A STUDY OF INTELLIGENCE MEASURE USING RAVEN STANDARD PROGRESSIVE MATRICES TEST ITEMS BY PRINCIPAL COMPONENTS ANALYSIS

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Abstract

The present study aimed to examine statistically the non verbal abilities of the individuals using Raven Standard Progressive Matrices (RSPM) test items. RSPM is a non verbal culture fair test that identifies non verbal reasoning abilities used in educational settings. RSPM was administered collectively (Group-class) for a representative sample of 268 adolescents/Boys and Girls. The sample is drawn through Gallup survey from Karachi University and Federal Urdu University, Gulshan-e-Iqbal Karachi. The results of descriptive Statistics and Principal Components Analysis, 75% student having very sound intellectual capacity, as well also having visual perception, and continuation perception which are suitable designing- interior graphics.

Introduction

Intelligence is a latent variable (underlying concept) therefore cannot be directly measured. It can be only measured by a battery of tests. The individual scores are used as an indirect measure of intelligence (Siddique, 1992). It is evident that assessment of intelligence required good measurement instruments. Intelligent tests are psychometric instruments, consists of standardized questions and tools for assessing an individual potential. They are designed to measure major mental abilities. There are lots of good measurement instruments on verbal scale: Information, digit span, Vocabulary, comprehension, similarities. And non verbal scale: Picture completion, Picture arrangement, Block design, object assembly, digit symbol, RSPM etc (Wechsler 1981).

In this paper intelligence measures on non verbal scale by Raven's standard progressive matrices (RSPM) 60 visual test items by using statistical procedure Principal Components Analysis.

The RSPM tests are in a wide practice nowadays were developed by J.C. Raven (1939) and distributed by US Psychological Corporation.

The RSPM is popular for Spearman and Wynn-Jones (1951) a number of reasons. First, it was designed specifically to measure Spearman's *'g'* (general ability factor) second it is the best test of fluid intelligence.
Fluid intelligent is generally correlates with measures of abstract reasoning; puzzle solving, problem solving, learning and pattern recognized (Vernon, 1950; Gabriel, 1954; Cattell ,1971; Caroll, 1993; Grew and Flanagan 1998).

The RSPM has therefore been used widely as an assessment tool to measure several abilities but it is popular universally as a test that measures general fluid intelligence.
RSPM is a standardized intelligence test that consists of 60 visually presented, geometric- parallel -like problems on 5 sets (A, B, C, D and E), 12 items in each sets. The A and B sections each contain 12 2x2 matrices, while the C, D, and E sections each contain 12 3x3 matrices. Section A involves simply filling in the missing part of an image; later sections require more abstract reasoning. The correct missing entry must be selected from a set of 6 possible answers for the 2x2 matrices, or a set of 8 possible answers for the 3x3 matrices (Lynn *et al* 2004).

The Statistical technique PCA developed Hotelling (1933) it is a capable device for examine high dimension data to identifying patterns in data. PCA is concerned with explaining the variance-covariance structure of a set of multivariate variables (p variables) through a few (k, k<p) linear combinations (PC) of these variables. The general objectives of PCA are (1) Data reduction and (2) Interpretation. There is (almost) as much information in the K principal components as there is in the original p variables. The k principal components can replace initial p variables and the original data set. (Johnson and Wichern, 2006; Raykov and Marcoulides, 2008). The components with large variance have important dynamics.

Review of the literature: Gabriel (1954) and Vernon (1950) have contested that the RSPM is largely a pure measure of g but also contains a small spatial ability factor. Vincent and Cox (1974) accept the RSPM provided a good estimate of IQ. Gustaffson (1984, 1988) acheived that the RSPM have a reasoning factor and a further factor that he labeled cognition of figural relations. Buros (1975) address the test has been reported to assess the abilities such as visual- perceptual processing, abstract reasoning, and concept formation (Anum 2006).

Demirtasli (2002) was investigated RSPM's items were ranked from the easiest to the hardest according to classic test theory and Rasch model.

