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DIFFERENCE BETWEEN VISUAL-MOTOR INTEGRATION STATUS OF TYPICALLY DEVELOPED LEARNERS AND LEARNERS WITH LEARNING-RELATED PROBLEMS

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ABSTRACT

Proficiency in visual-motor integration, visual perception and motor coordination plays an important role in academic skills of learners during the early school years. The purpose of this study was to determine the difference between the visual-motor integration status of typically developed learners and learners with learning-related problems between 7 and 8 years of age through a cross-sectional satudy design. Sixty-eight learners (boys=45; girls=23) were divided into a group with learning-related problems (LP; n=31) with a mean age of 7.58±0.43 years, and typically developed learners (TP; n=37) with a mean age of 7.54±0.31 years. The VMI-4 evaluated the learners' visual-motor integration, visual perception and motor coordination skills. The results indicated that the TP performed statistically and practically significantly better with regard to visual-motor integration (p≤0.001; d=0.81) and visual perception (p≤0.001; d=1.21) compared to the LP group. The highest percentage of learners in both the groups was in the average category in terms of visual-motor integration (LP: 74.19%; TP: 70.27%). More learners from the LP group were in the below 'average category' (25.58%) and the 'well-below average' category (3.23%). The results confirmed that learners with learning-related problems experience more visual-related difficulties than typically developed children. Typical group

***Keywords*:** Learning-related problems; Visual-motor integration; Visual perception, Visual-motor coordination.

INTRODUCTION

Proficiency in visual-motor integration, visual perception and motor coordination plays an important role in the academic skills of learners in the early school years and can have an impact on their reading, writing, mathematical skills or overall academic performance (Kramer & Hinojosa, 2010; Chen *et al.*, 2011; Pienaar *et al.*, 2013; Cheng *et al.*, 2014; Ayhan *et al*., 2015).

The development of visual-motor integration occurs from birth until about 15 years and is defined as the transference of visual perception into motor functions (Beery & Buktenica, 1997; Sortor & Kulp, 2003). According to Beery and Buktenica (1997), visual-motor integration skills are divided into two sub-components, namely visual perception and motor coordination (finger–hand movements). It refers to the integration of visual, perceptual and motor skills and includes well-coordinated finger-hand movements, which are necessary when it comes to fine motor skills (Tseng & Chow, 2000; Exner, 2005; Lane, 2005; Van Hoorn *et al.*, 2010). Visual perception refers to an acquired process that gives meaning to the environment through the creation of visually perceived images (Beery & Buktenica, 1997; Cheatum & Hammond, 2000; Haywood & Getchell, 2014). Lastly, according to researchers, motor coordination involves the use of information obtained from the visual system to perform an action or movement (Beery & Buktenica, 1997; Desrochers, 1999; Winnick, 2005), and plays an important role in fine motor skills, for instance pasting, cutting, colouring and writing (Desrochers, 1999; Winnick, 2005).

According to Beery and Buktenica (1997) and Lane (2005), the ability to copy geometric forms, letters and pictures in the correct space involves the effective development and implementation of spatial orientation, visual–spatial encoding, memory and motor planning. These researchers also state that these skills could show a significant correlation with learners' academic achievements. In this regard, Van Hartingsveldt *et al.* (2014) are of the opinion that visual–motor integration and fine motor coordination are important building blocks for scholastic tasks. They continue by adding that these skills could have an influence, especially on handwriting, spelling and writing skills, and a lack of these skills could in turn be related to learning problems.

A learning problem/disability can be defined as the malfunctioning of one or more psychological or physiological processes involved in understanding or using language, whether verbal or non-verbal. It can manifest in the inability to listen, think, speak, read, write, spell, do mathematical calculations or perform certain motor skills (Cheatum & Hammond, 2000; Winnick, 2005). The prevalence of learning-related problems among school-aged learners in the world is currently estimated between 4% and 15% (Cheatum & Hammond, 2000; Barlow & Durand, 2002; Shokane *et al.*, 2004). However, the prevalence among South African learners is believed to be approximately 10% to 30% (Vermoter, 2015). According to McHale and Cermak (1992), 30% to 60% of a learner's school day is spent on reading, writing and other near-point visual tasks that incorporate visual-motor integration, visual perception and motor coordination skills. Researchers are further of the opinion that learners with hidden visual deficits, which include visual-motor integration deficits, may become discouraged and avoid doing these visual tasks, which in turn could lead to learning-related problems (McHale & Cermak, 1992; Goldstand *et al.*, 2005; Parush *et al.*, 2006; Van Hoorn *et al.*, 2010; Pienaar *et al.*, 2013).

