Preliminary Validity of Computerized Neurobehavioral Assessment among University Students

Amirul Alif Zaidi, Azian Hariri, Nuur Azreen Paiman, Norlida Shaari, Ahmad Fu'ad Idris

Abstract: ***Neurobehavioral disorders is a disease of neurological damage. It affects human due to exposure of chemicals from the environment that damage the nervous system. In the early 90's, the World Health Organization (WHO) had introduced a Neurobehavioral Core Test Battery (NCTB) to detect human nervous system damage by using pen and paper method. A group of researchers at UTHM have taken the initiatives to convert the conventional WHO-NCTB pen and paper method into a new computerized neurobehavioral assessment tool called Neurobehavioral Risk Assessment and Evaluation System (NeuRAES 1.0). The purpose of this study is to test the preliminary validity of this newly developed assessment tool. This study was conducted among 40 respondents from a group of university students and 15 respondents from industry. There were three types of tests carried out on this assessment, such as Benton Visual Retention Test (BVRT), Trail Making Test (TMT) and Pursuit Aiming Test (PAT). All these tests were carried out by using both methods which are the conventional WHO-NCTB pen and paper method, and the computerized NeuRAES 1.0 method. Both of these test methods were conducted among the respondents and their results were recorded and analysed statistically. Results of the study shows that TMT section A produced strongest correlation between both conventional WHO-NCTB pen and paper method, and computerized NeuRAES 1.0 method for both students and industrial workers. However, PAT produced strongest correlation among industrial workers respondents only. Several factors had been identified for improvement of this study such as increase the sample size among students and industrial workers, usage of touch screen laptop for PAT and the need to decrease the scoring bias factor.***

Index Terms: ***Neurobehavioral, validity, WHO-NCTB, computerized neurobehavioral system.***

I. INTRODUCTION

Neurobehavioral is the studies of impact of neurological damage and disease. Neurobehavioral testing is commonly recognized as a valid method for detecting early psychological disorder of the nervous system resulting from exposure to neurotoxic agents [1].

Revised Manuscript Received on May 22, 2019.

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This testing is used to detect the subclinical dysfunction of nervous system. World Health Organization – Neurobehavioral Core Test Battery (WHO-NCTB) was introduced since early of 1990s which provided pen and paper method of assessment for neurobehavioral disorders [2]. In WHO-NCTB, there are seven tests for assessment of neurobehavioral function namely Simple Reaction Time (SRT), Trail Making Test (TMT), Digit Span (DSp), Santa Ana Dexterity (SAN), Digit Symbol (DSy), Benton Visual Retention Test (BVRT), Pursuit Aiming II Test (PAT), and Profile of Mood States (POMS) [1].

These tests were designed to assess the domain of neurobehavioral function, for example, BVRT assess the visual perception memory domain, while PAT assess the coordination psychomotor stability domain and TM assess the processing speed and sequence. The BVRT is the most effective test for detecting mercury exposure and PAT is the most effective test for lead exposure neurobehavioral disorders while DSp test, DSy test and PAT is the most effective test for organic-solvent exposure neurobehavioral disorders [1].

Basically, neurobehavioral problems caused by the chemical reaction in our daily life. WHO-NCTB was the most widely used tests in human neurobehavioral research as they are very effective to assess neurobehavioral disorders [2]. The neurobehavioral disorder may be cause by manganese alloy production, mining and crashing of manganese ore and in steel and dry cell battery production [3].

The computerized neurobehavioral assessment method has potential and advantages to assess the neurobehavioral disorder compared to conventional WHO-NCTB pen and paper method. Computerized method can be much less time consuming against conventional WHO-NCTB pen and paper method and do not require administration by a testing specialist [4]. Furthermore, the score result is automated and the test performance can be easily generated into a summary report for interpretation for statistical analysis data. However, limited study had been done on computerized neurobehavioral assessment in Malaysia.

In effort to allow the neurobehavioral assessment can be used to assess Malaysian population, a group of researcher in Universiti Tun Hussein Onn Malaysia (UTHM) make an initiative to develop a computerized neurobehavioral assessment system. The newly developed computerized system was called Neurobehavioral Risk Assessment Evaluation System (NeuRAES 1.0).

This tool have similar assessment as the conventional WHO-NCTB pen and paper method which are consists of BVRT, TMT and PAT. Thus, the performance of the new developed tool must be compared to the test performance of conventional WHO-NCTB pen and paper method to validate this assessment tool.

