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Repeatability of the VMI Supplemental Developmental Test of Visual Perception

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ABSTRACT

Visual perceptual ability has been found to be related to academic achievement. Therefore, the screening of perceptual skills in children should provide valuable information. However, the time required to administer and/or score many visual perceptual tests makes them difficult to use as a screening test. The VMI Supplemental Developmental Test of Visual Perception (VP) test 1) has been shown to be related to academic performance, 2) has an objective scoring system and 3) can be administered and scored quickly and easily. Therefore, the VP test may have the potential to be used as a stand-alone screening test of motor-reduced visual perception. However, its repeatability as a stand-alone screening test has not been evaluated.

Method: The Ohio State University institutional review board approved the study protocol, advertisements, and informed consent forms. Informed consent was obtained prior to administering any testing. A Modified Clinical Technique vision screening was administered on a different day prior to the perceptual testing. The VP test was administered to second, fourth and sixth grade children (n=171, mean age=10.08 years) from a middle class, primarily white, elementary school near Columbus, Ohio. Children (n=136, mean age=10.10 years) were then retested within one month. Repeatability analysis included McNemar analyses, repeated measures, and plotting the difference versus the mean of the scores obtained at the initial test and retest.

Results: The mean +/- standard deviation VP standard score was +115.5 +/- 14.5. For McNemar analyses, failure was defined as a score below one standard deviation below the mean. Analyses using both sample means and published norms revealed that children were referred similarly on test and retest. The mean difference between test and retest scores was similar to zero. The 95% limits of agreement were found to be –3.74 to 3.99.

Conclusion: No consistent learning effect appeared to be present upon retest.

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Keywords: children, repeatability, visual perception, VMI Supplemental Developmental Test of Visual Perception

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Introduction

Visual Perception involves the interpretation and organization of visual information, such as the identification of an image's distinguishing features and details. The literature has shown a significant relation between visual perception and academic abilities.[1-20] Furthermore, therapy has been shown to improve deficits in visual perception,[21-23] although controversy exists.[24] Therefore, a test of visual perceptual ability with good test-retest reliability and validity which could be quickly administered and scored for use as a screening test of visual perceptual ability in children would be valuable.

Performance on the VMI Supplemental Developmental Test of Visual Perception (VP) has been found to be related to academic achievement.[4] The VP test is a motor-reduced test of visual discrimination based upon the VMI forms in which the child identifies the matching forms in a multiple choice

format. The administration time is 3 minutes and the test can be scored quickly and easily. The VP test is normed and standardized to be administered after the VMI. However, like many tests of visual perception, the time required to administer and score the VMI and its Supplemental Developmental Tests of Visual Perception and Motor Coordination make it difficult to use as a screening tool for visual perception ability. Because of its ability to be administered and scored quickly, the VP test may have the potential to be used as a stand-alone test for screening visual perceptual ability in children. However, its repeatability and validity as a stand-alone test have not been evaluated. The purpose of this investigation was to assess the repeatability of the VP test in second through sixth grade children.

Subjects and Methods

A Modified Clinical Technique vision screening was administered on a different day prior to the perceptual testing. Informed consent was obtained prior to administering any testing. The VP test (4th edition) was administered to second, fourth and sixth grade children (n=171, mean age=10.08 years) from a middle class, primarily white, elementary school near Columbus, Ohio. Children were tested individually in a classroom in a screening setting (i.e. other perceptual testing was also being performed in the same room). Children were then retested within one month. Due to constraints of the examiners, only a subgroup of children (n=136, mean age=10.10 years) could be retested. Children were selected for retest based upon availability and without respect to perceptual, visual and/or academic ability. Seventy-two children were administered both the test and retest by the same optometric clinician. The retest was administered in the same room as the initial test administration. Testing and scoring was performed according to the test directions, with the exception that the VP test was administered as a stand-alone test (i.e. administration of the VP test did not follow the administration of the test of Visual Motor Integration).

Independent samples, two-tailed t testing was performed to determine whether or not performance on the Visual Perception test was significantly different in children who failed versus passed the vision screening. Repeated measures analysis was performed to determine whether or not there was a significant effect of having the same or a different examiner on test/retest. One way ANOVA was used to determine if a significant age effect was present for performance on the VP test. Repeatability analysis included McNemar analyses, repeated measures, and plotting the difference versus the mean of the scores obtained at the initial test and retest. Descriptive data, ANOVA, McNemar and repeated measures analyses were generated with SPSS for Windows. The difference versus the mean of the scores obtained at the initial test and retest was plotted using Microsoft Excel. An alpha level of 0.05 was used for all analyses.