In agreement with the above-mentioned researchers, the research of Pieters *et al.* (2012) on seven- to nine-year-old learners indicated that learners with moderate learning-related disabilities also presented with poor visual-motor integration, visual perception and motor coordination skills. Various researchers have indicated that visual-motor integration is related to cognitive performance and is one of the most important activities for the preparation of writing skills (Kramer & Hinojosa, 2010; Chen *et al.*, 2011; Cheng *et al.*, 2014; Pienaar *et al.*, 2013; Ayhan *et al.*, 2015). Poor visual-motor integration skills could therefore affect the way in which learners copy letters and numbers off the board, which could lead to poor handwriting skills (Tseng & Chow, 2000; Sortor & Kulp, 2003; Van Hoorn *et al.*, 2010). According to Khalid *et al.* (2010), learners in pre-primary schools who experience problems with visual-motor integration skills also experience problems with visual perception, fine motor coordination, cognitive planning, self-confidence and writing skills. Deficits in terms of mathematics, writing, spelling and reading, as well as poor word spacing, letter- and shape recognition, may be observed in a child who experiences visual-motor integration problems (Kulp, 1999; Son & Meisels, 2006; Van Hoorn *et al.*, 2010; Pienaar *et al.*, 2013). According to various researchers, visual problems could interfere with the learning process and complex visual perception skills are important building blocks for learning and mastering various academic skills, such as reading, writing and copying from the blackboard (Kulp, 1999; Cheatum & Hammond, 2000; Pienaar *et al.*, 2013) since 75% to 90% of these learning processes take place through visual observation. When learners learn to read, appropriate visual analysis skills should already be established so that they can distinguish between letters, like 'b' and 'd' or 'p' and 'q' (Kulp, 1999).

Research conducted by Pieters *et al.* (2012) on seven- to nine-year-old learners (106 typically developed learners; 39 learners with mathematics problems) in Flanders, Belgium, found deficits in visual-motor integration, visual perception and motor coordination in the group of learners that struggle with mathematics. Pienaar *et al*. (2013) evaluated the relationship between visual-motor integration, visual perception and motor coordination skills with regard to academic skills of 812 Grade One learners in the North-West province of South Africa. These researchers indicate a strong link between visual-motor integration, visual perception and motor coordination and academic skills like reading, writing and mathematics skills. The research findings of Bergert (2000) explain that learners who display poor coordination and clumsiness show early signs of learning-related problems. Therefore, it appears that if there is a problem with motor coordination, it may affect a child's academic performance, which again may lead to learning-related problems (Borsting & Barnhardt, 2001; Capellini *et al.*, 2010).

The literature indicates that the Beery-VMI is often used to assess learners' visual-motor integration, visual perception, motor coordination and academic-related difficulties among primary school learners (Beery & Buktenica, 1997; Feder *et al.*, 2000; Lim *et al.*, 2014). Furthermore, many learners that do have developmental delays, learning difficulties and neurological backlogs, also present with visual-motor integration, visual and motor coordination difficulties (Kushki *et al*., 2011; Sutton *et al*., 2011; Case-Smith *et al.*, 2013).