II. METHODOLOGY

A. Flow Chart of Study

Figure 1 shows the methodology flow chart for this study.

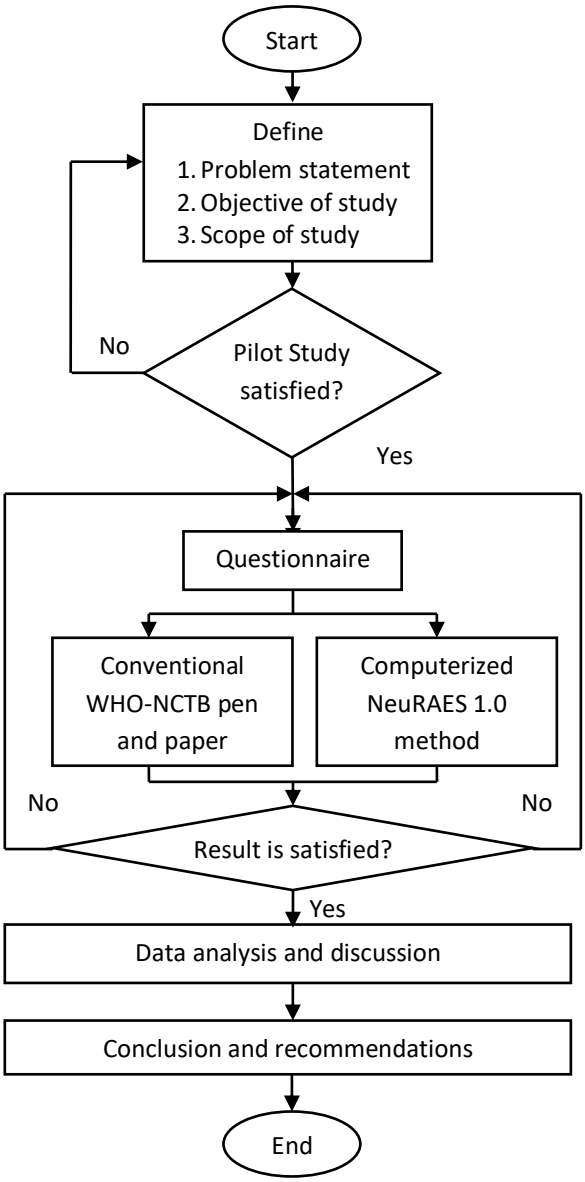

Fig. 1 Flow chart of the study

The study on neurobehavioral disorders was started by defining the problem statements, objective and scope of the study. A pilot study was conducted among several groups of students before conducting actual data collection to test the suitability of the selected method.

After that, the neurobehavioral assessment was continued with questionnaire session. The questionnaire consists of demographic data questions, open-ended questions, closed-ended questions and combination of open-ended and closed-ended questions.

The assessment were divided into two test which are conventional WHO-NCTB pen and paper method and computerized NeURAES 1.0 method. The conventional WHO-NCTB assessment method was conducted by using pen and paper while the computerized NueRAES 1.0 method was conducted by using laptop and computer mouse. After the assessment completed, the data for both assessment methods was compared for the validity analysis. The validity analysis of this research was conducted by using convergent and divergent validity method [5].

The data was analyzed by using Statistical Package for Social Sciences (SPSS). The mean and standard deviation of the data was also calculated to get the result of standard score of the data. Lastly, the validity of computerized NeuRAES 1.0 can be concluded based on the results analysis and recommendation was suggested for the further study.

B. Pilot Test

Pilot study is a preliminary test conducted on a small scale before conducting tests on a larger scale. The pilot study was started by answering the questionnaire provided. The respondents were given different sequence test methods to find out the appropriate method to be carried out.

This pilot study was also conducted by using the pen and paper, and ASUS brand laptop with computer mouse for the conventional WHO-NCTB test and computerized NeuRAES 1.0 test respectively. The first group respondent conducted the computerized NeuRAES 1.0 test method, then after three days later conducted the WHO-NCTB conventional method of pen and paper without the knowledge of the both test contents. The second group respondent did the test vice versa. The third group respondent did both tests at the same time without the three days interval period. The results of pilot study shows that the interval period did not influence significantly the standard score of the tests.

