due to the scope of the research study.

5.3.1.4 The effect of handedness and gender on the relationship between the visual-motor integration and eye-hand coordination

During the investigation on the effect of handedness and gender on the relationship VMI: EHC as seen in Table 4-7 (p94), it was established that handedness and gender did not reflect a statistically significant effect on the established relationship between VMI: EHC. Considering handedness, previous literature has commented on the difference between left- and right-handed children with regard to handwriting.[87,89] Furthermore, gender differences have been noted and reported by previous studies pertaining to perceptual-motor skills and handwriting.[2,6] Bruckner et al[89] examined the relationship between gender, handedness and visual-motor integration, and reported poorer drawing performance in left-handed children.[89]

The findings in the present study are therefore contradictory to findings reported in previous literature. One reason for this is that previous studies did not consider the relationship between the VMI: EHC when examining the effect of handedness and gender. Furthermore, the present study consisted of a study population where participants were referred for occupational therapy due to a developmental and/or school-related difficulty, which differs from the study populations of previous research studies. The researcher therefore concludes that few comparisons can be made between previous research findings and the findings of this research study.

5.3.1.5 Summary

It can be concluded that the VMI and EHC subtests contain little inherent similarity in view of the poor level of agreement between the subtests. It can therefore be established that using both subtests during occupational therapy evaluations prove complementary towards each other, as seen in the statistically significant relationship between the VMI: EHC.

As a result of the above, the hypothesis of the study is accepted i.e. that *a statistically significant relationship exists between the visual-motor integration subtest of the Beery VMI-4 and the eye-hand coordination subtest of the* DTVP-2. This relationship remained statistically significant for Grade R participants in the study, but decreased for Grade 1 participants. Furthermore, it has been established that handedness and gender do not have a statistically significant effect on the established relationship between VMI: EHC.

5.3.2 Discussion of Objective 2: The visual-motor integration subtest and the copying subtest

The findings pertaining to the second objective as reported and interpreted in Section 4.3.3 yielded interesting results. The sub-objectives, similar to Section 5.3.1 will be discussed below.

5.3.2.1 Level of agreement between the visual-motor integration and the copying subtests

In Section 4.3.3.1 the researcher reported that there is reasonable agreement between the VMI and the COP. These findings suggest that the VMI subtest and the COP subtest demonstrate reasonable similarity, which means that they measure similar abilities and skills.

One reason for this reasonable agreement can be that the subtests are similar in their development structure and execution. For instance, the VMI and the COP contain similar geometrical shapes that have to be copied in a block below the provided shape. Furthermore, both subtests are discontinued after a series of three consecutive mistakes.

The researcher hypothesises that the agreement between the two subtests may have been stronger if the subtests had been scored similarly, i.e. with participants obtaining only a 0 or a 1 score instead of a 0, 1 or 2 score for the COP of the DTVP-2. This allows for more leniency during the scoring of the COP. Participants may not have adequately copied the shape to obtain a score of 2, but may have provided a response that resemble the shape to some extent, therefore obtaining a score of 1. In the researcher's opinion the COP therefore makes allowences for slight mistakes made by the participants that could have originated from poor fine motor skills, decreased concentration or other perceptual-motor difficulties. The VMI does not make allowences for such mistakes, and the manual scoring is stricter than the COP scoring. However, the developers of the VMI accounted for this by stating that if the examiner is in doubt as to whether the shape is correct, the examiner should score the response as passed. Other differences between the subtests such as the number of the geometrical shapes in each subtest and the level of difficulty of the geometrical shapes may also have influenced the agreement between the subtests. For example, the VMI subtest contains 27 geometrical shapes, as compared to the 20 geometrical shapes of the COP. Furthermore, it is the researcher's opinion that the geometrical shapes of the VMI are more challenging than the geometrical shapes included in the COP.

This discussion is an attempt by the researcher to provide possibilities in explaining the reasonable agreement. Further research will have to be conducted to provide more in-depth answers. It is the researcher's opinion that the reasonable agreement does not indicate that the tests are interchangeable, or that the copying subtest can be used as a substitute for the visual-motor integration subtest.

In light of the original aim of establishing whether therapists are over-testing when using both the VMI and the COP, the researcher feels that therapists may implement both measurement instruments during occupational therapy evaluations. This will ensure that therapists obtain results that are supportive in nature, rather than duplicating.

5.3.2.2 Relationship between the visual-motor integration and the copying subtests for the total sample

A strong relationship was established between VMI: COP for the total sample as reported in Section 4.3.3.2. These findings are similar to findings by various researchers. Dunn and Loxton[25] commented on the positive correlation between visual-motor integration and visual copying using different research methods. During their research, Kaiser and Albaret[19] established significant relationships between quality of handwriting and the COP.[19] Furthermore, authors such as Cornhill and Case-Smith[18] have related the scores obtained on the Beery VMI to be predictive of handwriting competency. It can therefore be concluded that the results pertaining to this research study resemble findings reported by previous authors.

In view of the findings discussed in Section 5.3.2.1 and this current section, it can be reasoned that the VMI subtest and the COP subtest measure similar abilities. The tests are similar in their development structure and execution, demonstrate reasonable agreement, and a strong relationship was established between the two tests. It can be concluded that the VMI and COP contain more similarities as compared to the EHC.

5.3.2.3 Relationship between the visual-motor integration and the copying subtests for Grade R and Grade 1 participants

Daly, Kelley and Krauss[22] found that copying of the VMI shapes was related to copying of letters during writing. They suggested that visual-motor integration and copying abilities were therefore influential in aquiring letter formation abilities.[22] Demonstrated in Table 4-8 (p97), a statistically significant relationship was established for VMI: COP for the Grade R and Grade 1 subgroups. Contrary to the decline in the relationship for VMI: EHC across the Grade 1 subgroup, the relationship between the VMI: COP remained strong when the sample was divided into the subgroups for Grade R and Grade 1. This may demonstrate that the relationship between the VMI: COP remains strong for participants that are still developing handwriting abilities (Grade R) and participants who have had more formal handwriting instruction (Grade 1). These findings emphasise the strong relationship between VMI: COP, as well the connection of these subtests to handwriting competence.

Researchers have commented on the difference in skill development in the first years of primary school,[22] stating that children in Grade R are still developing their visual-motor integration skills, whereas children in Grade 1 implement visual-motor integration skills daily as part of handwriting.[2,22,33,66] It can therefore be assumed that the relationship between VMI: COP remains strong for participants with developing visual-motor integration and participants with established visual-motor integration skills.

5.3.2.4 Effect of handedness and gender on visual-motor integration and copying

The researcher established the effect of handedness and gender on the relationship VMI: COP as reported and interpreted in Table 4-9 (p97). Handedness and gender demonstrated no statistically significant relationships to the VMI: COP.

