Visual-motor integration (VMI) — a predictor for handwriting in Grade 0 children

Pragashnie Naidoo B.OT (UDW)
Senior Tutor, Discipline of Occupational Therapy, School of Audiology, Occupational Therapy & Speech-language Pathology, Faculty of Health Sciences, University of Kwa-Zulu Natal

Amy Engelbrecht B.Occ.Th (UKZN)
Occupational Therapist in paediatric private practice

Sharon Lewis B.Occ.Th (UKZN)
School-based Occupational Therapist in the United Kingdom

Bridget Kekana, B.Occ.Th (UKZN)
Occupational Therapist, Lebowakgomo Hospital, Limpopo Province

ABSTRACT

Introduction: *Occupational therapists (OTs) are often faced with the late referral of children with handwriting difficulties when intervention is less effective. It is thus essential for the OT and the teacher to be able to identify these children early for maximum therapeutic intervention. The researchers therefore attempted to investigate whether visual motor integration (VMI) can be a predictor of handwriting skills in Grade 0 children.*

Methodology: *A standardised visual perceptual test (the Test of Visual Motor Integration) [9] and handwriting assessments were conducted with 53 Grade 0 children in mainstream schools around Durban in an attempt to establish a link. Handwriting was analysed using adapted criteria from the Writing Rate Information Test (WRIT), which was developed by Steinhardt et al[10] in Kwa-Zulu Natal, South Africa.*

Results: *A significant correlation between the formation of letters e, f, and k and visual motor integration (VMI) was noted in the sample, whilst no significant link was found between legibility of handwriting and VMI. A relationship was found between writing the name from memory and VMI and a significant correlation was found when comparing reversals in a child's attempt at writing their name from memory and his / her VMI score.*

It was concluded that visual-motor integration as determined by the Test of Visual Motor Integration **can be a significant predictor** *of a child's ability to form letters, write his name from memory and of the presence of letter reversals in writing in the Grade 0 child.*

Key words: VMI, Handwriting, Letter Formation, Handwriting Legibility, Grade 0

Introduction

According to the Kwa-Zulu Natal Department of Education[1] children need to have adequate writing skills to be able to "express their thoughts, feelings and ideas for both themselves and the intended audience"[1]. In Grade 0, which is normally the pre-entry into formal schooling, children begin to develop an awareness that writing carries meaning. However, learning to write is much more than learning handwriting itself. Handwriting, as described by Goyen & Duff[2], is considered a complex skill involving an intricate interchange of not only visual and motor abilities, but also cognitive and perceptual processes, psychosocial, biomechanical, and environmental factors. According to McHale & Cermak[3] approximately 30% to 60% of a child's school day is spent on fine motor tasks, where 85% of these fine motor activities focus on writing skills. Children are often judged according to their neatness in handwriting and constantly compare their performance with the performance of their peers. Handwriting difficulties however often appear to persist until children are well into formal education. For

this reason, early success in handwriting is required to positively mould a child's academic experience.

The author of the Developmental Test of Visual-Motor Integration[4] (the VMI) determined that there was a significant correlation between academic achievement and a child's ability to copy geometric forms. The VMI was designed to measure visual-motor integration, the coordination of visual and motor functioning, and to reflect developmental age differences in that arena. Desai and Rege[5] found a significant correlation between the VMI and the Modified SCRIPT scores while researching the efficacy of remedial occupational therapy with children with cerebral palsy. The results indicated an increase in VMI Scores and in Modified SCRIPT[5] scores.

This study was therefore conducted to ascertain the link between handwriting skills and visual motor integration in Grade 0 children.

Literature Review

According to Cornhill and Case-Smith[6], international studies have established strong and significant correlations between VMI assessment scores and handwriting. In a study done by Weil and Amundson[7], a significant correlation between VMI scores and the child's ability to legibly copy letters was found. In a replication of this study done by Daly, Kelley and Krauss[8], these findings were further reinforced, as strong correlations were found between VMI assessment scores and children's ability to legibly copy letter forms[9]. These studies along with those done by Beery[4] show that the Developmental Test of Visual Motor Integration has been useful in assessing children's readiness for writing. This reinforces the researchers' decision to utilise the Developmental Test of Visual Motor Integration[9] as a means of assessment.

