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PSYCHOLOGICAL MEASURES OF SPATIAL ABILITIES

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Abstract: *Spatial abilities are divided into three categories: mental rotation, spatial relation and visualization. Several tests are cited in foreign literature that are frequently used in order to assess these abilities, but for Romanian specialists they are not on hand. The present paper is introducing new assessment tools for static spatial abilities that were successfully used along with already validated instruments. Data on statistical qualities of the new instruments are also discussed.*

Key words: *spatial abilities, validity, psychological tests.*

1. Introduction

Spatial abilities are recognized as an important type of cognitive ability, frequently presented in parallel with verbal abilities. There is also a trend to present spatial abilities as opposed to the verbal ones. Some reason for doing so are: the different dominance of cerebral hemisphere implication, the gender differences involved in both type of abilities and differences in performance noticed in the same person [4, 18].

The specialists in cognitive abilities are inclined to accept one classification of spatial abilities, which resulted from a meta-analysis conducted in 1985 by Linn and Peterson [11]. There were identified three categories as follows: mental rotation, spatial relation and visualization. Mental rotation is defined as the ability to mental rotate two or three-dimensional figure rapidly and accurately and to imagine the aspect of the figure after it was rotated around an axis with a certain number of degrees. Spatial relations are involved in determining spatial relationships with respect to the orientation of your own body. Visualization involves multiple and complex manipulation of spatially presented information and flexible activation of different operational strategies [11].

This classification was maintained over time and recent research added subtypes or clarifications upon the place of the above abilities in the field of cognitive psychology. Other research claimed that an important type and ignored by the mentioned meta-analyses is represented by dynamic spatial abilities [12]. In present many specialists consider that for static spatial abilities the most suitable tests are paper and pencil, hand written or virtual simulation and for the dynamic ones computer tests and digital format.

2. Objectives

In the present research we used a battery consisting in seven tests all related with spatial abilities. We anticipate that the whole battery is centered on two factors: one, more general, of non-verbal intelligence and the other, more specific, centred on spatial ability. The paper will

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introduce three tests that can be used to assess spatial abilities, completing the frequently used ones.

3. Material and Methods

3.1. Participants and General Procedure

The present research is a part of a larger one aimed at evaluating the relationship among computer games and spatial abilities. The sample selected for this presentation is constituted of 303 subjects (mean age 14,2, minimum 10,7 and maximum 19,2), coming from four schools from Brasov (48% from 2 secondary schools – Scoala Generala Nr. 15, Scoala Generala Nr. 28 and 51% from 2 high schools – Colegiul National Grigore Antipa, Colegiul National Kristian Kertsch). In order to assure the representativity of the sample, the selected schools are common, middle range schools, testing all children from a class.

The sex distribution is 58% of males and 42% of females.

There were used seven psychometric tests, administered individually and in-groups in two sessions, during September – November 2007. The first testing session was a group testing that took one hour (15-19 participants). The second one was individual session and lasted around 30 minutes.

3.2. Measures

Standard Progressive Matrices Test (Raven, 1938) a paper and pencil nonverbal intelligence test, contains 60 items of increasing difficulty, grouped in five series [9]. In order to give the solution one must operate with abstract figural stimuli, understand the gestalt and activate flexible strategies of solving. The test was administered in-groups with a time limit of 25 minutes.

Bender-Gestalt Test was used in a new version adapted by Clinciu [6, 7] starting from Kulcsar version presented in volume I of Psychodiagnostic Guide. The task of the test is to copy the five figures, and the results are judged in respect with: shape, size and distance constancy, proportion, orientation of the elements of the figure, angles, parallelism and perpendicularity. The task was administered in-groups, taking around 7 minutes to complete. Responsiveness of the test is high for scores at extremes, age but not gender requiring different standards.

Bender-Gestalt Test from memory is a recent version of the prior test in which the subjects had to redraw the five figures, from memory, 5 minutes apart from the first drawing. The task is a measure of the mental representation of bi-dimensional space. Cronbach α coefficient is α=.90, and Split-half reliability for both Bender Gestalt tests = .82.