Previous studies[8,81,89] have reported contrasting findings pertaining to handedness and gender and visual-motor integration. From the results in this research study it is interesting to note that no significant differences existed between boys and girls and left- and right-handed participants with regard to the relationship between VMI: COP.

One reason for the weak effect of handedness on the established relationship between the VMI: COP can be that left-handed participants obtained relatively similar scores when compared to right-handed participants. When considering the connection between visual-motor integration, copying and handwriting, it can be concluded that these findings differ from previous studies stating that left-handed children were more susceptible to writing difficulties.[91] Similarly, the poor effect of gender on the relationship VMI: COP also differs from previous authors stating that boys obtained better scores with regard to visual-motor integration as compared to girls.[6,31,81]

The findings reported in this research study indicate that handedness and gender are not predictive of visual-motor integration or copying skills. It should, however, be considered that these findings relate to participants identified as having developmental or school-related difficulties, by teachers, parents or other medical professionals. A study consisting of children without developmental or school-related difficulties may yield different results.

5.3.2.5 Summary

In conclusion to this section, the VMI and COP demonstrated reasonable agreement, which is noteworthy. This reasonable level of agreement would support the use of both measurement tools, and disregards the notion that therapists may be over-testing when implementing both tools during occupational therapy evaluations. It is, however, the researcher's opinion that this subject requires further research before conclusions can be drawn towards the interchangeability of the tests.

A significant relationship was established for the VMI and the COP. The researcher therefore accepts the hypothesis that *a statistically significant relationship exists between the visual-motor integration subtest and the copying subtests of the Beery VMI-4 and the DTVP-2*. Furthermore, the relationship between the subtests was significant for Grade R and remained strong for Grade 1 participants.

As explained in Section 5.3.2.3, this strong relationship may be significant to handwriting proficiency, as highlighted by several authors. This is, however, beyond the scope of this research study, but may prove valuable for future research. Lastly, it was established that handedness and gender did not prove to have a statistically significant effect on the relationship between the VMI: COP.

5.3.3 Discussion of Objective 3: The copying and the eye-hand coordination subtests

The findings pertaining to the third objective as reported and interpreted in Section 4.3.4 will be discussed in this section. The third objective, similar to Section 5.3.1 and 5.3.2, will be discussed below.

5.3.3.1 Level of agreement between the copying and the eye-hand coordination subtest

The researcher reported and interpreted the results of the level of agreement between the COP and the EHC in Section 4.3.4.1. It was reported that a weak agreement was established between the COP and the EHC. Similar to the rationalisation for the weak agreement between the VMI and the EHC, is that the COP and the EHC vary greatly in test content, administration and scoring. These results were therefore expected.

The developers of the DTVP-2[16] reported good discriminant validity between the subtests and stated that, although perceptual-motor skills are related to some extent, each subtest measures different skills with regard to perceptual-motor development.[16] Due to the two subtests measuring different abilities, the poor agreement between the two subtests is therefore desirable. The differences between these two subtests allow for a variety of perceptual-motor skills to be assessed during occupational therapy evaluations. This supports the use of the DTVP-2 during occupational therapy evaluations when evaluating eye-hand coordination and copying abilities.

5.3.3.2 Relationship between the copying and the eye-hand coordination subtest

Section 4.3.4.2 reported that although a poor agreement exists between the COP and the EHC, a statistically significant relationship is still established between the two subtests. It can therefore be assumed that participants that obtained good scores for the COP would have obtained similar scores for the EHC.

Limited research exists on the relationship between the COP: EHC. Kaiser and Albaret[19] have reported meaningful relationships between the quality of handwriting and the COP and the EHC individually. These researchers however, did not establish the relationship between the two subtests. It is therefore noteworthy to report a statistically significant relationship between the COP: EHC. Although these two subtests were designed to measure two different skills namely copying and eye-hand coordination, both skills are classified as perceptual-motor skills. Therefore a statistically significant relationship was expected. This confirms the notion that different perceptual-motor skills influence each other.

The authors of the DTVP-2[16] had a broader view of visual-motor integration in their definition of this term. They felt that eye-hand coordination, copying, spatial relations and visual-motor speed were abilities that together formed visual-motor integration as a whole. Similar to the conclusion drawn for the first objective, would be that eye-hand coordination is an important skill for adequate copying abilities. Without sufficient eye control and tracking abilities while drawing, the participant would find it difficult to copy the geometrical shapes and figures adequately.

The statistically significant relationship between visual-motor integration, eye-hand coordination and copying also demonstrates the importance of treating perceptual-motor skills during occupational therapy intervention programmes. If the child is exposed to eye-hand coordination tasks or activities during therapy, his/ her visual-motor integration and copying abilities should improve as a result and vica versa.

This demonstrates the rippling effect of therapeutic activities and tasks and the impact that the development of one skill will have on the other perceptual-motor skills. This emphasises the value of therapeutic intervention.

5.3.3.3 Relationship between the copying and eye-hand coordination subtests for Grade R and Grade 1

When the sample was divided into two subgroups for Grade R and Grade 1, both subgroups demonstrated a statistically significant relationship between the COP: EHC as reported in Table 4-10 (p100). Furthermore, the Grade R sample demonstrated a slightly stronger relationship when compared to the Grade 1 sample. Chueng, Poon, Leung and Wong[8] reported significant grade differences between Grade 1 and Grade 2 children in Hong Kong on the COP of the DTVP-2. They however, reported that no grade differences were observed for the EHC.[8] It is therefore noteworthy that slight grade differences exist between the Grade R and Grade 1 subgroups when a relationship is established between the COP: EHC, similar to when the COP was investigated individually.

Little additional research could be found to support the results and interpretations, but the researcher hypothesises that the Grade R participants may still be developing handwriting ability, and therefore rely on the skill of eye-hand coordination to master drawing tasks. Handwriting is strongly related to visual-motor integration and copying, as stated in Section 5.3.1.3. The more automated handwriting becomes, less eye-hand coordination occurs while increased copying skills are implemented, which may account for the decrease in the relationship between COP: EHC for Grade 1 participants.

5.3.3.4 Effect of handedness and gender on the relationship between copying and eye-hand coordination

Section 4.3.4.3 reported the results and interpretations regarding the effect of handedness and gender on the established relationship between the COP: EHC. As seen in Table 4-11 (p100) no significant relationship was observed for either handedness or gender on the relationship between the COP: EHC.

Previous research has not established the effect of handedness or gender on the COP or the EHC, and have not investigated the effect of handedness or gender on the relationship between the COP: EHC. Similar to the discussion in Section 5.3.2.4, is that literature have commented on differences in handedness and gender with regard to handwriting. Both eye-hand coordination and the skill of copying relate to handwriting to some extent. It can therefore be established that the findings pertaining to this research study may indirectly contradict findings from previous research studies. It is however important to note that these findings relate to children identified as having developmental and/ or school-related difficulties, and different results may be reported on children without these difficulties.