In studies conducted in 1998 and 2006, Graham *et al*[10, 11] found that competence in handwriting was usually described in terms of legibility and that features of poor handwriting legibility included added strokes, producing smaller letters, and exhibiting more variability in spacing and alignment.

Children with handwriting difficulties are often referred to occupational therapists. A study conducted by Case-Smith[12] to determine the efficacy of occupational therapy interventions, established that children who received occupational therapy demonstrated improved letter legibility. Another study by Dankert *et al*[13] found improved visual-motor skills following occupational therapy intervention.

At a short-term Remedial School in Durban, South Africa, the occupational therapists, Steinhardt *et al*[14], developers of the Writing Rate Information Test (WRIT) found that many children with learning disabilities are referred for an occupational therapy assessment, as they are slow or do not complete tasks. Writing involves many aspects of function, including sensori-motor (muscle tone, endurance, motor planning and vision), cognition, perception (both auditory and visual), language, memory and concentration. In children who have learning disabilities all these components of function need to interact to enable them to be successful at forming letters at a normal speed. Copying a passage can give an indication of the speed with which a child can perform the physical aspects of writing[14].

Given the above information, Steinhardt et al[14] felt it was necessary to devise a writing speed test for South African children (the WRIT) as they are expected to write only their names from memory, and to copy lower case letters at 5 years of age[15]. This is in contrast to America where children are taught literacy skills much earlier. In many other countries, children are also expected to do more at an earlier age with respect to writing. The WRIT is a useful tool by which to assess writing speed as well as observing the child's behaviour, pencil grip, and writing skills. Writing skills observed within the WRIT include general appearance, accuracy, size, spacing, slant, rhythm, letter formation, reversals and perseveration [14]. The norms for the WRIT were obtained from testing South African School going children.

Since young children need to also develop the skills of physically forming letters in a decipherable way, this study was conducted in an effort to understand how factors such as letter formation, legibility, and slant contributed to the overall quality of handwriting and to assist occupational therapists, parents and teachers to identify potential problems in handwriting in the preparatory phase of school. The research question is therefore: Does visual motor integration affect handwriting, more specifically, legibility and letter formation?

Methodology

A quantitative methodological approach was utilised and a pilot study conducted prior to the actual study identified possible difficulties that could have arisen in the data gathering process.

Assessments

The assessments were as follows:

- Biographical data were obtained from the child's parents via a short questionnaire.
- The Developmental Test of Visual-Motor Integration[9].
- The WRIT[14] in which a writing sample was obtained.

The children's handwriting legibility was examined from writing their names from memory, and their ability to copy letters "a" to "l" of the alphabet, as this is what they had covered in the curriculum at the time of testing. Handwriting legibility was scored according to general appearance, accuracy, size, slant, rhythm, reversals and perseveration. Legibility was scored using a 3-6 point Likert Scale as indicated by Steinhardt *et al*[14]. Samples were also marked in terms of letter formation, where a specific set of marking criteria were used to analyse how the child physically formed the letters. The score was either correct or incorrect. (Refer to *Figure 1* for an example). Each child received a page with a space for them to write their name, as well as a section for them to copy lower case letters of the alphabet.

Study population

The study population comprised children from culturally diverse pre-primary schools in Kwa-Zulu Natal, South Africa. The researchers selected eight schools in the greater Durban area that were logistically accessible. The inclusion criteria stipulated that the children had to be in Grade 0 and had to be between the ages of 4 ½ and 5 ½ years on the day of testing. (In the final study there were no children younger than 5 years of age due to the time of year). Moreover children should have attended pre-school for at least one year prior to Grade 0.