C. Questionnaire

The questionnaire have been divided into several sections to complete this study to discover the causes of the neurobehavioral disorders among the respondents. There are several section that involves in the questionnaire:

i. Section A: Respondents' profile.
ii. Section B: History of learning activity.
iii. Section C: Use of personal protective equipment (PPE) and chemical exposure.
iv. Section D: Health conditions.
v. Section E: Cigarette/e-cigarette/cigar habits.
vi. Section F: Alcohol consumption.
vii. Section G: Drug abuse.
viii. Section H: Health symptoms.

This questionnaire used in this study was used to get information of respondents. The factors that influence the neurobehavioral effects were also considers in this questionnaire.

D. Neurobehavioral Assessment

The neurobehavioral assessment was administered to 40 volunteer participants (n=40) among university students and 15 respondents from industrial workers (n=15). 20 of the participants from UTHM students conducted the computerized NeuRAES 1.0 method first and the conventional WHO-NCTB pen and paper method three days after that. Another 20 participants conducted the conventional WHO-NCTB pen and paper method first and the computerized NeuRAES 1.0 method three days after that. However, a total of 15 respondents from industry conducted the computerized NeuRAES 1.0 followed by questionnaire and conventional WHO-NCTB pen and paper method within the same day because of limitation of time in industry. This was done to avoid biased results from the participants. Fig. 2 shows the interface of computerized NeuRAES 1.0.

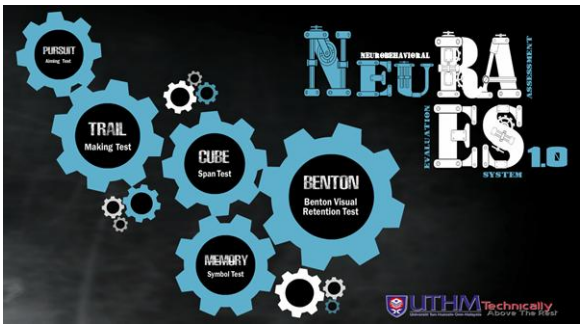

Fig. 2 NeuRAES 1.0 main page interface

The Benton Visual Retention Test (BVRT) is a neuropsychological test to assess visual memory perception domain [6]. It involved presenting a slowly drawing of a shape and the patient must memorize the shape that are slowly presented in several times given. Both of conventional and computerized test, the participants was given 10 different shapes and they must memorize the shape that was slowly presented on the paper and computer screen in 10 seconds for each of the shape. After that, the participants were given another ten seconds to select the memorized shapes from four different shape options in the answer sheet.

Trail Making Test (TMT). is administered as baseline measure of processing speed and sequence. TMT was divided into two parts which are Section A and Section B. Section A was administered as a baseline measure of motor and visual search speed while Section B was administered as a measure of set-shifting and inhibition [7]. In Section A, the participants requires to click and connect the numbers in the circles presented on the both paper and computer screen in ascending order. Section B requires the participants to click and connect the circled numbers with the circled alphabets also in ascending sequence. The participants asked to do that test as quickly as possible to get the time recorded of this test. The time taken for each participants was recorded to evaluate and analyze the participants' performances.

The Pursuit Aiming test (PAT) is a test used to assess the domain of coordination psychomotor stability [8]. The participants must observe the dotted pattern given. Firstly, the participants were given a trial in this test. After that, the participants requires to use a pencil to place dots inside each circle following the pattern given on the printed PAT sheet in conventional WHO-NCTB pen and paper method. The participants must click the dots by referring the number sequence for computerized NeuRAES 1.0 method. The participants must performed as quickly as possible in 60 seconds to place how much dots that they can score.

E. Statistical Analysis

The score of the results were calculated by using several formula such as mean, standard deviation and standard score. Mean is the numerical average in the set of data. Standard deviation is a measure used to quantify the amount of variation or dispersion of a set of data values. The formula for both mean and standard deviation are given as equation (1) and equation (2) respectively:

$$\text{Mean} = \frac{\text{Sum of data values}}{\text{Number of sample data}} \quad (1)$$

$$\text{Standard Deviation} = \sqrt{\frac{\sum(x-\bar{x})^2}{n-1}} \quad (2)$$

where, x : Value of sample
$\bar{x}$: Mean
n : The number of data in the sample

Standard score needs to be considered because of the different scoring method for each type of test. A standard score is a derived score that expresses how far a raw score is from some reference point such as the mean in terms of standard deviation units [9]. The standard score can be computed by using equation (3) with z-score calculation by using equation (4) respectively:

$$\text{Standard score} = \text{z-score} \times 10 + 50 \quad (3)$$

$$\text{z-score} = \frac{\text{Raw score - mean}}{\text{Standard deviation}} \quad (4)$$

F. Validity Analysis

Validation is a verifying process whether or not a combination of values is a member of a set of acceptable combinations [10]. Convergent and divergent validity are considered as a method to construct validity of a research. Convergent validity tests that construct that are expected to be related are, in fact related, while divergent validity tests that constructs that should have no relationship do, in fact does not have any relationship [5,11].

