Original Article

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Visual Perception Status and Its Relationship with Academic Performance among Primary Indigenous Schoolchildren in Selangor, Malaysia

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Abstract:

Objective: Visual perception (VP) is often linked to academic tasks and performances that involve literacy and numeracy skills. However, there is limited literature that discusses VP among primary indigenous children. This study investigated VP status among primary indigenous schoolchildren in Selangor and its relationship with academic performance.

Material and Methods: In this study, 90 primary indigenous schoolchildren aged 7–11 were recruited. They underwent a preliminary assessment for visual acuity using the Sonksen logMAR chart to ensure optimum visual function. The VP status was then assessed using the Test of Visual Perceptual Skills 4th Edition (TVPS-4). In addition, academic performance data for four core subjects, namely *Bahasa Melayu*, English, mathematics, and science, were obtained retrospectively and classified into six mastery levels known as *Tahap Penguasaan* (TP).

Results: The VP scores of primary indigenous schoolchildren were independent of gender and school attendance rate. Compared with the standard norms, the participants' subtest scaled scores and overall standard scores (mean±S.D.=93.26±6.58, p-value<0.001) were significantly lower. Most VP subskills showed no correlation with academic performance, except for the sequential memory subtest, which showed the strongest association in *Bahasa Melayu* and science. Furthermore, the visual discrimination subtest and overall VP scores were significantly correlated with *Bahasa Melayu*, English, and science proficiency, but not mathematics.

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Conclusion: Generally, primary indigenous schoolchildren demonstrated below-average VP performance. While not all VP subskills were found to be linked to academic performance, specific interventions that heavily target the sequential memory and visual discrimination sub-domains may be effective in improving the educational outcomes of primary indigenous schoolchildren.

Keywords: academic performance, primary indigenous schoolchildren, visual perception (VP)

Introduction

Visual perception (VP) is defined as the whole process of receiving visual stimuli and visual information through sensory and cognitive functions[1]. It involves the ability of the brain to extract, organize, interpret, and understand information obtained from the surroundings[2,3]. VP is often linked to higher-level cognitive processes, including reasoning and problem solving[4]. Children who have VP problems may struggle with academic tasks, including reading, spelling, and writing[1]. A study reported that VP in children can be improved over time with continuous practice, as they gradually learn and incorporate new knowledge[5]. Fostering and supporting VP skills from an early age can be beneficial for schoolchildren, given the importance of VP in numerous cognitive and academic tasks.

Indigenous schoolchildren have been experiencing impediments in accessing quality education, stemming from socioeconomic disadvantages, geographical accessibility, cultural and language barriers[6,7]. One of the primary concerns related to the younger population among indigenous people is their performance in academics and overall educational attainment[8]. A recent study conducted in two indigenous primary schools in Johor found that, out of 22 participants, more than half struggled to score well on the mathematics test[8]. The same study highlighted that the difficulties faced by the participants stemmed primarily from their limited mathematical comprehension and literacy skills, as well as misconceptions and inattentiveness in solving basic mathematical calculations.

In Malaysia, the current national curriculum in primary schools has shifted to the classroom-based assessment known as *Pentaksiran Bilik Darjah* (PBD) in order to measure the holistic progress of student academic performance[9]. PBD is determined by the *Tahap Penguasaan* (TP) levels achieved by students in each academic subject. *Kementerian Pendidikan Malaysia* (KPM) claimed that, unlike previous examination-based approaches, PBD relies not only on psychomotor and affective development but also on cognitive engagement with learning materials[10]. Given that VP is fundamental to cognitive abilities[11,12], deficits in VP could impose a direct impact on the student's mastery levels. However, existing literature offers limited insights into how VP impacts educational outcomes in the context of PBD, particularly among indigenous children in Malaysia. Thus, investigating the relationship between VP and academic performance (i.e., TP), as measured by the current PBD framework, can provide valuable insight into whether undetected perceptual deficits are a silent contributor to poor mastery levels in academic performance among primary schoolchildren, particularly the indigenous population.