The above literature indicates that various research studies have been conducted to evaluate the positive relationship between visual-motor integration, visual perception, motor coordination and academic skills. However, only a few studies focused on learners with learning-related problems, and most of these studies were conducted almost a decade ago in developed countries (Borsting & Barnhardt, 2001; Capellini *et al*., 2010; Kushki *et al*., 2011; Sutton *et al*., 2011; Pieters *et al.*, 2012; Case-Smith *et al.*, 2013). There is a lack of research on this relationship and status in developing countries, such as South Africa (Pienaar *et al.*, 2013). South Africa has a population of approximately 56 million and is described as a middle-income country with high socio-economic disparities (Zere & McIntyre, 2003). According to Statistics South Africa (Stats SA, 2017), only 35% of birth to four-year-old learners were enrolled in the pre-primary schools in 2016. Thus, many learners start their Grade R year without having been part of any early childhood education, where attention is given to perceptual-motor development programmes (Stats SA, 2017). According to Pienaar *et al.* (2013), a strong relationship is evident between visual-motor integration, visual perception and school success in the early school years. These researchers further indicate that learners growing up in high-risk environments have a greater chance of having problems with their visual perception skills. In turn, this could hamper their school readiness and academic performance (Pienaar *et al.*, 2013).

Studies in South Africa, with respect to the status of the visual-motor integration, visual perception and motor coordination skills in typically developed learners and learners with learning-related problems are sparse. Therefore, the research question of this study is: What is the difference between the visual-motor integration status of typically developed learners and learners with learning-related problems? Answering the above research question will provide guidelines for kinderkineticists and educators about how visual-motor integration, visual perception, motor coordination work and how deficits in these skills could possibly cause learning-related problems.

METHOD

Research design

A once-off cross-sectional design was used for the purpose of the study.

Participants

A convenience sample of 68 learners (45 boys and 23 girls) between seven and eight years of age from three primary schools from a similar socio-economical background (Quintile 4) in the Krugersdorp area, Gauteng Province in South Africa, was selected to participate in this study. The learners were divided into two groups which represented typically developed learners (TP; n=37) and learners with learning-related problems (LP; n=31). The teachers were asked to identify learners with learning-related problems who had been receiving remedial teaching in Grade One. Furthermore, these learners had to perform below average for his/her reading, writing, spelling and mathematics skills. Learners without learning-related problems, but who were representative in terms of age and gender, were selected to be part of the Typical group (TP) on the basis of availability.

Measuring instruments

Developmental Test of Visual-Motor Integration (4th ed.) Test battery (VMI-4).

The *Beery-Buktenica Developmental Test of Visual-Motor Integration*-4th (VMI-4, Beery & Buktenica, 1997) was used to assess the visual-motor skills of the learners. This test was developed for use in children between the ages of three and 18 years to identify possible problems that children may have in specific areas of visual-motor integration (VMI) and the degree to which visual perception and finger-hand movements are well coordinated. Two supplementary tests focus on visual perception (VMI visual perception) and motor coordination (VMI motor coordination, especially hand control). The complete test takes approximately 10–15 minutes to administer. In the VMI-4 test, learners are required to copy a series of geometric figures, starting with simple figures and ending with complex figures. The copies are scored as successful (1) or failed (0). The scoring stops when a child has scored three consecutive failures.

In the *VMI visual perception test*, the task is to identify the exact match for as many as possible of the 27 geometric forms during a three-minute period. In the VMI motor coordination test, which takes about five minutes to complete, the task is simply to trace the stimulus forms with a pencil without going outside double-lined paths. The three parts of the test are scored in sequence as required: first the VMI, then the visual perception and then the motor coordination subtest. The raw scores are converted to standard scores, and then to percentiles. Using the standard score of each subtest, children can be grouped into five different categories, ranging from well-above average (133 to 160), above average (118 to 132), average (83 to 117), below average (68 to 82) and far-below average (40 to 67). The VMI-4 test has been reported to be a culture-free and a valid test (Beery & Buktenica, 1997), and the VMI-4 subtests showed a validity of 0.92, 0.91 and 0.89 respectively (Beery & Buktenica, 1997).