Both of convergent and divergent validity were measured by correlation coefficient of each type of test for both conventional WHO-NCTB pen and paper method, and computerized NeuRAES 1.0 method by using SPSS software. The data that normally distributed correlates using Pearson's correlation while non-normally distributed data correlates using Kendall's Tau correlation. Table 1 shows the paired tests administered to assess the validity of NeuRAES 1.0.

Table. 1 Paired tests administered to assess the validity of NeuRAES 1.0

NeuRAES 1.0	WHO-NCTB	
	Convergent validity measure	Divergent validity measure
BVRT	BVRT	PAT
TMT	TMT	BVRT
PAT	PAT	BVRT

III. RESULTS AND DISCUSSION

A. Questionnaire Analysis

This questionnaire was distributed to 40 selected respondents (n=40) involved in this research. Respondents are required to answer all questions in this questionnaire before conducting the neurobehavioral assessment. Table 2 shows the frequency and percentage of respondents' profile collected through questionnaire.

Table.2 The frequency and percentage of respondents' profile collected through questionnaire.

Respondents' Profile	Variables	n (%)
University Students		
Gender	Male	30 (75.0)
	Female	10 (25.0)
Age	20-22 years-old	1 (2.5)
	23-25 years-old	37 (92.5)
	> 26 years-old	2 (5.0)
Current Education Level	Degree	38 (95.0)
	Master	2 (5.0)
Industrial Workers		
Gender	Male	15 (100.0)
	Female	0 (25.0)
Age	20-30 years-old	4 (27.0)
	31-40 years-old	8 (53.0)
	> 40 years-old	3 (20.0)
Current Education Level	UPSR	2 (13.0)
	PMR	3 (20.0)
	SPM	3 (20.0)
	Certificate	6 (40.0)
	Diploma	1(7.0)

B. Mean Score and Standard Deviation

The mean score and standard deviation results for raw scores and standard score had been calculated by using SPSS software. Table 3 summarized the difference of mean score and standard deviation value between of the raw score and standard score for conventional WHO-NCTB pen and paper method and computerized NeuRAES 1.0 method.

The raw score results of the BVRT found that both the WHO-NCTB conventional pen and paper method and computerized NeuRAES 1.0 method produced almost the same mean score. Computerized NeuRAES 1.0 produced lower mean score results than conventional WHO-NCTB pen and paper method for all tests.

Table. 3 The mean score and standard deviation results for university students

Type of Test	Method of Test	Raw Score		Standard Score	
		Mean Score	SD	Mean Score	SD
Benton Visual Retention Test (BVRT)	WHO-NCTB pen and paper	9.750	0.494	50.000	9.871
	NeuRAES 1.0	9.325	0.797	49.750	9.855
Trail Making Test (TMT) Section A	WHO-NCTB pen and paper	26.800	5.080	49.900	9.834
	NeuRAES 1.0	19.150	3.766	50.075	10.057
Trail Making Test (TMT) Section B	WHO-NCTB pen and paper	48.425	8.993	50.050	9.910
	NeuRAES 1.0	35.050	11.354	50.025	9.916
Pursuit Aiming Test (PAT)	WHO-NCTB pen and paper	117.550	15.583	49.950	9.966
	NeuRAES 1.0	85.350	12.891	49.975	10.012

Table 4. The mean score and standard deviation results for industrial workers

Type of Test	Method of Test	Raw Score		Standard Score	
		Mean Score	SD	Mean Score	SD
Benton Visual Retention Test (BVRT)	WHO-NCTB pen and paper	8.87	1.06	50.00	10.00
	NeuRAES 1.0	9.20	0.77	50.00	10.06
Trail Making Test (TMT) Section A	WHO-NCTB pen and paper	33.87	11.35	50.00	10.00
	NeuRAES 1.0	21.00	4.38	50.00	9.99
Trail Making Test (TMT) Section B	WHO-NCTB pen and paper	69.07	27.94	50.00	10.00
	NeuRAES 1.0	41.67	9.24	52.31	14.13
Pursuit Aiming Test (PAT)	WHO-NCTB pen and paper	202.07	26.02	50.00	10.00
	NeuRAES 1.0	140.53	51.90	50.00	10.00

