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ORIGINAL ARTICLE

VALIDITY AND RELIABILITY OF THE RAVEN COLOURED PROGRESSIVE MATRICES AND THE TEST OF NON-VERBAL INTELLIGENCE AMONG MALAYSIAN CHILDREN

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Abstract

Objective: **This study was conducted to evaluate the psychometric properties of the Raven Coloured Progressive Matrices (RCPM) and the Test of Nonverbal Intelligence-4th edition (TONI-4) among Malaysian primary school children.** ***Methods*****: A sample of 306 students with a mean age of 10.3 (SD=1.76) from Kuching, Kota Samarahan and Tebedu area in the State of Sarawak participated in this study. Participants were recruited based on multistage sampling. The schools were randomly selected, whereas participants were recruited based on convenience sampling. The test was administered face-to-face with the students. We administered all three sections of RCPM (A, AB and B) and we only administered Form A of TONI. TONI and RCPM were re-administered 14 days later. The same participants were given all three sections of RCPM and both Forms A and B of the TONI.** ***Results*****: Both RCPM and TONI-4 showed good construct validity (ranging from r=0.56 to r=0.77 for RCPM and r=0.85 for TONI-4) and good concurrent validity. Test-retest reliability for both measures showed a good correlation (from r=0.60 to r=0.78 for RCPM and r=0.77 for TONI-4).** ***Conclusions*****: The present findings suggest that RCPM and TONI-4 have good psychometric properties for testing the non-verbal intelligence of Malaysian primary school children.**

Keywords: Validity, Reliability, TONI, RAVEN, Intelligence testing

Introduction

Historically, intelligence tests (IQ) were used to classify children into categories like "smart" and "inferior". While such terms are no longer appropriate, IQ and general cognitive tests are still utilized for many other purposes today, such as research participation recruitment [1]. Educational setting assessment, neuropsychological and psychiatric evaluation and general cognitive performance assessments among adults and children [2-4]. Intelligence tests are widely used for research

and experimental studies related to children with intellectual disabilities such as Down Syndrome (DS). For example, Carmen and colleagues used IQ score as one condition for inclusion in a study on visual and mental image strategies to improve recall ability [5].

In educational settings, intelligence tests were designed to evaluate individual ability according to the mainstream educational system [1,6]. For example, SSAT is used for preparatory school admissions and college; MCAT for medical school; LSAT for law school and GMAT for business school. IQ tests can also be used for the purposes of identifying students who may be prone to difficulty in conventional settings, but not as a diagnostic test to pinpoint the source of a child's learning problem [2]. In a regular educational system with no adjustments made for them, special students were more likely to encounter failure in their mainstream academic studies [7].

Questions have also arisen as to how valid the instruments are for various populations. Previous studies have found that different cultures have different conceptions of intelligence [8-10]. Hence, an intelligence test with a limited language barrier, motor usage, or culturally influenced testing format is desirable. Two widely utilized tests, Raven's Colored Progressive Matrices (RCPM) and Test of Nonverbal Intelligence (TONI) have been developed to meet this need. Non-verbal intelligence tests like RPCM and TONI involve non-verbal communication, attention and problem-solving skills in connection with time and space [9,10].

Other studies have shown that different cultures perceive time and space differently [11,12]. For example, European-American, Asian-American and East Asian populations were asked to categorize a target object (e.g. a flower) to one of two groups [13]. All the stimuli in the first group shared a salient feature that was similar to the target object whereas the stimuli in the second group shared many features with the target stimulus, but none of them shared identical features. They found that European-Americans tend to categorize the target object into the first group, whereas East Asians are more likely to choose the second group, presumably based on

holistic judgments of family resemblance. This has been thought to demonstrate cultural differences in categorization processes.

Cultural differences in cognitive processes have also been demonstrated in color categorization stimulus comparison and attention [14,15]. Such findings appear to indicate intelligence is shaped and perceived culturally [11,12]. Therefore, a further validation of non-verbal intelligence tests in the Malaysian cultural context is needed.

Raven's Colour Progressive Matrices is one of the most popular non-intelligence tests used globally. RCPM has been used to measure two main components of general cognitive ability (g)-educative ability and reproductive ability [16,17]. Raven and colleagues distinguished educative and reproductive ability as the following, "educative ability is the ability to make meaning out of confusion, which is usually nonverbal; and reproductive ability is the ability to absorb, recall and reproduce information that has been made explicit and communicated from one person to another. RCPM measures the level of analogical thinking and abstract thought and claims to reduce the effect of language and culture [18,19]. Nonetheless, the validity and reliability of RCPM remain an open question among the Malaysian population.