5.3.3.5 Summary

In summary, a poor level of agreement was established for the COP and the EHC, which is desirable and proves that the DTVP-2 has good discriminant validity. A statistically significant relationship was established for the COP and the EHC. Therefore, the researcher accepts the hypothesis that *a statistically significant relationship exists between the copying subtest and the eye-hand coordination subtest of the DTVP-2.*

The established relationship was statistically significant for both Grade R and Grade 1 participants. However, this relationship was slightly stronger for Grade R participants, which indicates a slightly stronger relationship between the COP: EHC for Grade R participants, as compared to Grade 1 participants. Furthermore, no statistically significant results were obtained for handedness or gender on the established relationship between the COP: EHC.

5.3.4 Discussion of the effect of eye-hand coordination, copying, handedness and gender on visual-motor integration

5.3.4.1 Discussion for the total sample

According to the results and interpretation presented in Section 4.3.5, it is noted that 52.1 % of the variance in the VMI could be explained by the variance in the EHC, the COP, handedness and gender. As concluded in the previous sections, it was evident that the EHC and the COP both reflected statistically significant relationships to the VMI. The effect of handedness and gender on the established relationships between the subtests (VMI: EHC; VMI: COP; COP: EHC) was however weak. Therefore it would be assumed that only the EHC and the COP would have contributed to the variance in the VMI.

However, according to the results seen in Table 4-12 (p102), only the COP contributed significantly to this variation in the VMI. This relates to the discussions of Section 5.3.2.1 and Section 5.3.2.2 where a reasonable level of agreement and a statistically significant relationship was established for VMI: COP. This demonstrates that the variance in VMI can mainly be attributed to the variance in the COP, and confirms that the VMI and the COP provide similar results.

5.3.4.2 Discussion for the sample divided into Grade R and Grade 1

The sample was divided into the subgroups for Grade R and Grade 1 as reported in Table 4-13 (p103). This was done to distinguish whether a difference existed between Grade R participants, i.e. participants that were still developing handwriting and visual-motor integration skills, and Grade 1 participants, i.e. participants that have had more exposure to formal handwriting instruction. The results indicated that both samples demonstrated a percentage of variance of more than 50%.

As expected, from the findings for the total sample the COP contributed significantly to this percentage of variance in the VMI for the Grade R sample. However, when investigating the results for the Grade 1 sample, the COP as well as gender contributed significantly to this percentage of variance in the VMI. The findings that relate to gender contributing to the variance in the VMI were unexpected. No statistically significant results were obtained regarding gender and the visual-motor integration subtest when reported independently (see Section 4.3.1.1, Table 4-3, p85), or on any of the established relationships between the subtests (VMI: EHC; VMI: COP; COP: EHC).

As stated in Section 2.5 regarding gender and perceptual-motor skills, gender differences regarding visual-motor skills have been noted and reported by researchers.[6,31,81] However, the researcher cannot draw any significant conclusions concerning these findings, and further research will have to be conducted to establish the reason for the effect of gender in Grade 1 participants on the variance in the VMI.

5.3.4.3 Summary

It can be concluded that the COP subtest contributed 50% and more to the variance in the VMI. This confirms the reasonable agreement that was established between the two subtests and demonstrates the similarities between the two subtests. The results pertaining to gender contributing to the variance in VMI in the Grade 1 participant subgroup may indicate that boys' and girls' visual-motor integration skills vary.

In the researcher's clinical experience, boys tend to have more difficulty with regard to handwriting. This is confirmed by research stating that the ratio for handwriting difficulties in boys are five to one, as compared to girls. Other researchers, however, have reported that boys performed better during visual-motor integration tasks as compared to girls.[6,31,81] The effect of gender on visual-motor integration in the Grade 1 subgroup may indicate that either the boys or girls subgroup struggled to consolidate visual-motor integration skills, but no conclusions can be drawn as to the gender in question.

5.4 LIMITATIONS

The researcher endeavored to develop and execute a research study that was scientific in theory and in execution. Although care was taken during the development and planning of the study, some challenges were experienced and therefore identified as limitations to the research. Possible solutions to address these limitations for further research studies will be discussed in Section 5.5.

5.4.1 Population and study setting

The researcher identified the area of Tshwane East as the setting for this research study. The data was obtained from a paediatric private occupational therapy practice within Tshwane East which received referrals from different teachers, parents or medical professionals within the area. Although the population consisted of participants from different socioeconomic standings in private and public schools, the researcher acknowledges that if other private practices or public sector institutions had been included in the research study, a broader and more representative sample would have been obtained. Furthermore, this would have aided in including a larger sample of left-handed and female participants in the study. Such a sample would have been more generalisable to the broader population of Gauteng or South Africa.

5.4.2 Retrospective study design

Although a pilot study was conducted to ensure that the research design was sound, the researcher still experienced some difficulties due to her implementing a retrospective study design. Those challenges will be discussed below.

5.4.2.1 Measurement instruments

5.4.2.1.1 The Beery Buktenica Developmental Test of Visual-Motor Integration- 4th Edition[15]

The research study by design consisted of retrospective data analysis. This, however, resulted in an outdated standardised measurement tool being used in the research study. The Beery VMI-4 has been revised and updated to more current editions. However, the paediatric private practice still used the Beery VMI-4 for their evaluations during the time period 2009 to 2012.

Although the newer editions of the measurement tool remain similar in their structure and design as compared to the previous editions,[110] it is the researcher's opinion that using the newer version of the standardised measurement tool would have been preferable.

5.4.2.1.2 The Developmental Test of Visual Perception- 2nd Edition[16]

The DTVP-2 has also been revised and published in a new edition, namely the DTVP-3.[111] This research study therefore reports results obtained from the DTVP-2, which is currently the older edition. The DTVP-3 was only published in 2013 and was therefore not available from 2009 to 2012.

The newer edition features some changes, the subtests of spatial relations and visual motor speed having been omitted, and the eye-hand coordination and copying subtests have been adapted.[111] The changes, however, would not have influenced the findings and results of the study. Similar to the discussion in Section 5.4.2.1.1, it can be concluded that using the newer edition of this measurement tool would have been preferable.

5.4.2.2 Re-scoring of the measurement tools

In Section 3.5.6 the researcher stated that the measurement tools used for the total sample would be re-scored during the pilot study if the external-rater found inconsistencies with regard to the initial scoring of the subtests. As described in the results of the pilot study (see Section 3.5.7), this occurred and all the subtests needed to be re-scored by the researcher. This, however, did not transpire without difficulties.