Material and Methods

Study design and sampling

This is a cross-sectional and correlational study that involved Malaysian indigenous children aged between seven and eleven years old attending primary school at the time of data collection. Based on the previous

literature, the median value of the Test of Visual Perceptual Skills 4th Edition (TVPS-4) standard score among the indigenous schoolchildren was found to be 102±9[13]. By assuming normal distribution of standard scores within this population, the median dispersion value of ±9 was adopted as a conservative proxy for the score standard deviation. The sample size was determined using the Sample Size Calculator software[14]. Given that the study outcome was measured on a continuous scale (VP scores), the single mean formula within the software was utilized[15,16]:

$$sample\ size, n = \left(\frac{z \cdot \sigma}{\Delta}\right)^2$$

Z corresponded to a 95% confidence interval (1.96), was the population standard deviation (±9), and Δ was the precision level (±2). Precision level of ±2 was applied to minimize sampling error and to enhance the sensitivity of the correlation analysis between VP and academic achievement. Based on the formula, an initial sample size of 78 participants was required. After considering a 10.0% attrition rate, the final sample size calculated was 87. Participants were required to have distance and near habitual visual acuity of 0.2 LogMAR (equivalent to Snellen 6/9) or better in each eye and to be able to speak and understand *Bahasa Melayu* to be eligible to participate in the study. Children with physical, pathological, and/or cognitive disabilities, as well as children who had sustained ocular misalignment (strabismus), were excluded from the study.

A multi-stage sampling method for selecting participants was initiated upon receiving ethics approval from the Research Ethics Committee, Faculty of Health Sciences, Universiti Teknologi MARA (UiTM), and written approval from KPM. In the first stage, the list of indigenous schools was obtained from the KPM website[17]. The schools were stratified into four administrative districts before the sequence of districts and schools was randomly generated from the Research Randomizer website[18]. The school visits were conducted in a rotational sequence across districts to minimize selection bias at the geographical level. The next stage involved recruiting students through convenience sampling until the required sample size was attained. This method was strategically adopted to ensure study feasibility after considering inconsistent attendance patterns in indigenous primary schools. While the convenience sampling approach may introduce a degree of selection bias, this limitation was mitigated by the randomization executed at the district and school levels.

Before the study was conducted, permissions were acquired from the principals and teachers of the participating schools. Written consent was secured from all parents or guardians of the children, and written assent was obtained from the respective children who participated in the study.

Instruments

The VP performance of the participants was determined using the Test of Visual Perceptual Skills 4th Edition (TVPS-4). This instrument has a high level of internal consistency and stable test-retest reliability[19], thereby making it practical for assessment in children[20]. TVPS-4 allows comprehensive VP evaluation as it examines seven subskills consisting of visual discrimination, visual memory, spatial relationships, form constancy, sequential memory, visual figure-ground, and visual closure. Scoring of TVPS-4 involved calculating the correct responses for each subtest to obtain the subtest raw score with a maximum of 18 points per subtest. The raw scores were then converted to scaled scores ranging from 1 to 19 and to corresponding percentile ranks, as specified in the test manual. The overall standard score, derived from the sum of scaled scores, was then compared with the U.S. normative data, with a mean of 100 and a standard deviation of 15.

The academic performance of the participants, namely the TP levels from the latest school examination of four subjects—*Bahasa Melayu*, English, mathematics,

and science—was acquired from the respective classroom teachers. These subjects were selected as they primarily focus on foundational literacy, numeracy, and critical thinking[21]. The TP was assessed by the teachers and recorded in a grading scale system ranging from TP1 to TP6, with TP6 representing the highest mastery level for the subject. The TP of each subject was subsequently used to analyze the relationship between VP status and the academic performance of the participants.