The mean score and standard deviation for standard score shows that the conventional WHO-NCTB pen and paper method produced a larger mean score and standard deviation value compared to the computerized NeuRAES 1.0 method for BVRT. Next, the conventional WHO-NCTB pen and paper method produced lower mean score than computerized NeuRAES 1.0 method for TMT section A and contrast in section B but it produced larger standard deviation value for both section A and section B. For PAT, it produced larger value of both mean score and standard deviation for computerized NeuRAES 1.0 method. Overall, the standard score were almost the same for all tests conducted by both type of methods.

Table 4 shows the mean and standard deviation of the raw score and standard score for both conventional WHO-NCTB pen and paper method, and computerized NeuRAES 1.0 method for the investigated industrial workers.

The raw score results of the BVRT found that both of tests produced different mean score which computerized NeuRAES 1.0 method has larger value than conventional WHO-NCTB pen and paper method. For TMT, computerized NeuRAES 1.0 also produced lower mean score results than conventional WHO-NCTB pen and paper method for both section A and section B. Other than that, for PAT, the test of conventional WHO-NCTB pen and paper method produced a larger mean score than computerized NeuRAES 1.0. The results of standard score shows that all of the mean score and standard deviation have almost the same value but have some different value on TMT section B by using computerized NeuRAES 1.0.

The normality test was conducted by using SPSS software and the normality was determined based on significance value of Shapiro-Wilk Test [12]. If the significance value was greater than 0.05 ($p>0.05$), the data is normally distributed while if the significance value is lower than 0.05 ($p<0.05$), the data is significantly deviate from a normal distribution.

The BVRT in conventional WHO-NCTB pen and paper method was a non-normally distributed data for UTHM students. In addition, the results of the BVRT, and TMT section A and section B using computerized NeuRAES 1.0 method shows that the data were also non-normally distributed while the others was a normally distributed data. The tests of normality results for industrial workers shows that the BVRT and PAT was non-normally distributed data for conventional WHO-NCTB pen and paper method while the others are normally distributed data. For computerized NeuRAES 1.0 method, all of the tests was a normal distributed data except BVRT. The small range of test score of BVRT (seven to ten only) affected the data to be non-normally distributed. Correlation analysis. Correlation analysis is a method used in statistical analysis to evaluate the relationship between two variables [11].

In this study, bivariate correlation analysis was used to determine the relationship of neurobehavioral assessment between conventional WHO-NCTB pen and paper method and computerized NeuRAES 1.0. Pearson's correlation coefficient is a parametric statistics which the data is normally distributed while Spearman's correlation coefficient and Kendall's Tau is non-parametric statistics when the data is non-normally distributed. However, Kendall's value correlate more accurate in the data population [12].

Table 5 shows the correlation analysis of UTHM students for both conventional WHO-NCTB pen and paper method, and computerized NeuRAES 1.0.The convergent validity measures on UTHM students, there were only one test that correlated to each other that was TMT section. A. TMT section A had produced strongest correlation between both conventional WHO-NCTB pen and paper method and computerized NeuRAES 1.0 method due to the correlation was significant at the 2-tailed 0.05 level ($r=0.325$). It's based on the number of sample ($n=40$) and its 2-tailed significance value ($p=0.041$). For BVRT, the conventional WHO-NCTB pen and paper method does not correlate with computerized NeuRAES 1.0 because of its correlation coefficient was to small ($r=0.080$) and bigger significance value ($p=0.595$) was more than ($p>0.05$), it can be concluded that there was no significant relationship between both test methods. The TMT section B, PAT was also did not correlate because it have higher correlation value, r of 0.205 and 0.266 respectively, but the significance value was significantly different from zero ($p>0.05$). This means that correlation was too small to reject the null hypothesis