Research procedure

Ethical approval for the implementation of the study was obtained from the Ethics Committee of the NWU (NWU-00070-09-A1), as well as from the Department of Basic Education. Principals of the identified schools were visited and permission for the study and for the collection of the data during school hours was requested. The purpose and protocols of this study were also discussed with the principals involved. Each learner that was selected to take part in this study, received an informed consent form that was sent home to be completed by their parents/legal guardians. The participants whose parents responded positively to the informed consent forms for parental permission had to give assent themselves before they underwent testing. The learners were evaluated in terms of their visual-motor integration, visual perception and motor control. Kinderkineticists that received training in the VMI-4, evaluated the learners on the school premises during school hours. The learners were divided into groups of three and the VMI-4 was completed in a group, while the visual perception and the motor control subtests were completed on an individual basis.

Statistical analysis

The STATISTICA computer package (StatSoft, 2014) was used to analyse the data. The Statistical Consultation Services of the North-West University assisted with data analyses. The descriptive statistics (mean [M], standard deviations [SD], minimum and maximum values) of each variable was calculated first. Secondly, independent t-testing was used to determine whether differences occurred between the two groups (typically developed learners and learners with learning-related problems) regarding their visual-motor integration, visual perception and motor coordination skills. The level of statistical significance was set at $p \leq 0.01$ because of the small sample group. Effect sizes were calculated to determine the practical significance of the differences by dividing the difference in means by the largest standard deviation of the test. The interpretation of practical significance was done by using the following guidelines: $d \geq 0.2$ (small effect), $d \geq 0.5$ (medium effect) and $d \geq 0.8$ (large effect) (Cohen, 1988). Lastly, two-way frequency tables were used to compare the percentage of learners (learners with learning-related problems and typically developed learners) in the different categories with respect to their visual-motor integration, visual perception and motor coordination skills. A Pearson Chi-square of $p \leq 0.05$ served to indicate the statistical significance of the results. The strength of the correlations represented by the phi-coefficient was indicated by $w \approx 0.1$ (small effect), $w \approx 0.3$ (medium effect) and $w \geq 0.5$ (large effect).

RESULTS

Table 1 indicates the descriptive information of the 68 learners who participated in the study. The mean age of the total group (N=68) was 7.56 years, with a slightly higher mean age (7.58±0.48 years) for the LP group in comparison to the TP group (7.54±0.31 years). Both groups had a higher representation of boys (LP group=21 and TP group=24) than girls (LP group=10 and TP group=13).

***Table 1*. COMPOSITION OF LEARNERS: AGE AND GENDER**

Gender	Age: LP group Mean±SD	n	Age: TP group Mean±SD	n
Boys	7.62±0.41	21	7.57±0.31	24
Girls	7.51±0.47	10	7.48±0.31	13
Total	7.58±0.43	31	7.54±0.31	37

LP=Learners with learning-related problems; TP=Typically developed learners
n=Number of learners;

Independent t-testing was used to determine whether any significant differences in the visual-motor integration, visual perception and motor coordination of the two groups were present. Table 2 indicates that the TP group preformed statistically (p≤0.05) and practically (d≥0.8) significantly better than the LP group regarding the visual-motor integration (105.95 vs. 93.45) and visual perception (100.86 vs. 87.81) skills. With regard to motor coordination, the LP group showed a slightly lower average (M=95.71) than the TP group (M=102.78), although no statistically significant difference (p=0.125) was found between the groups.

***Table 2.* DIFFERENCES BETWEEN LEARNERS WITH LEARNING-RELATED PROBLEMS (LP) AND TYPICALLY DEVELOPED LEARNERS (TYPICAL)**

Variables	LP group (n=31) M±SD	TP group (n=37) M±SD	Significant differences df	t	p	d
Visual-motor integration	93.45±11.01	105.95±15.36	66	3.78	**≤0.001***	**0.81**^
Visual perception	87.81±11.65	100.86±10.74	66	4.81	**≤0.001***	**1.12**^
Motor coordination	95.71±16.88	102.78±20.09	66	1.55	0.125	**0.35**#

M=Mean SD=Standard Deviation df=degrees of freedom t=t-value * p-value ≤0.01
n=Number of learners # d-value ≥0.5 ^ d-value ≥0.8

Lastly, two-way frequency tables was used to compare the percentage of learners (LP and typically develop learners) in the different categories with respect to their visual-motor integration, visual perception and motor coordination skills (Table 3). Each skill was differentiated according to five categories, namely Category 1 (well-above average);

Category 2 (above average); Category 3 (Average); Category 4 (below average) and Category 5 (far-below average).

