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Relations between results on Raven progressive matrices plus sets and school achievement

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The relationships between results on the SPM+ and school grades were analysed for nine school subjects, including indicators of average school performance on a sample of 437 high school students. Correlation coefficients between SPM+ and final school achievement vary in range from 0.14 (history) to 0.35 (physics). The results do not support the hypothesis that teachers penalize intelligent students by giving them lower marks at the half-term in order encourage them to work harder.

Raven's Standard Progressive Matrices (SPM), originally published in 1938, rapidly became the standard test for the measurement of *g*-factor within the framework of Spearman's human intellect structure. According to the idea of their author, John Carlyle Raven (1907-1971), Progressive Matrices enable the measurement of mental abilities for eduction (lat. *educere* = to draw out). In the General overview of the Manual the authors explain that "Eductive mental activity involves making meaning out of confusion; developing new insights; going beyond the given to perceive that which is not immediately obvious; forming (largely non-verbal) constructs which facilitate the handling of complex problems involving many mutually dependent variables" (Raven, J., Raven, J.C., & Court, 1998, p. G3).

During its development over several decades, the basic idea of a simple intelligence test whose items are progressively more difficult to solve, thus allowing a discriminative assessment of subject's intellectual development, has experienced several changes and expansions.

In 1947, a series of Coloured Progressive Matrices (CPM) was offered, expanding the application of Raven's tests to small children, older subjects and intellectually retarded persons. During the same year, the Advanced Progressive Matrices (APM), slowly worked upon since 1941, became available for controlled application. The Advanced Progressive Matrices are intended for intellectually above-average individuals, more precisely, they are discriminative for the 20% of intellectually most developed persons (Raven, J.C., Court, J.H., & Raven J., 1995).

In the case of Standard and Coloured Progressive Matrices, the sequence of items was changed in 1956, while the Advanced Progressive Matrices reduced the number of items in 1962. However, there is no doubt that the most significant adaptation occured in recent times. In 1998, parallel forms of the Coloured and Standard Progressive Matrices were published, while a new version of the Standard Progressive Matrices, named the Plus Set (SPM+) was developed. The Plus version of the SPM would, according to its difficulty, be placed between the series of classic Standard and Advanced Progressive Matrices.

The newest versions of the Raven nonverbal tests were available in the Republic of Croatia as soon as they have been published. However, while various reports and research studies have been done on the Coloured and Standard Progressive Matrices, this is the first report in Croatia regarding their Plus version.

J. Raven and his colleagues (1998) emphasise that highly similar norms have been obtained for the Progressive Matrices, regardless of the national or cultural settings where they were applied. Despite this fact, the test publishers insist upon the establishment of national norms for individual countries in order to avoid interpretation errors, considering the fact that beside generally assessed positive experiences some cases have yielded significantly different data which have not always been easy to explain.

The current Manual for SPM Plus sets has been published without any norms. There is only a table for the conversion of results from SPM+ into the classic and parallel form of the Standard Progressive Matrices and vice-versa.

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Data were partially presented at the 42nd Congress of the German Society for Scientific Psychology held in Jena, Germany, 24th to 28th September, 2000.

Considering the fact that the majority of existing norms were obtained from available and relatively specialised samples, we believe that the publication of norms for our sample will be a useful contribution toward the standardisation of this test. The norms and basic data obtained in the first administrations of SPM+ in Croatia are presented in the Appendix.

Raven's tests were followed by numerous validation studies, far too numerous to be published in the manuals which are continually updated and expanded. For this reason, additional data are published separately as summaries (Raven, J., Court, et al, 1989), or as bibliographical appendices, to inform interested users of the advances and changes (Court, J.H., & Raven, J., s.a.).

One of the usual validation procedures concerns the comparison of performance on the Progressive Matrices and school achievement. Raven's Progressive Matrices are often used by school psychologists, thereby, along with correlation coefficients for performance on the Matrices and other intelligence tests, such as the WISC, data are available for the relationship between test results and school marks. These coefficients range from 0.10 to approximately 0.60, depending on the subject (Raven, J., Raven, J.C., & Court, J.H., 1998a).

Beside the data available in the original manual, reviews on the relations between the Progressive Matrices and school achievements cited in the German versions of the Raven manuals are significant for this issue (Schmidtke, Schaller, Becker, 1980; Kratzmeier and Horn, 1987). The Manual for the Advanced Progressive Matrices states that Horn, on a sample of army cadets, obtained negative correlations between teacher predictions and results on the Matrices, interpreting this as teacher's attempts to stimulate brighter students giving them lower grades. If this hypothesis were true, then the intelectually brighter students would obtain lower grades during the school year than at the end of it. As in Croatian school system the students are graded at the half term and then finally at the end of the school year, the change in grade levels could be compared with their intellectual abilities deteremined by SPM+.

That is why the aim of this investigation was to examine the hypothesis that teachers actually penalise their brighter pupils during the school year, in order to motivate them to study harder.