Procedures

Study procedures were performed by a single examiner, an optometrist who had undergone thorough training under the supervision of an experienced clinician with extensive expertise in TVPS-4 administration. Prior to the study, a demographic survey form was distributed to the parents and guardians to obtain information regarding the profile of the indigenous schoolchildren. It served as a screening tool to identify and exclude children with pre-existing physical, pathological, and cognitive disabilities. Once the demographic data were collected, a series of preliminary assessments began. Initially, visual acuity at distance and near was assessed using the Sonksen logMAR chart, a standardized chart with proven reliability in measuring visual acuity in children[22]. The smallest letter read by the participants before three consecutive failures for letter recognition was recorded as their final visual acuity. To ensure adequate visual function for subsequent VP assessment, only children achieving habitual visual acuity of 0.2 LogMAR (equivalent to Snellen 6/9) and better were deemed eligible to participate and proceed with VP assessment using the TVPS-4. Additionally, a cover test was performed by the examiner to screen for strabismus. Children found to have either manifest or latent strabismus through the cover-uncover and alternating cover tests were excluded from the main investigation. These preliminary assessments served as exclusionary screenings to mitigate confounding variables, thereby enhancing the internal validity of the data analysis.

The VP assessment was conducted in an adequately illuminated classroom within the school premises. To eliminate inter-rater variability and maintain a standardized testing environment, all tests were conducted and scored by a single, trained examiner. The examiner was seated slightly to the side of the participants to ensure a clear view of the stimulus plate in case the participants decided to provide their answer by pointing to their selected image. The test was administered individually to each student, following the standardized protocols provided in the test manual[19]. All seven subtests of TVPS-4 began with the examiner verbally introducing two sample plates to the participant before proceeding to the administration of 18 test plates. The sample plates were presented at the beginning to allow participants to get familiarized with the test. The examiner then ensured the participants understood the instructions of the samples in each subtest before continuing with the actual test items. Participants were allowed to provide the answer either by verbally mentioning the number of their selected image or by simply pointing to it. The 'ceiling rule' was utilized to discontinue the test when the participants provided five wrong responses out of seven consecutive items. Participants were also permitted to take breaks, or if necessary, the assessment session could be continued the following day to minimize the potential effects of fatigue and inattentiveness while ensuring an accurate estimate of the participant's maximum ability on the overall test performance. On average, every participant took approximately 5 minutes to complete each subtest and spent around 30 to 40 minutes completing the whole TVPS-4 assessment. Scaled scores of each subtest and the overall standard scores were derived after the completion of all seven test domains.

Statistical analysis

All data obtained throughout this study were analyzed using IBM SPSS Statistics version 30.0 and were tested for normality and homogeneity of variances to ensure that no assumptions were violated. Descriptive analysis was used to describe the patterns of demographic and socioeconomic distribution and to calculate subtest scaled scores as well as the overall standard scores of the TVPS-4. Subsequently, independent-samples t-tests and one-way ANOVAs were employed to compare differences in standard scores by gender and school attendance, respectively. A one-sample t-test was conducted to compare the participants' VP scores against the normative score. Additionally, the relationships between the scaled scores for each subtest and the overall standard scores, as well as between the scaled scores and the academic performance (TP levels), were examined using Spearman's rank correlation coefficient. The statistical significance was determined at an alpha level of 0.05 for all analyses in this study.

Results

Demographic pattern

A total of 90 indigenous primary schoolchildren in Selangor, aged 7 to 11 years (9.11±1.37), participated in this study. Table 1 summarizes the demographic distribution of the participants.

Independent sample t-test and one-way ANOVA were utilized to compare the mean standard score of the participants. The results showed no statistically significant difference in standard scores between males and females [t(88)=0.50, p-value=0.62]. Similarly, no significant difference in overall standard scores was found based on the attendance rates [F(2,87)=0.89, p-value=0.42] (Table 2).

Table 3 presents the descriptive statistics summarizing the participants' TP levels for Bahasa Melayu, English, mathematics, and science.