Table 3. **PERFORMANCE OF LP AND TP GROUPS FOR VARIABLES**

Variables	**Category 1** % (n)	**Category 2** % (n)	**Category 3** % (n)	**Category 4** % (n)	**Category 5** % (n)
Visual-motor integration					
LP	0.00 (0)	0.00 (0)	74.19 (23)	25.58 (7)	3.23 (1)
Typical	2.70 (1)	21.62 (8)	70.27 (26)	5.41 (2)	0.00 (0)
Visual perception					
LP	0.00 (0)	0.00 (0)	74.19 (23)	19.35 (6)	6.45 (2)
Typical	0.00 (0)	2.70 (1)	94.59 (35)	2.70 (1)	0.00 (0)
Motor coordination					
LP	0.00 (0)	0.00 (0)	77.42 (24)	16.13 (5)	6.45 (2)
Typical	8.11 (3)	16.22 (6)	72.97 (27)	2.70 (1)	0.00 (0)

Category 1=Well-above average; Category 2=Above average; Category 3=Average; Category 4=Below average; Category 5=Well-below average; n=Number of participants;

LP group: N=31; TP group: N=37; Visual-motor integration: p=0.045 & w=0.38; Visual perception: p=0.035 & w=0.36; Motor coordination: p=0.387 & w=0.25

The results in Table 3 indicate that the highest percentage of the LP group was in Category 3 (average) for visual-motor integration (74.19% vs 70.27%); visual perception (74.19% vs 94.59%) and motor coordination (77.42% vs 72.97%) compared to the Typical (learners without learning problems) group. Furthermore, it is clear that the TP group performed better overall than the LP group regarding visual-motor integration, visual perception and motor coordination, with more learners represented in Category 1 (well-above average) and Category 2 (above average). Furthermore, Table 3 indicates that more learners in the LP group struggled with the VMI-4 and the two subtests and were in Category 4 (below average) and Category 5 (far-below average) with respect to the visual-motor integration [(25.58%; n=7 and (3.23%; n=1)], visual perception [(19.35%; n=6) & (6.45%; n=2)] and motor coordination [(16.13%; n=6) & (6.45%; n=2)]. Statistical and practical significant differences with a medium effect were found between the two groups, with the TP group showing higher statistical and practical values for visual-motor integration (p=0.045 & w=0.38) and visual perception (p=0.035 & w=0.36). With regard to motor coordination, no statistically significant (p=0.387) differences were found, although a small practically significant effect (w=0.25) was found.

DISCUSSION OF RESULTS

This study aimed to determine the difference in the visual-motor integration status of typically developed learners and learners with learning-related problems. The results of this study revealed that there were differences between typically developed learners and learners with learning-related problems with respect to their visual-motor integration, visual perception and motor coordination skills. Typically developed learners performed statistically ($p \leq 0.01$) better during visual-motor integration and visual perception than learners with learning-related problems. These findings correspond with research findings of numerous researchers, which indicates that learners with visual-motor integration and visual perception problems exhibit more learning-related problems compared to their peers (Tseng & Chow, 2000; Sortor & Kulp, 2003; Kramer & Hinojosa, 2010; Van Hoorn *et al.,* 2010; Chen *et al.,* 2011; Cheng *et al.,* 2014; Pienaar *et al.,* 2013; Ayhan *et al*., 2015). This could be because learners, who usually struggle with non-verbal learning barriers, have problems with visual-spatial and visual perception problems (Ayda *et al*., 2009).

Visual-motor integration also plays an important role in reading, mathematics, writing and spelling skills, and according to Kulp (1999), all of the these aspects are directly related to academic achievement. Khalid *et al.* (2010) also indicate that learners in pre-primary schools who experience problems with visual-motor integration skills, also experience problems with visual perception, fine motor coordination, cognitive planning, self-confidence and writing skills. In agreement with the results of the current study, the study of Pieters *et al*. (2012) on seven- to nine-year-old learners also indicated that learners with moderate learning-related disabilities presented poor visual-motor integration and visual perception skills. Pienaar *et al.* (2013) also reported a relationship between visual-motor integration, visual perception and the academic skills of Grade One learners in the North-West province of South Africa.