Van der Ven and Ellis (2000) achieved that SPM is broadly used as a general intelligence test in the world and has following two significant factors

(1) Gestalt continuation (2) Analogical reasoning

(1) Gestalt continuation is a visual perception law, says our brain try to collect knowledge and arrange concise order from what we see, gestalt psychologist assumes sudden changes in the movement of a line brain does not prefers. In other words a smooth continuation of a line the brain does seek.

(2) Analogical reasoning is a cognitive process of transferring information or meaning from a particular source to another particular target, and a linguistic expression corresponding to such a process. Analogy plays a significant role in problem solving, decision making, perception, memory, creativity, emotion, explanation and communication (Moore and Fitz,1993).

Lynn *et al.* (2004) using exploratory and confirmatory factor analysis on SPM items which were identified the three factors, as the gestalt continuation, verbal–analytic reasoning and visulspatial ability further analysis of the three factors showed a higher order factor as g.

Mc Gregger *et.al* (2010) presented a Fractal technique for solving complex geometric analogy problems by using the Standard Raven's Progressive Matrices tests of general intelligence.

In this study Principal Components Analysis is used to identify visual spatial ability of the students.

Materials and Methods

The Raven's Standard Progressive Matrices having 60 images in 5 sets A, B, C, D & E were administered collectively (Group-class) in Karachi to a representative sample of 268 adolescents/Boys and Girls through gall up survey. The ages of participants ranged from 17 to 25 years, belonging to graduate and post graduate levels. The sample was drawn from Karachi University and Federal Urdu University of Arts, sciences and technology, Gulshan-e-Iqbal campus, Karachi. Data were collected on March-May 2010. The test was administered in Statistics, Physics, Mathematics, Business administration, Computer science, Microbiology and chemistry departments, without any time limits so that this would allow us to asses intellectual capacity without the interruption of speed in the task. The test scores of 60 images have been analyzed using the MINITAB for Descriptive Statistics and for Principal Components.

Results and Discussion

Individual Sets Scores Discussion: Table 1 presents the descriptive statistics. The means of the test scores of set A to E were 10.97, 9.843, 8.172, 8.507 and 4.679 respectively. Indicating students are getting 11, 10, 8, 9 and 5 scores out of 12 in set A, B, C, D and E, respectively that provide the sense that 92, 83, 67, 75 and 41%, respectively answers are correctly attempted by the students, since mean of set A is very high, showing this task is very easy to respondent, but each progressively harder than the last, because the mean scores of the students in set E are showing very low. Demirtasli (1995), Lovett, *et al* (2010) was also investigated RSPM's items were ranked from the easiest to the hardest according to classic test theory and Rash model.

The median of the test scores of set A to E were 12, 11, 9, 9 and 5 respectively that 50% student secured less than 100 , 92 , 75 ,75 and 42% tests scores, respectively in set A, B, C, D and E, respectively

The standard deviation of test scores of set A to E were 1.67, 2.39, 2.51, 2.40 and 2.82, respectively that may be interpreted in the round off figure as the students have the variability of almost 2, 2, 3, 2 and 3 scores among each others from set A to E, respectively. In the whole set the variation among the scores of the students from set A to E are almost lying in between the interval 2 to 3 scores provide the evidence that there is no huge marginal difference among the score of the student with respect to sets.

Table 1 also exhibits that scores of set A have very large kurtosis >3,indicated that the test results being highly concentrated around the mean, thicker tail and the variations within the test scores of student were low, showing most of the student secured same test scores showing leptokurtic distribution. Therefore the nonverbal abilities of the student for item A are strong and items B, C and D gave kurtosis < 3, indicating that the platykurtic distribution of scores have a large spread around the mean and more rounded peak and shorter thinner tails.

Combined measures (A to E sets) Discussion: The whole Raven Progressive Matrices test which had 60 items, the mean of total scores was 41.877 may be interpreted in the round off figure 42, provided the sense that 70% answers are correctly attempted by the students, the median of total scores was 44 showing that 50% student secured 73% tests scores it appeared that intellectual capacity of the 50% student is very sound, the first quartile Q_1 = 36.25 showing 25% student secured 60% tests scores and the third quartile Q_3= 49 showing 25% student secure more than 81% tests scores.