Test of Non-verbal Intelligence test (TONI) is another non-verbal intelligence test that is widely used. Based on Spearman's general intelligence, TONI was designed to measure two main components of non-verbal intelligence, abstract reasoning and problem-solving [20]. It also showed good validity and reliability of TONI in terms of its screening, diagnostic and research purpose [21]. They declared it had minimized the cultural and language factors rendering it feasible for use. However, TONI was only validated mostly across Western populations and has not been tested in Asia or among Asian nations who are among themselves diverse enough to make generalization difficult. As such, validation for use in Malaysia is appropriate. Thus, the objective of this study is to determine to construct, concurrent validity and test-retest reliability of these instruments.

Method

Participants

Data in the present study were collected from a total responding population of 306 children with 54.9% (n=168) female and 45.1% (n=138) male, aged from 7 to 14 (Mage=10.3, SD=1.76). Individuals with an obvious disability or a diagnosis by doctors or experts, such as physically handicapped children, children with learning difficulty, children with autism spectrum disorder and attention-deficit/hyperactivity disorder were all excluded in the present study. Children who participated in this study were from several ethnic groups: Malays (40.8%), Chinese (24.8%), Iban (17.0%), Bidayuh (11.4%) and other ethnic minorities including Indians and Kelabit (5.9%).

Measure

Raven Coloured Progressive Matrices, RCPM. The RCPM contains three sections-Section A, AB and B [16]. Each section has 12 items. In our study, children answered all 36 items. For each item, children were presented with an incomplete design. Children were required to choose one answer from six available alternatives to best complete the design. One mark was given for each correctly selected item. The total maximum score is 36. In a previous study, the Cronbach's coefficient alpha for the RCPM was 94 [22].

Test of Nonverbal Intelligence 4th edition [20]. The TONI can be used with individuals from 5 to 85 years in age. There are two forms, A and B, which contain 55 items each arranged in order of difficulty. Form A is recommended when the test is administered for the first time and Form B for post-measures. In this study, form A was used during the first test administration. During the second test administration, both form A and B were used. All of the items require abstract problem-solving. The respondent is required to identify relationships among abstract figures by selecting the correct figure from among four to six alternatives. If the participants consecutively answer three questions incorrectly, the test is stopped, and the total raw score is counted. The total raw score is obtained by totaling up the number of correct answers. Percentile ranks below 25 indicate developmental disabilities, while scores above 75 indicate high intellectual functioning. The previous study indicated that the Cronbach's coefficient alpha for TONI-2 Form A was α=0.86 [22].

Procedure

All participants were recruited based on multistage sampling. The schools were randomly selected based on a school list provided by the State of Sarawak Education Department. Meanwhile, participants were recruited based on convenience sampling. All participants and their parents were given written consent forms and briefed on participant rights, confidentiality, risks and background of the study. With co-operation from the school, the test was

administered face-to-face with the students. All three sections of RCPM (A, AB and B) but only Form A of TONI were administered. TONI and RCPM were re-administered 14 days later. The same participants were given all three sections of RCPM and both Forms A and B of the TONI. This study obtained an approval from the Malaysian Ministry of Education, the State of Sarawak Education Department. It was also received an ethical approval from the ethics committee of the Faculty of Medicine and Health Sciences, Universiti Malaysia Sarawak. Both RCPM and TONI was purchased using the Ministry of Higher Education Research Funding (RACE/e (1)/888/2012 (06)). Figure 1 illustrates the data collection procedures.