The results further indicate that although most of the learners in both groups were in the average category regarding their visual-motor integration, visual perception and motor coordination skills, it appeared that the learners with learning-related problems struggled more with these skills compared to the typically developed learners. More learners with learning-related problems were represented in the below average and well-below average categories with respect to their visual-motor integration (28.81% vs. 5.41%), visual perception (25.8% vs. 2.7%) and motor coordination (22.58% vs. 2.7%) in comparison to learners who did not have any learning-related problems.

These results could be explained by the fact that visual-motor integration and visual perception skills are closely linked with cognitive performance and a child’s intelligence coefficients. These learners possibly struggle to extract and organise visual information from the environment, which makes it even more difficult for them to integrate this information with their other senses (Parush *et al*., 2006). Another possible explanation for the current findings could be that some of these learners could have underlying developmental problems, inadequate fine motor skills or visual delays (Tseng & Chow, 2000; Parush *et al*., 2006; Van Hoorn *et al.,* 2010; Pienaar *et al.,* 2013). It could also be argued that not enough attention had been given to these skills during their school readiness year (Grade R) (Parush *et al*., 2006; Pienaar *et al.,* 2013).

Furthermore, Kulp (1999) is also of the opinion that it appears that visual perception problems, especially in the early years, shows a direct link with learning readiness and academic achievement in reading, mathematics and writing. The findings of several researchers correspond with the results of this study, which proves that learners with learning-related problems show more disabilities with respect to visual perception than their peers (Griffin *et al*., 1993; Kulp, 1999; Bergert, 2000; Winnick, 2005; Papavasiliou *et al*., 2007). According to researchers like Griffin *et al*. (1993), Cheatum and Hammond (2000) and Papavasiliou *et al*. (2007), it is clear that learners need more complex visual perception to read and write effectively. The reason might be that the words and letters they read or view should be connected to the meaning of the words and their pronunciation. Moreover, it includes the understanding of the differences between various formsand shapes and where to place the answers to mathematical questions.

Bergert (2000) states that poor motor coordination, clumsiness and discomfort in motor skills could be described as common early warning signs of learning-related problems, and, therefore learners showing signs of motor coordination problems could be more prone to develop scholastic problems later in their school years. Various researchers also indicated that if a child has problems with visual-motor coordination skills, it could lead to motor disabilities, such as coordination (hand-eye and foot-eye coordination), spatial orientation, balance, as well as fine motor disabilities, which in turn may influence the academic performance of the child (Kulp, 1996; Desrochers, 1999; Winnick, 2005).

LIMITATIONS

This study had some limitations that should be acknowledged. This research involved a small group of learners, which might influence the generalisation of the results. Despite this shortcoming, the study generated valuable information regarding the visual-motor integration, visual perception and motor coordination differences between learners with learning-related problems and typically developing learners. Nevertheless, it is recommended that future research does more invasive investigations in the area of the status, correction and improvement of the visual-motor integration, visual perception and motor coordination skills in learners with learning-related problems in South Africa, given the importance of these skills in scholastic performance. It is also recommended that the relationship between visual-motor integration, visual perception and motor coordination should be evaluated in relation to the different school learning areas. Detecting deficits in these skills and implementation of the appropriate intervention programmes to improve these skills could also help to decrease the number of problems during the learner’s school years.

CONCLUSION AND RECOMMENDATIONS

The results of this study confirm that learners with learning-related problems show more problems related to visual-motor integration, visual perception and motor coordination than their peers. Evidence exists that visual-motor integration plays an important role in reading, mathematics, writing and spelling skills, which are all directly related to academic achievement. Therefore, it is important to evaluate learners regarding visual-motor integration, visual perception and motor coordination skills as early as possible, to make sure that if any delays do exist, these skills are improved so that these backlogs do not lead to further school failure.

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