Mental rotation task is a component of a cognitive abilities battery proposed by a psychologist's team from Babes Bolyai University [19] and it measures the ability of a person to transform mental imagines especially through rotation. Each participant was tested individually, having five minutes to respond to 10 problems.

Spatial orientation task [19] in which three dimensional figures placed in a target position are shown to the subjects and they are required to indicate from a changed perspective which two of four images are identical with the target one. There are 10 situations, 20 maximum points for correct answers and five minutes time limit.

Image generation test [19] is a measure of visualization ability and consists in two series of 15 cardboard's depicting black squares in certain positions. The task was administrated individually and took around 7 minutes to be solved.

Blocks test - Clinciu version [6, 7], adapted by Block design subtest from Wechsler Intelligence Scale for Children-Revised consists in 12 models which have to be reproduced using red, white or red/white sides of three dimensional blocks. It requires spatial visualization, gestalt comprehension and manual action combining nonverbal intelligence and spatial conceptualization. The test showed a satisfying internal consistency in the present research (Chronbach α=.78 to .82).

3. Results

In this paper the focus is on the results obtained by Bender Gestalt, Bender-Gestalt Test from memory and Blocks tests and the characteristics that can be drawn out of these results.

The data showed an ontogenetic evolution of the scores ($F_{2,\ 276}$ = 37.64 for Bender Gestalt, $F_{2,\,276}$ = 54.13 for Bender Gestalt from memory and $F_{2,\,284}$ = 32.92 for Blocks), which support the need of different standards depending on age.

Table 1 *Reliability Coefficients for Blocks Test*

Blocks	Scale mean if item deleted	Corrected item-total correlation	Alpha if item deleted
Block_1	121.45	.00	.79
Block_2	121.49	.15	.79
Block_3	120.57	.22	.79
Block_4	119.83	.17	.79
Block_5	117.92	.35	.78
Block_6	118.65	.52	.77
Block_7	117.66	.55	.77
Block_8	116.05	.44	.78
Block_9	113.10	.70	.74
Block_10	116.16	.76	.72
Block_11	115.97	.80	.72
Block_12	114.12	.83	.72

The internal consistency of each of these three tests were high (table 1 and table 2), with the alpha Crohnbach = .78 for blocks (N of cases = 287, N of Items = 12) and alpha Crohnbach = .90 for the two forms of Bender Gestalt (N of cases = 270, N of Items = 10). Separately measured, Bender Gestalt has an internal consistency of α = .85 and Bender Gestalt from memory an Alpha Crohnbach α = .80.

The test-retest reliability for Blocks is also statistical significant and with a satisfactory level (r = .88 for one month time elapsed between assessments).

Table 2 *Reliability Coefficients for Bender Gestalt and Bender Gestalt from memory*

Item of the test	Scale mean if item deleted	Corrected item-total correlation	Alpha if item deleted
BG_1	52.98	.69	.89
BG_2	53.11	.67	.90
BG_3	54.94	.72	.89
BG_4	56.50	.71	.89
BG_5	55.11	.70	.89
BGm_1	53.67	.70	.89
BGm_2	53.60	.56	.90
BGm_3	55.77	.67	.89
BGm_4	57.27	.65	.90
BGm_5	56.20	.63	.90

The entire battery was submitted to a factor analysis (see table 3) and the results confirm the above hypothesis. The results separated in two major factors: one of nonverbal intelligence and the second on spatial abilities.

An interesting result is the fact that image generation, a test that is a component of spatial ability battery from BTPAC, is saturated in general intelligence probably due to the complex strategies that are required to solve its tasks.

The analysis also showed that the first factor explain 45.26 % of total variance and the second one another 21.22 % of total variance, so the analysed battery demonstrates its value in testing nonverbal and spatial abilities.