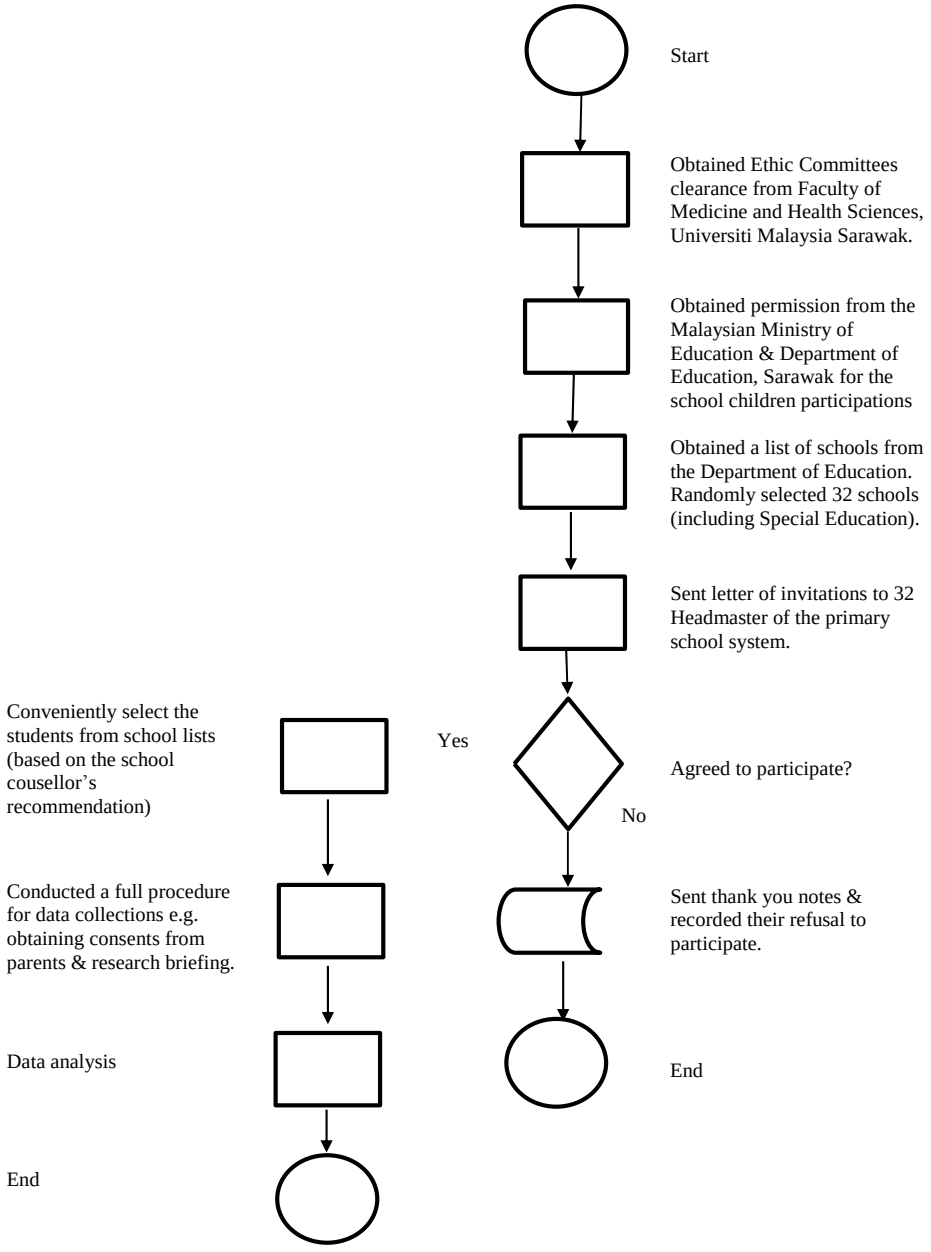

Figure 1. Flow-chart of the data collections.

Data analysis

Data were analyzed using the Statistical Program for the Social Sciences (SPSS version 16.0). The construct and concurrent validity of both non-verbal tests were determined by establishing a bivariate correlation between the subscales. A bivariate correlation was used again to establish test-retest reliability. A similar approach was used by Costenbader and Ngari and McGhee and Lieberman in determining construct and concurrent validity, and also test-retest reliability for these instruments when they validated it among Kenya and the Western population [23,24].

Result

The socio-demographic data of the respondents was described in Table 1.

Table 1. Demographic characteristics of participants.

Characteristic	N	(%)
Gender		
Female	138	45.1
Male	168	54.9
Ethnicity		
Malay	130	42.5
Chinese	80	26.1
Iban	53	17.3
Bidayuh	36	11.8
Others	7	2.3
Age		
6	3	1
7	24	7.8
8	37	12.1
9	38	12.4
10	32	10.5
11	84	27.5
12	82	26.8
13	2	0.7
14	5	1.3
Living with		
Both parents	261	85.3
Single parent	25	8.2
Others	7	2.3
Number of siblings		
Single	13	4.2
2-3	138	45.1
4-6	115	37.5
>7	22	7.2
Missing value	18	5.9

Construct and concurrent validity

Bivariate correlation analysis showed that the TONI-form A at t1 and form B at t1 were well correlated (r =0.85,p<0.001). As such, these two forms of TONI appeared to contain items that reliably identify common core variables, implying construct validity. Independent t-test results showed that there was no significant gender difference in TONI, t (296)=0.69, p=0.491. ANOVA results also showed that there were no significant ethnic differences in TONI, F (4,165)=2.16, p=0.076. Bivariate correlation of real and assumed age via TONI assessment was significant, r=0.46, p<0.001, implying construct validity. Concurrent validity of TONI was analyzed with RCPM. The results from the bivariate correlation revealed a significant correlation between TONI and RCPM (Table 2). Both Form A and B were highly correlated with RCPM set A, AB, B, and RCPM total score. These results support the concurrent validity of the TONI.

Table 2. Concurrent Validity of TONI and Raven via bivariate correlation analysis (N=306).