At times the researcher found it challenging to draw conclusions on some of the drawings of the participants. The researcher attempted to re-score the subtests as truthfully as possible with regard to the test manual. However, it is the researcher's opinion that if the initial evaluations had been conducted by the researcher or research assistant with clear observation notes, it would have aided in scoring the subtests more accurately, which would in turn have increased the reliability and validity of the results.

The researcher is also of the opinion that re-scoring of the measurement tools by the researcher herself, had its limitations. The re-scoring of the measurement tools could have been administered by another occupational therapist, which would have increased the validity and reliability of the results. Furthermore, there is a difference in the researcher's level of experience when compared to the skilled occupational therapists that conducted the evaluations. This contributes to the limitations experienced during the re-scoring of the measurement instruments.

5.4.2.3 Background information form

The background information form was used to obtain information regarding each participant's age, date of birth, preschool years i.e. whether he/she attended nursery school, and current grade. In retrospect, it is the researcher's belief that this form was not sufficient in providing the additional information the researcher was aiming for. Some parents completed this form briefly, without providing in-depth information regarding the participant's preschool years. It was therefore difficult to draw conclusions on some participants' attendance of Grade R. More in-depth information would have aided the researcher in making additional conclusions on participants' performance with regards to the subtests. Although the researcher attempted to eliminate recall bias, certain aspects still influenced the study.

5.5 RECOMMENDATIONS FOR FUTURE STUDIES

As mentioned above, the execution of the research study posed challenges to the researcher. The researcher will provide recommendations for future studies regarding the research topic, which may assist future researchers in possibly avoiding similar challenges.

5.5.1 Population and study setting

The identified population provided a large enough sample to yield statistically significant results that address the research objectives. It is, however, the researcher's opinion that a more diverse population would have been obtained if additional private practices had been included in the research study. In addition, the South African population consists of a wide variety of cultures and various socio-economic ranks, some of which will never be identified as having developmental or school-related difficulties and as a result will not be referred for occupational therapy evaluations.

These populations, however, still need to be reached and included in current research. To adress this limitation, the researcher suggests identifying clinics or public hospitals where children referred for occupational therapy evaluations can be accessed. This will ensure that children that do not have access to occupational therapy within the private setting can be included in a study population.

5.5.2 Retrospective study design

Although some challenges were experienced with respect to the retrospective study design, the researcher still feels that this design aided her in analysing data from a large sample of participants with developmental and/or school-related difficulties in a controlled environment. There are, though, some recommendations to be made pertaining to the challenges experienced.

5.5.2.1 Measurement instruments

As mentioned in Section 5.4.2, the use of current editions of measurement instruments such as the Beery VMI-6 and the DTVP-3 is preferable. It is, however, the researcher's opinion that the results obtained in this research study would have been similar to the results obtained from the Beery VMI-6 and the DTVP-3. The researcher therefore believes that the results from this current study should extrapolate to the current versions.

5.5.2.2 Re-scoring of the measurement instruments

The researcher recommends that, when measurement instruments are used during research studies, the evaluations be conducted either by the researcher or a research assistant trained specifically for the research study. This will allow the researcher or research assistant to record valuable observations during the evaluation, which could aid in drawing conclusions with respect to the reported results and findings. It will also result in providing increased structure to the evaluations, which will increase the reliability and validity of the results. This, however, could always prove as a limitation to retrospective study designs. It is therefore the researcher's opinion that other study designs be considered, before selecting a retrospective study design. The researcher also recommends that if measurement tools are re-scored, the rescoring be conducted by another occupational therapist in order to preserve the reliability and validity of the results.

5.5.2.3 Background information form

Obtaining background information during a retrospective study design would pose difficulties similar to those in the discussion above. The researcher therefore recommends that additional background information be obtained from the participants' parents, if informed consent was granted by the parents. This can be done via email or parent interviews.

5.6 CONCLUSION

"Research is formalized curiosity. It is poking and prying with a purpose."

Zora Neale Hurston

This research study allowed the researcher to examine and investigate specific questions with a purpose, and in addition contribute towards existing knowledge regarding the study topic. The primary aim of this research study was to examine the relationship between the visual-motor integration subtest, the eye-hand coordination subtest and the copying subtest of the Beery VMI-4 and the DTVP-2 respectively. Although only the visual-motor integration and the copying demonstrated a significant level of agreement between the two subtests, all three subtests displayed significant relationships, which permitted the researcher to accept the hypothesis of the research study. Previous research highlighted the relationship between visual-motor integration, handwriting ability and academic achievement. The significant relationships between visual-motor integration, copying and eye-hand coordination open broader questions such as whether the copying subtest and the eye-hand coordination subtest of the DTVP-2 can be associated with handwriting abilities and academic achievement. Therapists may then prefer to only select one of the measurement instruments during evaluations, rather than using both the Beery VMI-4 and the DTVP-2.

This will contrubute to the National Education Department's aim of identifying standardised measurement tools that are accurate, inexpensive and effective. It is however still the researcher's opinion that both the Beery VMI-4 and the DTVP-2 are valuable measurement tools, as discussed during this chapter, and should not be interchanged.

The relationship between perceptual-motor skills still remains a topic with many unanswered questions. Limited research exists in the South African population regarding this topic. The researcher desires that the findings in this research study will aid future studies in literature pertaining to the South African population. Furthermore, perceptual-motor skills have a significant influence on the child's school-related functioning, and the findings may assist teachers and therapists in identifying and treating perceptual-motor delays that are related to handwriting difficulties.

The secondary aim of this research study was to examine the effect of handedness and gender on the established relationships between visual-motor integration, copying and eye-hand coordination. As no statistically significant results were found, the researcher concludes that handedness and gender are not related to the relationships between visual-motor integration, copying and eye-hand coordination.

The exploration of whether eye-hand coordination, copying, handedness and gender could explain the variation in visual-motor integration resulted in the suggestion that only copying could account for the variation in visual-motor integration. Although gender did significantly account for the variation in visual-motor integration in Grade 1 participants, no other data regarding gender proved similar. Therefore, these results remain unresolved and the researcher proposes that further research be done regarding this topic.

Lastly, the researcher hopes that the recommendations provided in the final chapter will aid future researchers in avoiding some of the limitations experienced during this research study.