Table 1 Demographic distributions

Variable	Frequency (n)	Percentage (%)
Gender		
Male	48	53.3
Female	42	46.7
Grade		
1	16	17.8
2	13	14.4
3	24	26.7
4	19	21.1
5	18	20.0
Estimated school attendance rate		
Very frequent (90.0–100.0%)	41	45.6
Frequent (70.0–89.0%)	36	40.0
Sometimes (50.0–69.0%)	13	14.4
Glasses wearer		
Yes	2	2.2
No	88	97.8

Table 2 TVPS-4 standard scores (mean±S.D.) based on gender and school attendance rate

Variable	Standard score (Mean±S.D.)	p-value
Gender		
Male	93.58±7.12	0.62
Female	92.88±5.96	
Estimated school attendance rate		
Very frequent (90.0–100.0%)	93.44±6.19	
Frequent (70.0–89.0%)	92.36±7.19	0.42
Sometimes (50.0–69.0%)	95.15±5.98	

Comparison of VP performance between study participants and U.S. normative data

A one-sample t-test was conducted to compare the indigenous schoolchildren's performance in the VP against the U.S. normative. Findings revealed that they scored significantly lower (p-value<0.05) than the normative population in all the VP subtests, with a strong effect size, r, ranging from 0.26 to 0.96. In addition, a one-sample

t-test also identified that the overall standard scores of the indigenous schoolchildren (93.26±6.58) fell significantly below the normative mean [t(89)=-9.73, p-value<0.001]. Table 4 summarizes the comparisons of scaled scores and standard scores between the participants and the normative standard.

Relationship of VP status and academic performance among indigenous primary schoolchildren

Table 5 shows the result of the Spearman correlation test, where there was a positive, yet small correlation yielded between the visual discrimination subtest with *Bahasa Melayu* [r_s (88)=0.27, p-value=0.010], English [r_s (88)=0.30, p-value=0.005], and science [r_s (88)=0.25, p-value=0.018]. Notably, a similar trend was noted between the sequential memory subtest and all four subjects. However, the strength of the association differed, in which it was moderate for *Bahasa Melayu* [r_s (88)=0.44, p-value<0.001], English [r_s (88)=0.33, p-value<0.001] and Science [r_s (88)=0.39, p-value<0.001], but less pronounced for Mathematics [r_s (88)=0.28, p-value 0.007]. Finally, the overall standard score demonstrated statistically significant positive correlation with modest association for *Bahasa Melayu* [r_s (88)=0.32, p-value=0.002], and smaller correlation for English [r_s (88)=0.29, p-value=0.005] as well as Science [r_s (88)=0.28, p-value=0.009].

Table 3 Distribution of TP levels of participants across all four academic subjects

TP level	Bahasa Melayu		English		Mathematics		Science	
	n	%	n	%	n	%	n	%
1	13	14.4	19	21.1	11	12.2	5	5.6
2	21	23.3	33	36.7	29	32.2	26	28.9
3	26	28.9	27	30.0	30	33.3	37	41.1
4	28	31.1	10	11.1	18	20.0	20	22.2
5	2	2.2	1	1.1	2	2.2	2	2.2

Table 4 Comparison of indigenous primary schoolchildren and the U.S. normative population for scaled scores (Mean±S.D.=10±3) and standard scores (Mean±S.D.=100±15)

TVPS-4 Score	Participants' scores	US norms	Confidence interval		t-value	p-value	Effect size (Cohen's d)
			Lower	Upper			
Visual discrimination	8.27±2.68		-2.30	-1.17	-6.12	<0.001	-0.65
Visual memory	8.71±1.98		-1.70	-0.87	-6.16	<0.001	-0.65
Spatial relationships	8.46±2.38		-2.04	-1.05	-6.17	<0.001	-0.65
Form constancy	9.08±2.51	10±3	-1.45	-0.40	-3.49	<0.001	-0.37
Sequential memory	9.33±2.57		-1.21	-0.13	-2.46	0.016	-0.26
Visual figure- ground	8.19±1.89		-2.21	-1.42	-9.09	<0.001	-0.96
Visual closure	8.84±2.36		-1.65	-0.66	-4.65	<0.001	-0.49
Overall standard score	93.26±6.58	100±15	-8.12	-5.37	-9.73	<0.001	-1.03