Table. 5 Correlation analysis for UTHM students

NeuRAES 1.0 method	Convergent Validity Measure		Divergent Validity Measure	
	WHO-NCTB pen and paper method	Correlation Coefficient (Sig. 2-tailed)	WHO-NCTB Pen and paper method	Correlation Coefficient (Sig. 2-tailed)
Benton Visual Retention Test (BVRT)	Benton Visual Retention Test (BVRT)	0.080 (0.595)	Trail Making Test (TMT) Section A	0.027 (0.870)
			Trail Making Test (TMT) Section B	0.076 (0.640)
Trail Making Test (TMT) Section A	Trail Making Test (TMT) Section A	0.325* (0.041)	Benton Visual Retention Test (BVRT)	-0.26 (0.106)
Trail Making Test (TMT) Section B	Trail Making Test (TMT) Section B	0.205 (0.204)		0.033 (0.841)
Pursuit Aiming Test (PAT)	Pursuit Aiming Test (PAT)	0.266 (0.098)	Benton Visual Retention Test (BVRT)	-0.012 (0.943)

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

For divergent validity measures as shown in Table 4-11, it shows that all of the tests produced smaller correlation coefficient and bigger significance value (p>0.05). This means that there are no correlation between all computerized NeuRAES 1.0 tests with its divergent validity measures which is conventional WHO-NCTB pen and paper method with different test domains. It can be concluded that the bigger value of significance rejected the null hypothesis because of the correlation coefficient value was too small.

Table 6 shows the correlation analysis of industrial workers for both conventional WHO-NCTB pen and paper method, and computerized NeuRAES 1.0 method. The results of correlation between computerized NeuRAES 1.0 and conventional WHO-NCTB pen and paper method for industrial workers shows that the correlation of TMT section A and PAT was significant at the 0.05 level (2-tailed). This is because both that tests produced correlation coefficient -0.526 (p=0.044) and 0.621 (p=0.014) respectively. For the TMT section A, the negative value of correlation coefficient shows that the relationship was negative which indicates a perfect linear descending relation (higher scores on the computerized NeuRAES 1.0 method imply lower scores on the conventional WHO-NCTB pen and paper method). Next, the BVRT, TMT section B and PAT shows that there are no correlation to each other due to the bigger significance value was not significantly different from zero. This correlation was too small to reject the null hypothesis.

The divergent measure for industrial workers results shows that there are no correlation between both of the tests. The reasons are the value of correlation coefficient was smaller than the convergent validity measure. It is also shows that there are no correlation was significant at the 0.05 level (2-tailed). Furthermore, the value of significance shows that it was the larger value which means that most differ from zero value or (p>0.05).

Table. 6 Correlation analysis for industrial workers

NeuRAES 1.0 method	Convergent Validity Measure		Divergent Validity Measure	
	WHO-NCTB pen and paper method	Correlation Coefficient (Sig. 2-tailed)	WHO-NCTB Pen and paper method	Correlation Coefficient (Sig. 2-tailed)
Benton Visual Retention Test (BVRT)	Benton Visual Retention Test (BVRT)	-0.317 (0.249)	Trail Making Test (TMT) Section A	-0.106 (0.627)
			Trail Making Test (TMT) Section B	0.093 (0.667)
Trail Making Test (TMT) Section A	Trail Making Test (TMT) Section A	-0.526* (0.044)	Benton Visual Retention Test (BVRT)	-0.046 (0.870)
Trail Making Test (TMT) Section B	Trail Making Test(TMT) Section B	0.333 (0.225)		-0.120 (0.671)
Pursuit Aiming Test (PAT)	Pursuit Aiming Test (PAT)	0.621* (0.014)	Benton Visual Retention Test (BVRT)	-0.166 (0.554)

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

By comparing the results of both of Table 5 and Table 6, it can be concluded that there is only one test that correlate to each other between university students and industrial workers which is TMT section A. There are several factors that affecting the result of this study. First, the sample size of this study was small (n=40). Small simple size can affect the results of this study because of the sample size is directly proportional to Z-score and inversely proportional to the margin of error [13]. Second, most of the respondents said that they faced difficulty on conducting the PAT in computerized NeuRAES 1.0. The results shows that the conventional WHO-NCTB pen and paper method produced higher score than the computerized NeuRAES 1.0 method.

IV. CONCLUSION AND RECOMMENDATIONS

This study was conducted to assess preliminary validity of the computerized NeuRAES 1.0. A group of 40 respondents was selected among university students to conduct both conventional WHO-NCTB pen and paper method and computerized NeuRAES 1.0 method. Both of the test methods consists of three tests which are BVRT, TMT and PAT. The results of the both test was analyzed by using SPSS software to show the correlation coefficient between both of the test methods.