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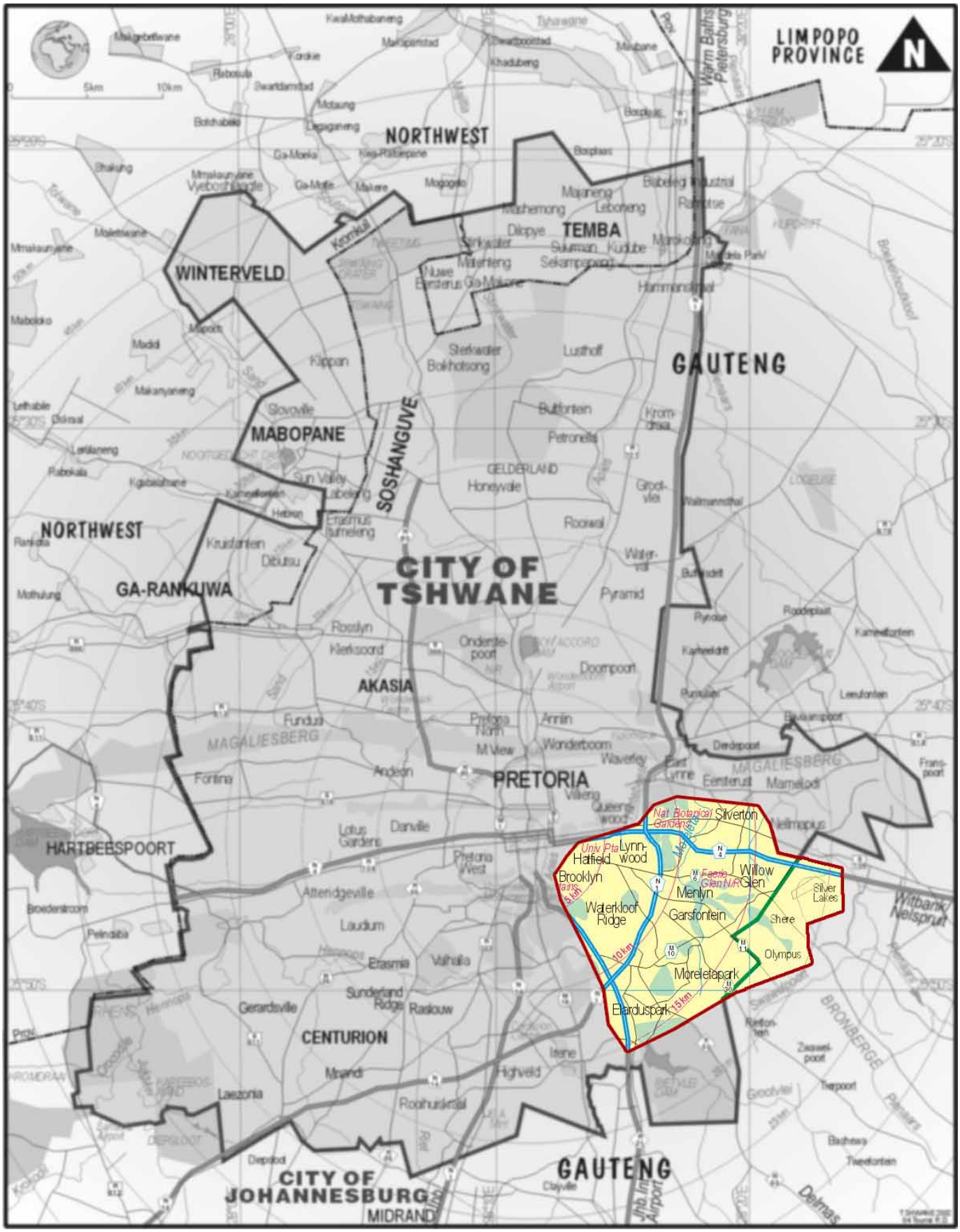
ANNEXURES

Annexure A

Geographical study setting



Reference: Mappery [Internet]. Tshwane City Maps. ICOSMOS; [cited 2014 June 26]. Available from: www.mappery.com/Tshwane-City-Map

Annexure B

List of medication prescribed for ADHD

LIST OF MEDICATION PRESCRIBED FOR ADHD

Class	Drug Name	Form	Duration
Amphetamine Stimulants	Adderall	Short-acting	4- 6 hours
	Dexedrine	Short-acting	4- 6 hours
	Dextrostat	Short-acting	4- 6 hours
	Dexedrine Spansule	Long-acting	6- 8 hours
	Adderall XR	Long-acting	8- 12 hours
	Vyvanse	Long-acting	10- 12 hours
Methylphenidate Stimulants	Focalin	Short-acting	4- 6 hours
	Methylin	Short- acting	3- 4 hours
	Ritalin	Short- acting	3- 4 hours
	Metadate ER	Intermediate- acting	6- 8 hours
	Ritalin SR	Intermediate- acting	4- 8 hours
	Metadate CD	Intermediate- acting	8- 10 hours
	Ritalin LA	Intermediate- acting	8- 10 hours
	Concerta	Long- acting	10- 12 hours
	Quillivant XR	Long- acting	12 hours
	Focalin XR	Long- acting	6- 10 hours
	Daytranapatch	Long- acting	10- 12 hours
Nonstimulants	Strattera	Long- acting	24 hours
	Intuniv	Long- acting	24 hours
Antidepressants	Wellbutrin	Short- acting	4- 5 hours
	Wellbutrin SR	Sustained relearse	12 hours
	Wellbutrin XL	Extended release	24 hours
	Tofranil	N/A	8- 24 hours
	Pamelor	N/A	8- 24 hours
	Aventyl	N/A	8- 24 hours
	Norpramin	N/A	8- 24 hours

Reference: Web MD [Internet]. ADHD medication chart. [updated 2014 May 10; cited 2015 July 22]. Available from: http://www.webmd.com/add-adhd/guide/adhd-medication-chart.

Annexure C

Data collection instrument

Background information form

The letterhead has been removed to ensure confidentiality

NAME & SURNAME OF CHILD: _____

DATE OF BIRTH: _____/_____/_____ AGE: _____YEARS_____MONTHS_____

Position in Family (how many children, age, position): _____

_____

Pregnancy (any complications): _____

_____

Birth (any complications, normal, ceasarian): _____

_____

Neonatal Condition (Apgar score / Birth weight / Allergies / Feeding problems):

_____

_____

Milestone (Eg sit, crawl, walk - describe): _____

_____

Pre-School Years (Was he/she in a Nursery School or Daycare – From what age / Serious illness)

_____

_____

School (Which school / Grade / Achievements / Extra mural activities): _____

_____

_____

Reason for referral: _____

_____

_____

Additional comments, data regarding problems at school, academically or behaviour:

_____

_____

_____

Describe your child's personality:

_____

_____

SIGNATURE OF PARENT: _____

The letterhead has been removed to ensure confidentiality

NAAM EN VAN VAN KIND: _____

GEBOORTEDATUM: _____/_____/_____ OUD: _____JAAR_____MAANDE

Posisie in Gesin (noem aantal kinders, geslag, ouderdomme) : _____

_____

Swangerskap (enige komplikasies): _____

_____

Geboorte (enige komplikasies, normaal/keiser): _____

_____

Pasgebore toestand (Apgartelling / Gewig by geboorte / Allergieë / Voedingsprobleme):