Results

All the children in the sample (n = 171) were able to complete the Visual Perception Test (VP). One child was absent for the vision screening and forty-seven children (27%) were referred from the vision screening (70% of these referrals were for myopia or astigmatism). Independent samples t-test revealed

Table 1. Descriptive Data for Visual Perceptual Test and Retest Results

Visual Perception Test Session	n	Mean Raw Score	Std. Dev.	Std. Error	Mean Standard Score	Std. Dev.	Std. Error
Initial Test							
Grade 2	62	22.2	2.83	0.36	120.4	18.5	2.3
Grade 4	56	23.9	2.34	0.31	113.7	12.8	1.7
Grade 6	53	25.3	1.38	0.19	111.9	8.2	1.1
Total Group	171	23.7	2.63	0.20	115.5	14.5	1.1
Retest							
Grade 2	49	23.0	2.21	0.32	126.1	15.5	2.2
Grade 4	43	24.1	1.55	0.24	115.2	8.8	1.3
Grade 6	44	25.1	1.50	0.23	110.8	9.1	1.4
Total Group	136	24.0	1.98	0.17	117.7	13.4	1.1

Table 2. Pass/Refer Classification of Children According to Sample Norms

Pass/Refer Status at Initial Test	Pass/Refer Status at Retest		
	Refer	***Pass***	***Total***
Refer	7	9	16
Pass	10	110	120
Total	17	119	136

Table 3. Pass/Refer Classification of Children According to Published Norms

Pass/Refer Status at Initial Test	Pass/Refer Status at Retest		
	Refer	***Pass***	***Total***
Refer	0	2	2
Pass	2	132	134
Total	2	134	136

no significant difference in the mean performance of children who were passed versus referred on the vision screening (initial test, $p = 0.901$; retest, $p = 0.981$). Repeated measures analysis showed no significant effect of having the same versus a different examiner from test to retest ($p = 0.802$). Therefore, the data from all children in the group were included in the analysis. Means and standard deviations were determined for the test and retest populations because the distributions were sufficiently normal (See Table 1). A one-sample t-test revealed that the mean standard score was significantly higher than that of the normative population on both test and retest (test: $p < 0.001$, mean difference = 15.5; retest: $p < 0.001$, mean difference = 17.7).

One way ANOVA revealed a significant age effect on performance on the VP test for both grade and age in the sample population ($F = 27.113$, $df = 2$, $p < 0.001$; $F = 12.936$, $df = 5$, $p < 0.001$, respectively).

McNemar test using a failure criterion of performance below one standard deviation from the sample population mean revealed no significant difference between how children were classified at test and retest ($p = 1.00$) (see Table 2). In this analysis, 19 of the 136 children (13.9 %) were classified differently on test and retest. Similarly, McNemar test using a failure criterion of performance below the 16th percentile according to the published normative data revealed no significant difference between how children were classified at test and retest ($p = 1.00$) (see Table 3). In this analysis, only 4 of the 136 children (2.9 %) were classified differently on test and retest. However, only 4 children were referred on either test administration and no children were referred on both test administrations when using the published norms in this population.

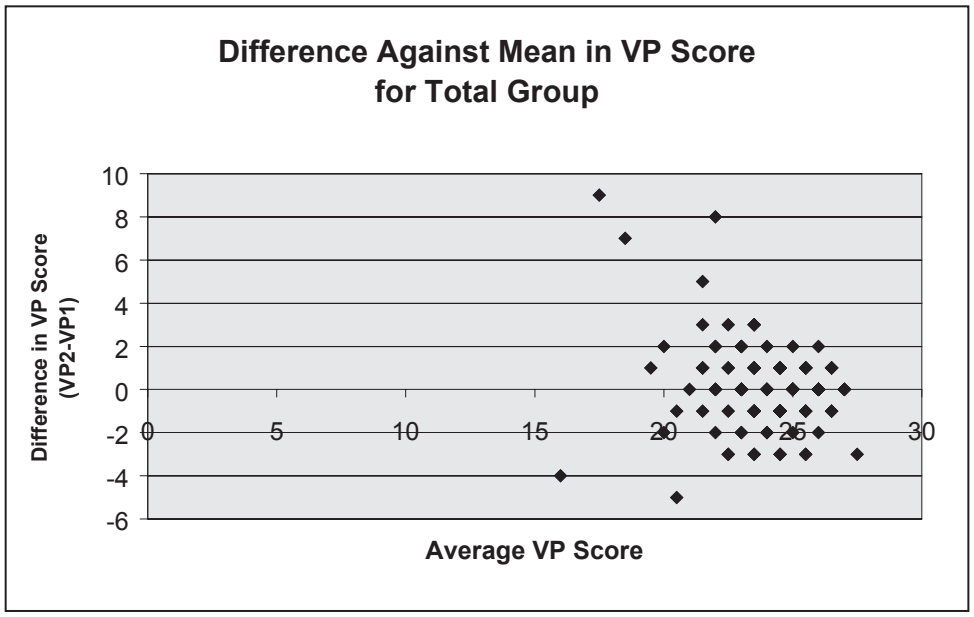
Repeated measures analysis showed no main effect of test session, vision screening status (pass/refer), or examiner (same/different) (all p values ≥ 0.369). However, repeated measures analysis controlling for age showed significant effects of test session and age, but no significant effects of MCT status (pass/refer) or examiner (same/different) or any significant interactions (see Table 4). The underlying assumptions of the repeated measures analysis were met.