Table 5 Correlation of the TVPS-4 scaled scores for each subtest and the overall standard score with the TP levels of four subjects: *Bahasa Melayu*, English, mathematics, and science

TVPS Measure	Bahasa Melayu		English		Mathematics		Science	
	r_s	p-value	r_s	p-value	r_s	p-value	r_s	p-value
Visual discrimination	0.27**	0.010	0.30**	0.005	0.18	0.085	0.25*	0.018
Visual memory	0.13	0.241	0.13	0.228	0.18	0.087	0.14	0.175
Spatial relationships	0.13	0.213	0.16	0.144	0.09	0.417	0.07	0.510
Form constancy	0.16	0.143	0.06	0.548	0.06	0.581	0.10	0.329
Sequential memory	0.44**	<0.001	0.33**	0.001	0.28**	0.007	0.39**	<0.001
Visual figure- ground	0.01	0.925	0.02	0.878	-0.07	0.518	0.04	0.708
Visual closure	0.15	0.173	0.16	0.142	0.10	0.337	0.14	0.195
Overall standard score	0.32**	0.002	0.29**	0.005	0.19	0.067	0.28**	0.009

*Correlation is significant at the 0.05 level (2-tailed), **Correlation is significant at the 0.01 level (2-tailed)

Discussion

The present study sought to assess the VP status of indigenous primary schoolchildren in Selangor in comparison to the U.S. normative score, as well as the association between gender and school attendance with VP skills. In addition, this study also analyzed the relationship between the VP and their academic performance in the four core subjects: *Bahasa Melayu*, English, mathematics, and science.

The results of the present study showed that the VP standard scores of indigenous primary schoolchildren were independent of gender and in agreement with reports from previous studies[23,24]. This result can be traced back to the shared upbringing environment experienced by the studied population, which lives in remote settings and has engaged in similar customs and culture since early childhood. Interestingly, the present data revealed that VP skills do not differ by school attendance rates. While this finding may suggest that formal schooling is not the sole factor of VP performance, it is important to consider that the finding is restricted to the current cohort. The exclusion of data from schoolchildren with less than 50% attendance rate may limit the generalizability of the results.

Upon comparing the TVPS-4 performance with U.S. normative standards, it was observed that primary indigenous schoolchildren in the present study performed significantly poorly relative to the normative population in five out of seven subtests, namely visual discrimination, visual memory, spatial relationships, visual figure-ground, and visual closure. Despite the performance gap being slightly attenuated in form constancy and sequential memory, the scores for these two subtests also remained below the standard norms. The observed gap in VP performance may likely arise due to the difference in educational provision and cognitive style between these two populations. Generally, children in the U.S. receive their childhood education as early as 3 years old[25]. As the brain undergoes a sharp decrease in malleability once children turn 7[26], early interventions to foster cognitive engagement targeting young children in preschool ages 3 to 6 will be beneficial to encourage the maturation of overall VP skills for the present well-being and future success of the children[27]. However, in Malaysia, despite government efforts to provide equal education opportunities for all children, the indigenous population and those living in rural areas still lack access to quality education[28-31]. This phenomenon may raise difficulty

for indigenous children to absorb more complex skills once they enter primary school.