Standard error of kurtosis of sets A to E was 5.5 explains that the variation in the kurtosis of the distribution of sets of 6 scores but this high value may be due to the large value of kurtosis of set A i.e. 14.301. So, to get the actual picture of variation in the kurtosis of sets, the set A is excluded from the calculation of standard error. Now the standard error of set B to E is 1.377 we say that the variation in the kurtosis of sets is of 1 score that is much less than the previous.

Table. 1. Descriptive Statistics for (RSPM) test scores.

Visual Test items	Mean	Standard Deviation	Q_1	Q_2	Q3	Skewness	Kurtosis
Set A	10.97	1.67	11	12	12	-3.28112	14.30137
Set B	9.843	2.39	09	11	12	-1.58759	2.631928
Set C	8.172	2.51	07	09	10	-1.04384	1.036164
Set D	8.507	2.40	07	09	10	-1.19733	1.345288
Set E	4.679	2.82	02	05	07	0.34004	-0.71309
Combined measures (A to E sets)	41.877	9.24	36.25	44	49	-1.17649	1.68752

Standard error of skewness (From A to E sets): 1.1649
Standard error of Kurtosis (From A to E sets): 5.4605
Standard error of Kurtosis (From B to E sets): 1.377904

Table 2. Principal Components Analysis of sample Correlation Matrix for RSPM test Scores exploring non verbal abilities.

Visual test items	PC1	PC2	PC3	PC4	PC5
Set A	0.379	0.787	0.412	-0.07	0.248
Set B	0.470	0.237	-0.437	0.334	-0.648
Set C	0.476	-0.235	-0.334	0.379	0.68
Set D	0.482	-0.202	-0.18	0.833	-0.032
Set E	0.42	-0.478	0.703	0.215	-0.233
Variance Eigenvalues	2.7873	0.7614	0.5885	0.436	0.4269
Proportion	0.557	0.152	0.118	0.087	0.085
Cumulative % of total variation	55.7	70.9	82.7	91.5	100.0

To identify visual perception ability of the students we also performed the PCA and extracted the five Principal Components(Table 2) in which first Principal Components (PC1) explained 55.7% of the total sample variance, the second PC explained 15.2% the third PC explained 11.8%, the fourth PC explained only 8.7% similarly fifth PC explained only 8.5%. After examine the Eigen values we consider only PC1and PC2 for interpretation in which a sharp drop from first Eigen value to second Eigen value while there is no successive differences between the third, fourth and fifth Eigen values. Hence only first two Principal Component is reasonable.

Table 2 exhibits the first PC which denote by U_1:

U_1 = 0.379A +0.470B +0.476C +0.482D +0.420E

in first PC the component coefficients appears approximately equaled in all visual sets (A, B, C, D, E), it is indicated that all the visual sets moderately correlated with first PC hence all the visual sets equally contributes in the formation of first PC may be interpreted as it is contribution of general intelligence ‘g’ on the scores of the test RSPM. According to Psychologist Spearman 'g' gives, the spirit for the action and a specific agent that is responsible for the execution of the lesson, Spearman also concluded that testing give an idea about the attributes of intelligence to a certain limit.

Table 2 exhibit the second PC which denote by U_2:

U_2 = 0.787A+ 0.237B-0.235 C- 0.202D -0.478E

In second PC only relatively easiest set A are strongly positively correlated and set E is negatively correlated.

Conclusion: Over all result showing student of Karachi University as well as Federal Urdu University having very sound intellectual capacity, nonverbal reasoning abilities, abstract reasoning, puzzle solving, problem solving, and pattern recognize (Fluid intelligence).

students also having very strong visual perception, use brain to seek as much as possible a smooth continuation of a line, which indicates the students are suitable for Interior designing, graphic designing and as musicians. When graphic designers that laying out advertisements, posters, or even business cards, they lay out the information and graphics in such a way that readers follow the lines of the layout. When professional musicians organize their musical expressions without breaking the rhythm, they too, conform to the law of continuation. (Behrens, 1984; Mullet and Sano, 1995; Moore and Fitz, 1993).

Recommendation: For employment purpose one may use this method. The SPM assesses the ability to make new insights and information out of that which is perceived or already known, the ability to extract meaning out of confusion or puzzle.

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