The analysis of descriptive statistics shows that both of the test methods produced almost the same value of mean and standard deviation for all type of tests except TMT section B when the data was converted into standard score. It can be concluded that both of test methods have similarity of the results if it were conducted either by using conventional WHO-NCTB pen and paper method or computerized NeuRAES 1.0 method.

The normality test is important before make the correlation of the test because to know either the data are normally distributed or not. The data that normally distributed was a parametric data and the correlation result was taken from Pearson's correlation analysis. The data that not normally distributed was a non-parametric data and the result of correlation was taken from Kendall's Tau correlation coefficient.

The analysis of correlation coefficient was conducted by using bivariate correlation analysis. The results shows the convergent validity measure that there are only TMT section A was significantly correlated between both of the test methods for UTHM students.

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For industry workers, there are only two test that are correlated each other which are TMT section A and PAT. This three test are correlated at the 0.05 level of significant (2-tailed).

There are several recommendations to improve finding in this research study as listed below:

(i) The sample size of the data must be increased. This means that the number of respondents must be added to be lager than 40 respondents for both group of respondents.

(ii) Use of high technology. In this case, the efficiency of the laptop mouse is the most important thing for all type of tests. The failure of the laptop mouse performance is a factor to get poor results. Thus and upgrade from computer to tablet or touchscreen computer is strongly suggest.

(iii) Study on the appropriate interval period between both methods and practicality to be conducted in industry must be conducted to lower the scoring biased (due to the respondent still remembering the test contents).

ACKNOWLEDGMENT

The This research was supported by Ministry of Education Malaysia under the Fundamental Research Grant Scheme (FRGS) vote 1539 in Universiti Tun Hussein Onn Malaysia. The authors also gratefully acknowledge Research Management Centre (RMC) of Universiti Tun Hussein Onn Malaysia on their endless support.

REFERENCES

1. W. Zhou, Y. Liang, and D. C. Christiani, “Utility of the WHO Neurobehavioral Core Test Battery in Chinese Workers N A Meta-Analysis,” *Environ Res*, vol. 102, pp. 94–102, 2002.
2. W. K. Anger, “Neurobehavioural tests and systems to assess neurotoxic exposures in the workplace and community,” *Occup. Environ. Med*., vol. 60, no. 7, 2003.
3. D. G. Ellingsen, M. Chashchin, R. Bast-pettersen, E. Zibarev, Y. Thomassen, and V. Chashchin, “NeuroToxicology A follow-up study of neurobehavioral functions in welders exposed to manganese,” *Neurotoxicology*, vol. 47, pp. 8–16, 2015.
4. J. P. Arrieux, W. R. Cole, and A. P. Ahrens, “A review of the validity of computerized neurocognitive assessment tools in mild traumatic brain injury assessment,”.*Injury Assessment*,” vol. 2, 2017.
5. R. H. Paul, J. Lawrence, L. M. Williams, C. C. Richard, N. Cooper, and E. Gordon, “Preliminary validity of ‘IntegneuroTM’: A new computerized battery of neurocognitive tests,” *Int. J. Neurosci*., vol. 115, no. 11, pp. 1549–1567, 2005.
6. F. Motamedi, B. Ghobari, and S. Mohabat, “Validity and Reliability Benton visual-Retention test in brain- injured diagnosis of 8 to 10 years old children in Tehran,” *International Academic Journal of Humanities*,vol. 4, no. 1, pp. 1–9, 2017.
7. S. E. MacPherson et al., “Processing speed and the relationship between Trail Making Test-B performance, cortical thinning and white matter microstructure in older adults,” *Cortex*, vol. 95, pp. 92–103, 2017.
8. “Methods Pooled Pursuit Aiming II and VISTECH 6000.”
9. T. O. Adeyemi, “The effective use of standard scores for research in educational management,” *Res. J. Math. Stat*., vol. 3, no. 3, pp. 91–96, 2011.
10. M. Di Zio, N. Fursova, T. Gelsema, and S. Gießing, “Methodology for Data Validation,” Essnet Validat Foundation ‚June, pp. 0–75, 2016.
11. M. Shuttleworth, “Convergent and Discriminant Validity.” [Online]. Available: https://explorable.com/convergent-validity.
12. A. Field, Discovering Statistics Using SPSS: Third Edition, Third Edit. SAGE Publications, 2009.
13. N. Shaari et al., “Preliminary Reliability Study Neurobehavioural Test Method of Computerized,” *International Journal of Integrated Engineering*, vol. 10, pp. 99–108, 2018.