Notably, contrary to our finding, a recent study on preschool children and urban indigenous schoolchildren in Malaysia revealed that their overall VP skills were on par with U.S. normative standards[13,23]. The discrepancy between previous studies and the current finding suggests that indigenous schoolchildren living in non-urbanized areas may not be exposed to the same early childhood stimulation and educational affordances, which likely becomes the root of the widening gap in VP skills between them and their urban counterparts. Developing and implementing interventions that increase accessibility and opportunities for indigenous children living in rural areas may serve as a solid foundation for the improvement of their VP and overall cognitive development.

A correlation analysis to investigate the relationship between VP and academic performance (TP levels) suggested that no significant associations were noted between visual memory, spatial relationships, form constancy, visual figure-ground, and visual closure subtests with TP levels across all four subjects. The insignificance may imply that PBD assessment rubrics to determine TP levels for these subjects prioritize higher levels of cognitive synthesis over basic VP skills. However, a moderate correlation between sequential memory subskill and academic performance was demonstrated across all subjects. The present finding mirrors a previous study on the correlation between sequential memory with English and mathematics[32]. The positive correlation indicates that sequential memory is not only pivotal for specific subjects but also is a foundational requirement for indigenous schoolchildren to master the primary school curriculum. For instance, *Bahasa Melayu* and English, which are literacy-related subjects, heavily rely on sequential memory processing for spelling and syntax. Likewise, mathematics and science are also subjects that require the ability to recall sequences in specific order to solve arithmetic operations and to understand experimental procedures, respectively. Conversely, the visual discrimination subtest and overall VP scores were revealed to be significantly correlated with *Bahasa Melayu*, English, and science, but not with mathematics. Such a finding may imply that mathematics necessitates higher mastery levels that extend beyond visual perception alone. Generally, the investigation on the relationship between VP and academic performance suggests that strong grounding of VP skills, particularly sequential memory and visual discrimination, may serve as key components for the improvement of the learning quality of the indigenous population in Malaysia.

Despite the strengths of this study, several improvements should be considered for future studies. For instance, although the present study investigated a reasonable number of indigenous primary schoolchildren, the sample recruited was limited to the indigenous population in Selangor; hence, it may not represent the broader indigenous primary schoolchildren population in Malaysia, which has a highly diverse sociodemographic background[28]. Subsequent research may consider collecting data from indigenous populations across various states to allow a broader yet better in-depth understanding of VP in this population. Additionally, the utilization of TVPS-4 as a test battery to assess the VP performance was indeed reliable, as it can provide a standardized and comprehensive evaluation of VP. However, during the assessment, inattentiveness and fatigue can be observed among participants due to the lengthy duration taken to complete the entire TVPS-4. Although this challenge was overcome by allowing a break upon any sign of lapses in concentration to ensure reliable VP evaluation, future studies may consider using alternative VP measures, such as the Motor-free Visual Perception Test – fourth edition (MVPT-4), to investigate VP status among indigenous primary schoolchildren. Given that MTVP-4 can often be

administered in a shorter duration and can assess VP skills without the need for motor response, it is similar to TVPS-4[20,33]. Furthermore, the comparison of participants' VP performance with U.S. standards may introduce socio-cultural bias. Future research comparing VP skills of the indigenous and urban primary schoolchildren in Malaysia is warranted to account for the cultural variations. Despite these limitations, the data gathered from this study were carefully selected for evaluation to ensure credibility, thereby establishing a foundational framework for future studies.

Conclusion

Overall, understanding the relationship and contribution of VP to academic performance may provide valuable insights for educators and policymakers in establishing a robust baseline for quality education. Given the findings in this study, authorities could develop VP enhancement strategies that can be implemented equally across the genders and that are accessible in non-formal, out-of-school settings for indigenous children. The evidence regarding underperformance in VP among the study participants implies the urgent need for targeted scaffolding for the indigenous population to elevate their VP performance to a standard level. Finally, focusing on interventions that specifically target VP-related learning demands, such as sequential memory and visual discrimination, may be pivotal for supporting the academic performance and educational equity of this population.

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Conflict of interest

There is no conflict of interest to be declared by the authors.

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