	Raven Set A	**Raven Set AB**	**Raven Set B**	**Raven Total**	**TONI A**	**TONI B**
Raven Set A	1					
Raven Set AB	0.811**	1				
Raven Set B	0.752**	0.854**	1			
Raven Total	0.890**	0.937**	0.919**	1		
TONI A	0.787**	0.779**	0.797**	0.824**	1	
TONI B	0.787**	0.800**	0.814**	0.855**	0.872**	1

** Pearson correlation is significant at the 0.01 level (2-tailed)

Test-retest reliability

A total of 115 valid retests were collected. Both bivariate correlation analyses of TONI Form A at t0 and t1, and TONI Form A t0 and Form B t1 showed good correlation (both r =0.77, p<0.001).

Construct and concurrent validity of RCPM

Bivariate correlation analysis showed that the RCPM set A, AB and B were well correlated between one another; set A with set AB (r=0.811, p<0.001), set A with set B (r=0.75, p<0.001), and set AB with set B (r=0.85, p<0.001). As such, these forms appeared to contain items that reliably identify common core variables, implying construct validity. Independent t-test showed that there was no significant gender difference in RCPM total score, t(297)=0.31, p=0.757. Concurrent validity of the RCPM was analyzed with TONI. The results from the bivariate correlation revealed a significant correlation between RCPM and the TONI scale (Table 1). RCPM set A, AB, B, and total score were all highly correlated with TONI Form A and B. These results support the concurrent validity of the RCPM.

Test-retest reliability

A total of 115 valid retests were collected. Bivariate correlation of RCPM at t_0 and t_1 showed a good correlation; RCPM set A (r=0.60, p<0.001), set AB (r=0.78, p<0.001), and set B (r=0.60, p<0.001) (Table 3).

Table 3. Test -retest reliability andconvergent validity of Raven test via bivariate correlation (N=306).

	RAVEN_A at t_1	**RAVEN_AB at t_1**	**RAVEN_B at t_1**	**Raven_A at t_2**	**Raven_AB at t_2**	**Raven_B at t_2**
RAVEN_A at t_1	1					
RAVEN_AB at t_1	0.698**	1				
RAVEN_B at t_1	0.555**	0.765**	1			
Raven_A at t_2	0.597**	0.619**	.672**	1		
Raven_AB at t_2	0.628**	0.784**	.704**	0.776**	1	

Raven_B at t_2	0.611**	0.756**	.780**	0.645**	0.777**	1

**Pearson correlation is significant at the 0.01 level (2-tailed).

Discussion

Intelligence tests are popularly used with mainstream and non-mainstream children relative to school progress, language ability, and verbal and non-verbal problem-solving skills. Non-verbal intelligence tests are highly recommended because they minimize cultural and language barriers in the assessment of intellectual functioning.

The present study showed that the reliabilities for TONI and RCPM were both above 0.60, indicating a high degree of reliability. This provides support for McGhee and Lieberman who obtained similar results on a somewhat small sample of students (N=50) [24]. In Kenya, a study found similarly good test-retest reliability for RCPM [23]. They obtained a Cronbach's alpha of 0.87 among 1370 school children. Although they only conducted test-retest reliability with 50 participants, it resulted in good test-retest reliability (r=0.84).

Convergent and concurrent validity for TONI and RCPM was high, indicating that both tests are able to measure intelligence among a diverse Malaysian student body and bolstering the findings of concurrent validity of among clinical patients and a control group [22]. Some researchers have argued that TONI does not cover the whole range of intelligence (nor multi-dimensional tests of intelligence), but is only a test of visual organization, visual comprehension, and the ability to focus on essential detail [25]. However, a more recent study has shown that TONI has a positive correlation with the Matrix Reasoning subtest of WISC-IV, indicating that TONI not only measures visual intelligence but also the verbal ability and processing speed The current study provides further support for the construct validity of TONI, showing no significant gender and ethnic difference and accurately predicting participant age [26]. This adds value to the previous findings, as TONI not only can measure verbal intelligence in a non-verbal assessment setting but appears unencumbered by cultural and language factors [27].

Previous reliability and validity studies have shown that RCPM has good psychometric properties and also showed reasonably good reliability and validity of RCPM among Omani children [28,29]. The present study showed no significant gender difference, providing further evidence for construct validity among Malaysian students.

Although the present study demonstrated the psychometric properties of TONI and RCPM, it is still lacking local normative data. Future researchers should extract norms, especially for Malaysian students from different age and gender groups. Reporting age-related norms will act as baseline data, enabling future identification and differentiation of school children, and for screening and research purposes.

Analyses of the present study revealed good validity and reliability among Malaysian primary school students, supporting the construct of TONI and RCPM. Although it is believed that both of these non-verbal intelligence tests are feasible for use in Malaysian culture, they are recommended to be used with other standardized tests to provide a fuller image of Malaysian primary student intelligence.

Conclusion

In conclusion, both TONI and RCPM are reliable and valid instruments to test intelligence among Malaysian children. We hope that with this finding, both instruments can be utilized for educational, intervention, research, program development, and other purposes.

Acknowledgments

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