All children that met the inclusion criteria were invited to be part of the study. This ensured that there was no sampling bias. 98 children were eligible for the study in terms of age, however due to absenteeism and not being able to attain consent timeously, only 70 children were included. From this, a further 17 were excluded as a result of their having either received occupational therapy; repeated the year; not attended preschool previously or undergone VMI testing within the preceding 6 months. These children were excluded to prevent possible skewing of the results. Thus a sample of 53 children participated in the study.

Methods

Testing was done at each participating school within a two day period, with a maximum of 7 children per researcher per testing session. Group testing was suitable as "the VMI norms have been found to be appropriate for both group and individual administrations"[9]. Extraneous variables were eliminated through maintaining similar environmental conditions, using the same equipment, and giving standardised instructions. The researchers aimed at preventing bias from the tests by prescribing the order of the tests to avoid the possibility of the first test influencing the second. Therefore half of the children were given the VMI first and then the handwriting test, and *vice versa* for the other half of the study population.

Scores obtained from the VMI test were analysed using the standardised form of scoring[9].

The scoring criteria for marking the letters were adapted from the WRIT by the researchers. This was achieved by using the relevant sections of the test, and scoring them correct or incorrect according to the letter formation *(refer to Figure 1 for an example)*.

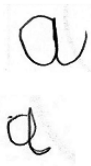
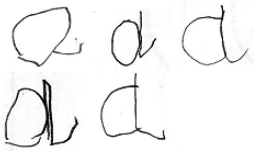
Letter	Criteria	Marked appropriate	Marked incorrect
'a'	Must be one continuous stroke beginning at the upper 'ball' of the letter		

Figure 1: E.g. of marking criteria for letter 'a'

The child's name was marked using similar criteria, as incorrect or correct, and a note of the presence of reversals was made. The Statistical Analysis System (SAS)[16] software package was utilised to analyse the data. This program allows for conversion of data to easily understandable tables and graphs. Analysis was done to determine the correlation between the subjects' VMI score and their handwriting skills. When one compares two variables, the degree of correlation is shown in a number. P=0.05 is a significant statistical marker, and therefore if the number is below this then it is said to be significant, i.e. there is a good correlation between these variables.

Parents were advised that the study would not replace a comprehensive assessment of their child should this become necessary. Ethical clearance was obtained from the relevant structures within the University of Kwa-Zulu Natal and written consent was obtained from the parents of the children. A brief summary of the overall findings was provided in writing to the principal of each school at the end of the study. These overall results were then disseminated to the parents from the schools themselves.

Findings and Interpretation

The sample consisted of 26 boys and 27 girls who participated in the study. Refer to *Table 1* for age ranges and race distribution.

Table 1: Demographics

Chronological Age Ranges	%	Race Distribution	%
5.0 years – 5.1 years	19%	African	41%
5.2 years – 5.3 years	30%	Coloured	6%
5.4 years – 5.5 years	34%	Indian	34%
5.6 years	17%	White	19%

Letter Formation of "a" to "l"

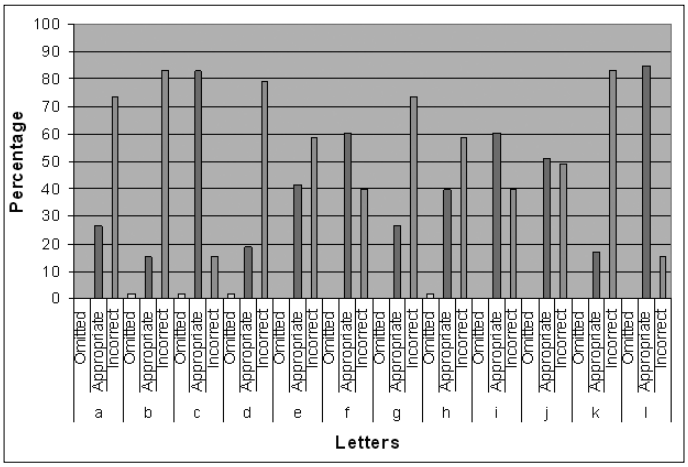


Figure 2: Letter Formation of "a" to "l"

Figure 2, shows that children performed better in the letters **"c"**, **"f"**, **"i"** and **"l"** than the other letters in the research sample. According to Brindise[17] letters formed through simple downward strokes are easier to form than letters involving curves. Letters such as "**h**", "**b**" "**k**" contain more curves and pencil marks and are therefore more complex. Although the letter **"c"** is a curve, this is a simple curve and therefore was easier to form than others within the a-l sequence.