Repeatability was also evaluated according to the method described by Bland and Altman.[25] Specifically, the difference in VP scores was calculated and plotted against the average VP score. Repeatability was then assessed through analysis of this plot and calculation of the 95% 'limits of agreement' (95% limits of agreement were calculated according to the mean difference ± 2 times the standard deviation of the differences).[25] A plot of the difference versus the average of the two VP scores for the total group is shown in Figure 1. For instance, one child scored 18 points on the first administration and 14 points on the retest resulting in average and difference VMT scores of 16 and -4, respectively. Overall, the mean of the differences for the total group was found to be 0.125 and the 95% limits of agreement were found to be –3.7 to 4.0. Six children were found to have a difference of ≥ |4| between test and retest. An analysis of children who passed the vision screening revealed similar results.

Table 4. Tests of Between and Within Subjects Effects Controlling for Age

Source of Variation	df	SS	MS	F	P Value
Between Subjects					
Age	1	256.8	256.8	53.7	<0.00
Same/Different Tester	1	59.78	59.78	1	1
Pass/Fail Vision Screening	1	3	3	2.04	0.155
Interaction (between same/different tester	1	1.417	1.417	6	0.587
& pass/fail screening)	129	5.685	5.685	0.29	0.278
Error		616.8	4.782	6	
Within Subjects					
Test Session	1	14.86	14.86	8.42	0.004
Age	1	9	9	1	0.006
Same/Different Tester	1	13.69	13.69	7.75	0.320
Pass/Fail Vision Screening	1	7	7	7	0.420
Interaction (between same/different tester	1	1.762	1.762	0.99	0.712
& pass/fail screening)	129	1.156	1.156	8	
Error		0.241	0.241	0.65	

Specifically, the mean of the differences was determined to be 0.093 and the 95% limits of agreement were found to be –3.5 to 3.7 in the children who passed the screening. Four children who passed the screening were found to have a difference of ≥ |4| between test and retest. All of children with a difference of ≥ |4| between test and retest were in the 2nd grade (see Figure 2). Highly repeatable results were found in the 4th and 6th graders (see Figure 3). The mean of the differences was found to be 0.6122 in the 2nd graders and –0.149 in the 4th graders. The 95% limits of agreement were calculated to be –4.74 to 5.96 in the 2nd grade children and –2.7 to 2.4 in the 4th and 6th grade children.



Note: Some points on the graph represent the performance of more than one child.

Figure 1. *Difference Against Mean in VP Score for the Total Group.*

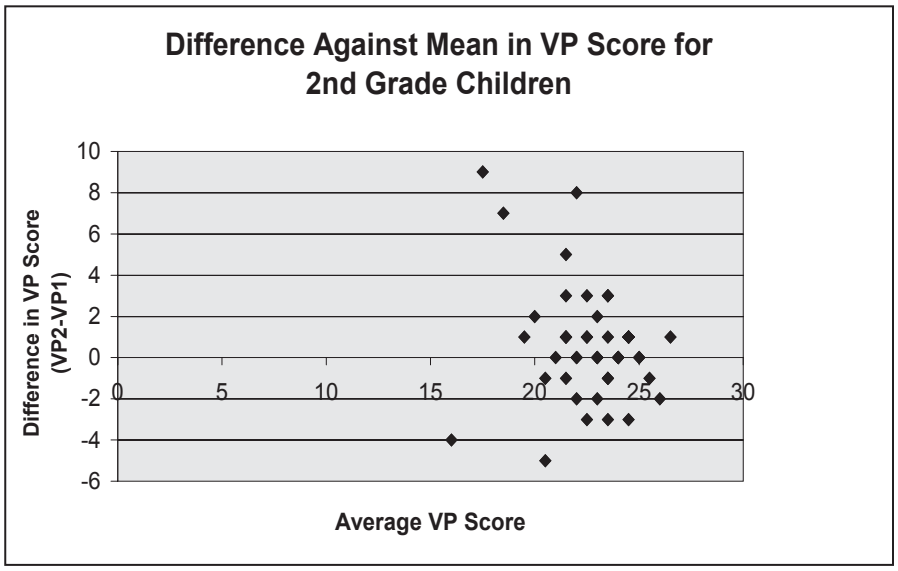
Discussion

Visual perception has been found to be significantly related to academic skills.[1-20] Therefore, the screening of visual perceptual ability in children should be valuable. The VMI Supplemental Developmental Test of Visual Perception (VP) has objective scoring criteria and can be quickly and easily administered and scored. Furthermore, performance on the VP test has been found to be related to academic ability.[4] Consequently, it may be a valuable screening instrument for visual perceptual ability. However, the VP test is normed and standardized to be administered after the VMI and its repeatability as a stand-alone test has not been previously evaluated.