_____

_____

Mylpale (Bv sit, kruip, loop - omskryf): _____

_____

Kleuterjare (Was hy/sy in kleuterskool/dagsorg - Vanaf watter ouderdom / Ernstige siektes):

_____

_____

Funksionering op skool (Watter skool / Graad / Prestasies / Buitemuurse aktiwiteite):

_____

_____

Rede vir ondersoek: _____

_____

_____

Noem asseblief enige inligting wat die onderwysers genoem het as probleme by die skool, akademies of wat gedrag betref:

_____

_____

Beskryf jou kind se persoonlikheid:

_____

_____

_____

HANDTEKENING VAN OUER: _____

Annexure D

Data collection instrument

Evaluation summary form

The letterhead has been removed to ensure confidentiality

NAME OF CHILD : _____ BIRTH DATE : _____ AGE: ___YR ___ MTHS

		BELOW	AVERAGE	ABOVE AGE
1.	**BEHAVIOUR RESPONSES**			
	Self-confidence			
	Interaction			
	Task orientation			
	Speech language auditory perception			
	Hyperactivity and distractibility			
	Attention and concentration			
	Impulsive behaviour			
	Fidgety and abnormal behaviour			
2.	**CLINICAL OBSERVATION**			
	Asymmetrical tonic neck reflex			
	Symmetrical tonic neck reflex			
	Prone extension			
	Supine flexion			
	Equilibrium			
	Protective extension			
	Postural security			
	Co-contraction			
	Muscle tone			
	Controlled slow movements			
	Controlled fast movements			
	Praxis			
	Eye control			
	* Fixation			
	* Following			
	* Convergence			
	* Localisation			
	* Peripheral vision			
	* Midline crossing			
	Dominance Hand_____ Foot_____ Ear_____ Eye_____			
3.	**STOTT TEST FO MOTOR IMPAIRMENT : SCOTT, HENDERSON**			
		LEFT	**RIGHT**	**BILATERAL**
	Item 1 : Static balance			
	Item 2 : Upper limb co-ordination			
	Item 3 : Co-ordination of body during movement			
	Item 4 : Upper limb dexterity			
	Item 5 : Repetitive hand movement			
4.	**BASIC CONCEPTS** Body:_____ Shape:_____ Number:_____ Colour:_____ Size:_____			
5.	**DEVELOPMENTAL TEST OF VISUAL MOTOR INTEGRATION : K. BEERY**	**VMI**	**VISUAL**	**MOTOR**
6.	**SOUTHERN CALIFORNIAN SENSORY INTEGRATION TESTS : A J. AYERS**			
	Visual perception			
	1. Spatial visualization			
	2. Figure-ground			
	3. Position in space			
	Somato-sensory perception			
	1. Kinesthetic awareness			
	2. Object recognition			
	3. Finger identification			
	4. Graphesthesia			
	5. Localization of tactile stimuli			
	6. Double tactile stimuli			
	Motor skills			
	1. Imitation of postures			
	2. Bilateral motor integration			
	3. Standing balance eyes open			
	4. Standing balance eyes closed			
	Other			
	1. Midline crossing			
	2. Left right discrimination			
7.	**DEVELOPMENTAL TEST OF VISUAL PERCEPTION 2 : M. FROSTIG**			
	1. Eye-hand co-ordination			
	2. Position in space			
	3. Copying			
	4. Figure-ground			
	5. Spatial relations			
	6. Visual closure			
	7. Visual-motor speed			
	8. Form constancy			
8.	**TEST OF VISUAL PERCEPTUAL SKILLS : GARDNER**			
	1. Visual discrimination			
	2. Visual memory			
	3. Visual spatial relations			
	4. Visual constancy			
	5. Visual sequential memory			
	6. Visual figure-ground			
	7. Visual closure			
9.	**HIGHER COGNITIVE**			
	Visual discrimination			
	Visual analysis and synthesis			
	Visual sequencing			
	Visual memory			
8.	**SCHOOL RELATED FUNCTIONS**			
	Writing and transcription			
	Reading			
	Word construction			
	Spelling			
	Mathematics			
NAME OF THERAPISTS:			**DATE:**	

The letterhead has been removed to ensure confidentiality

NAAM VAN KIND : _____ GEB. DAT: _____ OUD: ____JR ____MDE

1. GEDRAGSRESPONSE	SWAK	NORMAAL	BO OUDERDOM
Selfvertroue			
Interaksie			
Taaksgereedheid			
Spraak, taal en ouditiewe begrip			
Hiperaktiwiteit en afleibaarheid			
Aandag en konsentrasie			
Impulsiewe gedrag			
Vroetelrigheid en abnormale gedrag			
1. KLINIESE OBSERVASIE Assimmetriese toniese nek refleks			
Simmetriese toniese nek refleks			
Schilders arm ekstensie postuur			
Maagliggende ekstensie postuur			
Rugliggende fleksie postuur			
Ekwilibrium en houdingsaanpassings reaksies			
Beskermde ekstensie			
Posturele sekuriteit			
Ko-kontraksie			
Spiertonus			
Vermoë om stadige bewegings uit te voer			
Vermoë om vinnige bewegings uit te voer			
Praksis			
Oogspierkontrole :			
* Fiksasis			
* Navolging			
* Konvergensie			
* Vinnige lokalisasie			
* Perifere visie			
* Midlynkruising			
Dominansie: *Hand* _____ *Voet* _____ *Oor* _____ *Oog* _____			

3. STOTT TEST OF MOTOR IMPAIRMENT : SCOTT, HENDERSON	LINKS	REGS	BILATERAAL
Item 1 : Statiese balans			
Item 2 : Koördinasie van die boonste ledemate			
Item 3 : Koördinasie van liggaam tydens beweging			
Item 4 : Take wat vaardigheid v boonste ledemate vereis			
Item 5 : Take wat herhalende bewegings v hande vereis			