Factor analysis –VARIMAX method Table 3

Tests	**Factors**	
	1- non-verbal intelligence	2 – spatial aptitude
Raven	.767	
Mental rotation		.839
Spatial orientation		.766
Image generation	.620	
Blocks	.793	
Bender Gestalt	.871	
Bender gestalt –m	.872	

The correlation matrix presented in table 4 is also relevant for the way the tests are grouping. We mentioned before that Blocks, Bender Gestalt and Bender Gestalt from memory showed an increasing of scores with age. The same variation is present in Raven scores and in Image generation scores, but is missing for metal rotation and spatial orientation.

Correlation coefficient among the tests used in the battery Table 4

Tests	**Raven**	**Rot_or**	**Gen_im**	**Blocks**	**B G**	**B G_m**
Raven	1.000					
Rot_or	.219**	1.000				
Gen_im	.331**	.192**	1.000			
Blocks	.432**	.241**	.450**	1.000		
B G	.289**	.081	.239**	.365**	1.000	
B G_m	.292**	.135*	.176**	.382**	.790**	1.000

So, the ontogenetic characteristic common for some tests may explain also the common variation. The correlation matrix (table 4) shows significant results for all the tests, with values varying from small to moderate.

We noticed the correlation between Blocks Test and Image Generation test (r = .45) and also between Blocks Test and Bender Gestalt and Bender Gestalt from memory (r = .36, respectively r = .38). These correlations signify the possibility that visualization process is involved in solving the tasks of all of these tests.

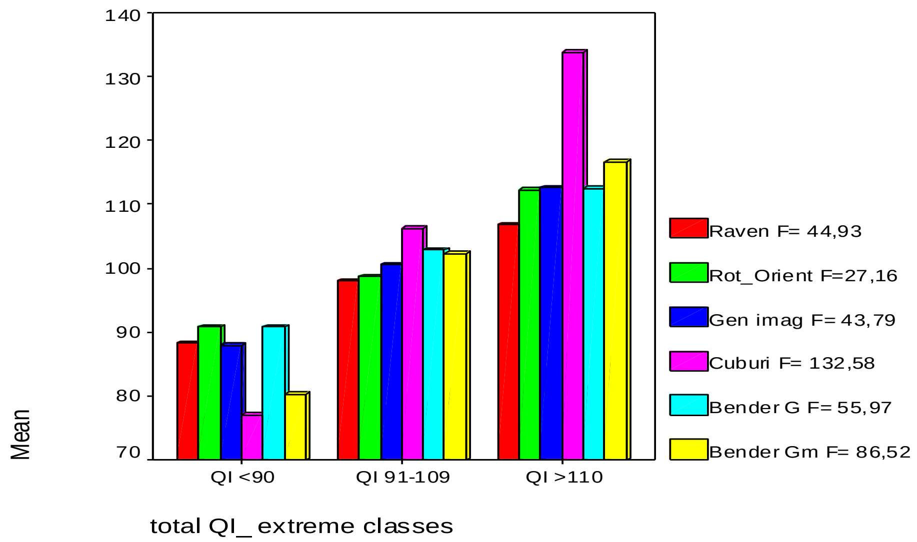

Fig. 1. *Results of the tests' scores grouped in three classes*

4. Discussion

The present data support the data found in specialized literature. The new instruments can be used in order to assess spatial visualization in human subjects. Visualization is the most complex spatial ability and is important to obtain test results from different tasks. This ability is involved in some academic courses such as: geometry, chemistry, physic, design and also in professions like: construction engineering, architecture, surgical investigations, traffic controller, or in daily activity like: route finding, orientation, sports, driving, etc. [3, 8, 10, 13-17].

The presented tests were all selected because they are involved in visual input processing, and they may be used to assess spatial ability.

The spatial orientation test corresponds more to the description made by Carroll [5] than the one of Linn and Peterson [11]. Nonverbal intelligence is supraordinated to spatial visualization that is a larger ability than mental rotation and spatial orientation. In Carroll's theory and also in Allen and Rashotte [1, 2] mental rotation, visualization and spatial orientation are presented as parallel forms. In the present research visualization seems to incorporate the other two types and testing this hypothesis can be a valuable contribution in both theoretical and practical field.

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