The Relationship of VMI to Letter Formation

On initial analysis, there appeared to be a correlation between the letter formation of only the letters "**e", "f"** and **"k"** and **the VMI** (statistical values below a 0.05 significance level).

A further analysis using the t-test was done, where letter formation scores were compared to the **mean** score of the VMI (*Figure 3*). In this analysis, as depicted in the graph, the statistically significant values are shown below the p=0.05 significance line using the t test. A significant correlation with the VMI was found in 83.3% of the letters (10 out of 12). No correlation was found between handwriting legibility and the VMI scores.

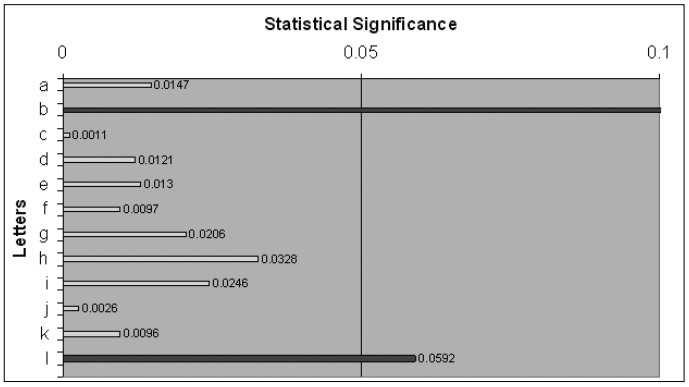


Figure 3: Letter Formation Compared to VMI Scores (Using Mean Values)

The Relationship between the VMI and Name Writing

A correlation was found between the writing of the name from memory and VMI, at a 5% significance level. The interpretation of this level of significance is that a child is who is able to write his name from memory is more likely to have a high VMI score compared to a child who is unable to do this. When analysing the correlation between reversals and the VMI, it was found that children who do not reverse letters in writing their names are more likely to have a high VMI score compared to children that do have reversals of letters in their name.

Conclusion

This study was aimed at establishing whether a correlation exists between Visual Motor Integration and Handwriting Skills, specifically letter formation and handwriting legibility, in pre-school children aged between 4½ - 5½ years. In summary, general appearance, accuracy, size, slant, rhythm, reversals and perseveration indicated the quality of handwriting legibility. The way the children physically formed the letters was considered letter formation.

The results of this study indicated a significant correlation between **VMI** and **letter formation,** but no significance was found between **VMI** and **handwriting legibility** in contrast to Daly *et al*[8] and Weil & Amundson[7] who found a significant correlation between VMI assessment scores and a child's ability to copy letters legibly.

More robust statistical information could be obtained from using a larger and more varied sample population as more extensive data analysis can be done. In addition, investigating children from more than one age group may lend itself to more extensive data analysis and enhance the degree of significance.

The significant correlation yielded in this study can serve to identify visual motor and handwriting problems within the grade 0 age group. This would allow for early writing programmes to be implemented by not only occupational therapists but also teachers. This study adds to the international research that already confirms the link between handwriting and VMI. [2,4,5,6,8,9]

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Corresponding Author

Pragashnie Naidoo
Senior Tutor
Discipline of Occupational Therapy
School of Audiology, Occupational Therapy & Speech-language Pathology
Faculty of Health Sciences
University of Kwa-Zulu Natal
E-mail: naidoopg@ukzn.ac.za