4. BASIESE KONSEPTE
Liggaam: _____ Vorm: _____ Getal : _____ Kleur: _____ Grootte: _____

5. DEVELOPMENTAL TEST OF VISUAL MOTOR INTEGRATION : K. BEERY	VMI	VIS.PER.	MOT.KOÖRD.

6. SOUTHERN CALIFORNIAN SENSORY INTEGRATION TESTS : A J. AYERS			
Visuele persepsie			
1. Ruimtelike visualisering			
2. Voorgrond-Agtergrond			
3. Posisie in die ruimte			
Somato-sensoriese persepsie			
1. Kinestesie			
2. Vorm taspersepsie			
3. Vinger identifikasie			
4. Grafestesie			
5. Lokalisasie van tasstimuli			
6. Dubbel tasstimuli			
Motoriese vermoëns			
1. Nabootsing van posture			
2. Bilaterale motoriese integrasie			
3. Staan balans : oë oop			
4. Staan balans : oë toe			
Ander			
1. Midlynkruising			
2. Regs-links diskriminasie			
7. DEVELOPMENTAL TEST OF VISUAL PERCEPTION 2 : M. FROSTIG			
1. Oog-hand koördinasie			
2. Posisie in die ruimte			
3. Nateken			
4. Voorgrond-Agtergrond			
5. Ruimtelike verhoudings			
6. Visuele sluiting			
7. Visio-motoriese spoed			
8. Vormkonstantheid			
8. TEST OF VISUAL PERCEPTUAL SKILLS : GARDNER			
1. Visuele diskriminasie			
2. Visuele geheue			
3. Visuele ruimtelike verhoudings			
4. Visuele konstantheid			
5. Visuele opeenvolging geheue			
6. Visuele voorgrond-agtergrond			
7. Visuele sluiting			
9. HÖER KOGNITIEF Visuele diskriminasie			
Visuele analise en sintese			
Visuele opeenvolging			
Visuele geheue			
10. SKOOLVERWANTE FUNKSIES Skrif en transkripsies			
Lees			
Woordbou			
Spelling			
Wiskunde			

NAAM VAN TERAPEUTE : DATUM:

Annexure E

Letter from statistician

Date: 31 / 3 /2014

LETTER OF CLEARANCE FROM THE BIOSTATISTICIAN

This letter is to confirm that the researcher(s)/student(s),

with the name(s) Ms SARIZA COETZEE

Studying at the University of PRETORIA

discussed the Project with the title

Relationship among three perceptual-motor skills in children aged six years referred to Occupational Therapy in Tshwane East with me.

I hereby confirm that I am aware of the project and also undertake to assist with the Statistical analysis of the data generated from the project.

The analytical tool that will be used will be Multivariable Linear regression for each response (standscore, age equiv, z-score). R^2 that will measure strength of relationship. to achieve the objective(s) of the study. Also see attached section from the protocol

Name PJ SCHOEMAN Date 31/3/14

Signature Tel: 012-339-8519

Department or Unit RESEARCH OFFICE, FAC HEALTH SCIENCES, UP & BIOSTATISTICS UNIT, MRC (RSA)

MEDICAL RESEARCH COUNCIL
Biostatistics Unit
Private Bag X385
Pretoria
0001
Tel: 012 339 8523 / Fax: 012 339 8582

Official Stamp of Biostatistician
31/3/14

Annexure F

Written permission by custodians of the data to conduct research study

Permission to access Patient Records at an Occupational Therapy Private Practice

TO: Alma de Wet
Chief Executive Officer/Information Officer
Alma de Wet Occupational Therapists
Private Practice

FROM : Sariza Coertzen [Name]
Investigator
Student at the Occupational Therapy Department
University of Pretoria

Re: Permission to do research at Alma de Wet Occupational Therapists Private Practice

TITLE OF STUDY: Relationship among three perceptual-motor skills in children aged 6 years referred for occupational therapy in Tshwane East

This request is lodged with you in terms of the requirements of the Promotion of Access to Information Act. No. 2 of 2000.

I am a researcher at the Department of Occupational Therapy at the University of Pretoria and herewith request permission to conduct a study on the above topic on the private practice grounds. This study involves access to patient records.

The researcher requests access to the following information: patient files and record books.

I intend to publish the findings of the study in a professional journal and/ or to present them at professional meetings like symposia, congresses, or other meetings of such a nature.

I intend to protect the personal identity of the patients by assigning each individual a random identification number.

I undertake not to proceed with the study until I have received approval from the Faculty of Health Sciences Research Ethics Committee, University of Pretoria.

Yours sincerely

Signature of the Principal Investigator

Permission to do the research study at this private practice and to access the information as requested, is hereby approved.

Title and name of Chief Executive Officer: Alma de Wet

Name of Occupational Therapy private practice: Alma de Wet Occupational Therapists

Signature: Alma de Wet Date: 29/7/2014

1 Title(s) and surname(s) of co-investigator(s) / supervisor(s)

Official Stamp

Annexure G

Letter of approval from Faculty of Health Sciences Research Ethics Committee

The Research Ethics Committee, Faculty Health Sciences, University of Pretoria complies with ICH-GCP guidelines and has US Federal wide Assurance.
- FWA 00002567, Approved dd 22 May 2002 and Expires 20 Oct 2016.
- IRB 0000 2235 IORG0001762 Approved dd 22/04/2014 and Expires 22/04/2017.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences Research Ethics Committee

4/09/2014

Approval Certificate
New Application

Ethics Reference No.: 312/2014

Title: Relationship among three perceptual-motor skills in children aged six years referred for occupational therapy in Tshwane East

Dear Miss Sariza Coertzen

The **New Application** as supported by documents specified in your cover letter for your research received on the 4/08/2014, was approved by the Faculty of Health Sciences Research Ethics Committee on the 27/08/2014.

Please note the following about your ethics approval:
- Ethics Approval is valid for 2 years.
- Please remember to use your protocol number (**312/2014**) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committee may ask further questions, seek additional information, require further modification, or monitor the conduct of your research.

Ethics approval is subject to the following:
- The ethics approval is conditional on the receipt of 6 monthly written Progress Reports, and
- The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.

We wish you the best with your research.

Yours sincerely

Dr R Sommers, MBChB; MMed (Int); MPharMed.
Deputy Chairperson of the Faculty of Health Sciences Research Ethics Committee, University of Pretoria

The Faculty of Health Sciences Research Ethics Committee complies with the SA National Act 61 of 2003 as it pertains to health research and the United States Code of Federal Regulations Title 45 and 46. This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki, the South African Medical Research Council Guidelines as well as the Guidelines for Ethical Research: Principles Structures and Processes 2004 (Department of Health).

☎ 012 354 1677 🖷 0866516047 deepeka.behari@up.ac.za http://www.healthethics-up.co.za
✉ Private Bag X323, Arcadia, 0007 - 31 Bophelo Road, HW Snyman South Building, Level 2, Room 2.33, Gezina, Pretoria

Annexure H

Letter of approval from Faculty of Health Sciences Research Ethics Committee for amendments

The Research Ethics Committee, Faculty Health Sciences, University of Pretoria complies with ICH-GCP guidelines and has US Federal wide Assurance.
- FWA 00002567, Approved dd 22 May 2002 and Expires 20 Oct 2016.
- IRB 0000 2235 IORG0001762 Approved dd 22/04/2014 and Expires 22/04/2017.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences Research Ethics Committee

29/01/2015

Approval Certificate
Amendment
(to be read in conjunction with the main approval certificate)

Ethics Reference No.: 312/2014

Title: Relationship among three perceptual-motor skills in children aged six years referred for occupational therapy in Tshwane East

Dear Miss Sariza Coertzen

The **Amendment** as described in the documents received on 19/11/2014 was approved by the Faculty of Health Sciences Research Ethics Committee on the 28/01/2015.