Although repeatability analysis is frequently based upon calculation of correlation coefficient, comparison of the means (e.g., t test), or linear regression, Bland and Altman have pointed out the limitations of such approaches. For example, while a correlation coefficient reflects the degree to which two measurements are related, it cannot show the degree to which they agree. For example, if children invariably scored 5 points higher upon retest, the correlation between the two testing sessions would be 1.0 despite the fact that the two scores would not agree. In addition, one would expect two measurements using the same test upon the same child to be related. Consequently, correlation analysis does not provide meaningful information concerning repeatability. Therefore, repeatability analysis included McNemar's testing, repeated measures and the method described by Bland and Altman.

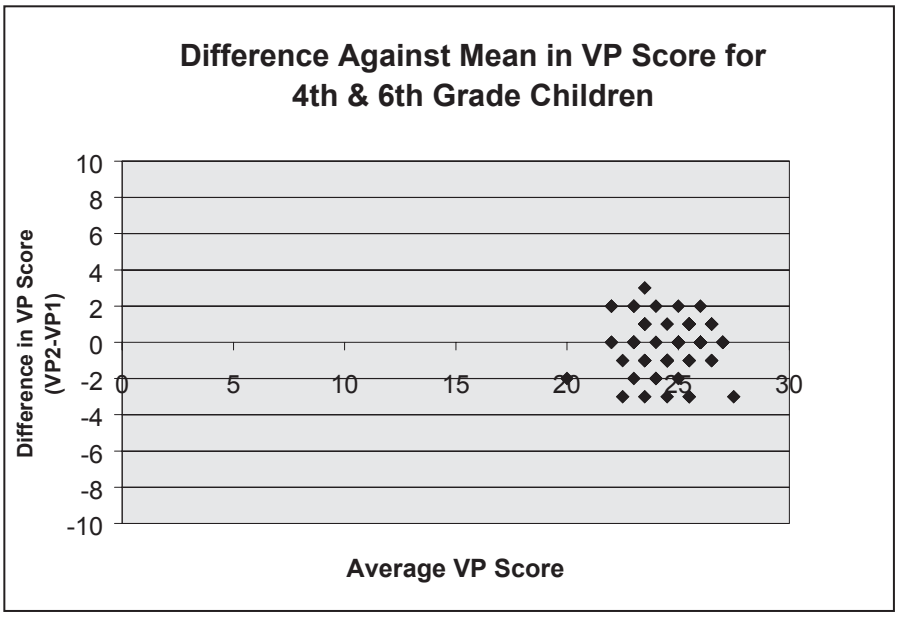
McNemar analyses showed no significant difference in pass/refer classification on test and retest using either sample means or published norms. Repeated measures analysis revealed no significant effects of test session, examiner (same/different), vision screening status (pass/refer), or interactions when age was not included in the model. However, when age was controlled for in the model, significant effects of test session and age were found.

Bland Altman analysis revealed that the mean of the differences was close to zero. Therefore, no significant bias was apparent upon retest. In other words, there was not a consistent learning curve with subsequent testing. The 95% limits of agreement were found to be –3.7 to 4.0 for the total group, -4.74 to 5.96 for the 2nd graders and –2.7 to 2.4 for the 4th and 6th graders. Only 4.4% (6/136) of children had a difference of ≥ |4| points between their test and retest scores, all of whom were in the 2nd grade. Thus, the VP test appears to show acceptable measurement error and sufficient repeatability. A limitation of this study is that the sample population scored higher on average than expected based upon the published VP normative values, therefore, it is not known if the repeatability of the VP test would differ in a group of children with reduced VP ability. Further research is needed to address this question. If the test is to be used as a stand-alone test, further research is also needed to determine whether or not new normative tables would be needed. It is not



Note: Some points on the graph represent the performance of more than one child.

Figure 2. *Difference Against Mean in VP Score for 2nd Grade Children.*



Note: Some points on the graph represent the performance of more than one child.

Figure 3. *Difference Against Mean in VP Score for 4th and 6th Grade Children.*

known whether the administration of the VP test as a stand alone test versus administration after the VMI would affect the child's performance on the VP test. Furthermore, further research is needed on the validity of the VP test as the validity of the VP test has not been previously established.

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