Please note the following about your ethics amendment:
- Please remember to use your protocol number (**312/2014**) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committe may ask further questions, seek additional information, require further modification, or monitor the conduct of your research.

Ethics amendment is subject to the following:
- The ethics approval is conditional on the receipt of 6 monthly written Progress Reports, and
- The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.

We wish you the best with your research.

Yours sincerely

Professor Werdie (CW) Van Staden
MBChB MMed(Psych) MD FCPsych FTCL UPLM
Chairperson: Faculty of Health Sciences Research Ethics Committee

The Faculty of Health Sciences Research Ethics Committee complies with the SA National Act 61 of 2003 as it pertains to health research and the United States Code of Federal Regulations Title 45 and 46. This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki, the South African Medical Research Council Guidelines as well as the Guidelines for Ethical Research: Principles Structures and Processes 2004 (Department of Health).

♦ Tel:012-3541330 ♦ Fax:012-3541367 Fax2Email: 0866515924 ♦ E-Mail: fhsethics@up.ac.za
♦ Web: http://www.up.ac.za/healthethics ♦ H W Snyman Bld (South) Level 2-34 ♦ Private Bag x 323, Arcadia, Pta, S.A., 0007

Annexure I

Informed consent by custodians of the data

Updated 29/07/2014

CUSTODIAN'S INFORMATION LEAFLET & INFORMED CONSENT FORM FOR A NON-INTERVENTION STUDY

STUDY TITLE:

Relationship among three perceptual-motor skills in children aged six years referred for occupational therapy in Tshwane East

Principal Investigator: Sariza Coertzen

Custodian of data: Alma de Wet Occupational Therapists

DAYTIME AND AFTER HOURS TELEPHONE NUMBER(S):

Daytime numbers: 082 782 4662

Afterhours: 082 782 4662

DATE AND TIME OF FIRST INFORMED CONSENT DISCUSSION:

27	07	2014
dd	mmm	ivy

8:00
Time

Updated 29/07/2014

Dear custodian of data date of consent procedure 09./09./2014

1) INTRODUCTION

Your private practice is invited to participate in a research study. This information leaflet is to help you to decide if you would like your practice to participate. Before you agree to take part in this study you should fully understand what is involved. If you have any questions, which are not fully explained in this leaflet, do not hesitate to ask the investigator. You should not agree to take part unless you are completely happy about all the procedures involved.

2) THE NATURE AND PURPOSE OF THIS STUDY

Your private practice is invited to take part in a research study. The aim of this study is to *determine the relationship among visual-motor integration, copying and eye-hand coordination in children aged six years.* By doing so we wish to learn more about *the relationship among these three perceptual motor skills in order to enhance occupational therapy assessment and treatment.*

3) EXPLANATION OF PROCEDURES TO BE FOLLOWED

This study involves accessing patient files from your practice between 2002 to 2012, and recording the data

4) RISK INVOLVED.

No risks are involved in partaking in this study.

5) POSSIBLE BENEFITS OF THIS STUDY.

This study will aim to benefit occupational therapists working with school-related difficulties.

6) HAS THE STUDY RECEIVED ETHICAL APPROVAL?

This Protocol was submitted to the Faculty of Health Sciences Research Ethics Committee, University of Pretoria, telephone numbers 012 3541677 / 012 3541330 and written approval has been granted by that committee. The study has been structured in accordance with the Declaration of Helsinki (last update: October 2008). A copy of the Declaration may be obtained from the investigator should you wish to review it.

7) INFORMATION

If I have any questions concerning this study, I should contact:

Miss S Coertzen cell: 082 782 4662

Updated 29/07/2014

10) CONFIDENTIALITY

All records obtained whilst in this study will be regarded as confidential. Results will be published or presented anonymously.

11) CONSENT TO PARTICIPATE IN THIS STUDY.

The directors of the practice have read the above information before signing this consent form. The content and meaning of this information have been explained to us. We have been given opportunity to ask questions and are satisfied that they have been answered satisfactorily. We understand that if we do not participate it will not affect us in any way. The practice directors hereby give consent to take part in this study.

We have received a signed copy of this informed consent agreement.

1. Print Name of Director: SUZANNE HEYDENRYCH
   Signature of Director: Heydenrych
   Date: 9/9/2014
   Day/Month/Year

2. Print Name of Director: Alma de Wet (ALMA DE WET)
   Signature of Director: Alma de Wet
   Date: 10/9/2014
   Day/Month/Year

3. Print Name of Director: MIA DE WET
   Signature of Director: MdeWet
   Date: 15/9/2014
   Day/Month/Year

ANNEXURE J

Declaration regarding plagiarism

DECLARATION OF ORIGINALITY

UNIVERSITY OF PRETORIA

The Department of Occupational Therapy places great emphasis upon integrity and ethical conduct in the preparation of all written work submitted for academic evaluation.

While academic staff teach you about referencing techniques and how to avoid plagiarism, you too have a responsibility in this regard. If you are at any stage uncertain as to what is required, you should speak to your lecturer before any written work is submitted.

You are guilty of plagiarism if you copy something from another author's work (eg a book, an article or a website) without acknowledging the source and pass it off as your own. In effect you are stealing something that belongs to someone else. This is not only the case when you copy work word-for-word (verbatim), but also when you submit someone else's work in a slightly altered form (paraphrase) or use a line of argument without acknowledging it. You are not allowed to use work previously produced by another student. You are also not allowed to let anybody copy your work with the intention of passing if off as his/her work.

Students who commit plagiarism will not be given any credit for plagiarised work. The matter may also be referred to the Disciplinary Committee (Students) for a ruling. Plagiarism is regarded as a serious contravention of the University's rules and can lead to expulsion from the University.

The declaration which follows must accompany all written work submitted while you are a student of the Department of Occupational Therapy. No written work will be accepted unless the declaration has been completed and attached.

Full names of student:	Sariza Swart
Student number:	26076943
Topic of work:	The relationship among three perceptual-motor skills in children aged six years referred for occupational therapy in Tshwane East

Declaration

1. I understand what plagiarism is and am aware of the University's policy in this regard.
2. I declare that this dissertation (eg essay, report, project, assignment, dissertation, thesis, etc) is my own original work. Where other people's work has been used (either from a printed source, Internet or any other source), this has been properly acknowledged and referenced in accordance with departmental requirements.
3. I have not used work previously produced by another student or any other person to hand in as my own.
4. I have not allowed, and will not allow, anyone to copy my work with the intention of passing it off as his or her own work.

SIGNATURE _____