METHOD AND PARTICIPANTS

The SPM+ was administered during the last month of the school year 1999/2000 to students of the first, second, third and fourth grade of a high school in one region in Croatia. A total of 437 students aged 15-19 years were tested (174 boys and 263 girls). The administration time of the SPM+ was limited to 40 minutes.

Half-term and final grades were collected for all 437 students. School grades in Croatia comprise five scores, ranging from 1 (which is the lowest grade) to 5 (which is the best one). In other words, a larger numerical value indicates a better result.

RESULTS AND DISCUSSION

Due to the fact that the SPM Plus manual does not provide any norms, it seemed useful to present the results of 437 students who, coming from a typical Croatian high-school, could be treated as at least orientation norms for this test. Seven tables in the Appendix contain descriptive statistical values (Apendix A), item difficulty for all parts of the test (Apendix B and Figure 1), correlations between various parts of the test (Apendix C), main results of the principal components analysis (Apendix D). Table in Apendix E gives percentiles for boys and girls separately, no statistically significant gender diferences were found (M_b = 39.5, SD_b = 6.50, n_b = 174; M_g = 38.7, SD_g = 4.73, n_g = 263). There were also no statistically significant differences between younger and older students (15 - 19 years), but test for the homogeneity of variance has shown a significant diference (p< 0.002) in a favour of the female students, that is their results have a smaller range of distribution than those of males students. The internal consisteny of the test estimated using the Cronbach alpha procedure is 0.79, similar to coefficients obtained in numerous investigations. Despite the fact that the Manual's authors claim that coefficients of internal consistency are mainly above 0.90, they admit that this value has been around 0.70 for some groups (Raven et al., 1988a).

Average grades that our students achieved in nine school subjects (mother tongue, first foreign language - which was most often English, second foreign language - mostly German, history, geography, mathematics, physics, chemistry, and biology) at the half-term and at the end of the school year are presented in Table 1.

The above mentioned subjects were chosen because they are being taught in all four high-school years, and have the greatest number of teaching hours. In other words, they are regarded as important subjects. Table 1 also shows the averages derived from the grades in these nine subjects as well as those derived form all subjects as well. As high-schools in Croatia have approximately 12 to 15 subjects in each class or school year, these last averages based on the grades in all subjects taken together.

Table 1

The average grades achieved at the half-term and final grades for 437 students at the half-term and the end of year

	Half-term		End of the school year		
	M	*SD*	*M*	*SD*	*t*
mother tongue	3.27	1.02	3.48	0.97	8.11**
foreign language 1	3.39	1.07	3.6	1.07	7.67**
foreign language 2	3.42	1.23	3.59	1.13	5.48**
history	4.19	0.92	4.26	0.89	2.57**
geography	4.02	1.02	4.15	0.94	5.15**
mathematics	2.59	1.14	2.92	1.08	11.78**
physics	2.49	1.07	2.76	0.96	10.02**
chemistry	2.49	0.94	2.73	0.95	8.8**
biology	3.79	1.02	3.96	0.94	6.35**
Nine subjects	3.6	0.63	3.77	0.64	16.64**
All subjects	3.03	1.43	3.83	0.89	15.37**

** $p<.01$

Table 1 shows also the data about statistical significance of the obtained differences between the average grades at the half-term and the average grades at the end of the school year. As shown in Table 1, all differences are statistically significant ($p< 0.01$), and in all cases the final grades were higher than the half-term grades. It is thus possible to conclude that teachers generally grade students somewhat lower at the half-term than at the end of the school year. These results make an attempt to determine the reason for this phenomenon and its generality (does it, for example, apply to all students or maybe only to those above average) worthwhile.

Table 2

Correlation between results on SPM+ and school marks ($N = 437$)

Subject	Half-term	End of year
mother tongue	.19	.23
foreign language 1	.28	.24
foreign language 2	.21	.26
history	.14	.14
geography	.12	.20
mathematics	.34	.32
physics	.30	.35
chemistry	.19	.23
biology	.18	.21
Nine subjects	.31	.34
All subjects	.28	.30

All correlations are statisticaly significant ($p<.01$)

Correlations between grades obtained at the half-term and the SPM+ results, and correlations between grades obtained at the end of the school year and SPM+ scores are presented in Table 2.

All coefficients in Table 2 are statistically significant ($p <0.01$). Correlations between final grades and SPM+ scores are higher in all cases, except for the first foreign language, but the differences are not statistically significant. The systematic increase of correlations between final grades and SPM+ scores might indicate teachers' trend to include in the final student's grade their estimation of his/her intellectual abilities. Be it as it may, these data do not tell us anything about the possibility that teachers use the grading process to motivate intellectually stronger students to study harder.

We have tried to examine the hypothesis that teachers during the school year try to motivate brighter students to study harder by giving them lower grades by dividing the sample in two groups. One group included students whose grades at the end of the school year were equal or lower than at the half term, and in the second group those whose final grades were higher than their half-term grades (see Table 3).

Table 3

Frequencies and percentages of students who had varying school grades between the half-term and the end of school year

	Equal or lower school grades at the end of school year end		Higher school grades at the end of school year	
Subjects	*n*	%	*n*	%
mother tongue	325	74.4	112	25.6
foreign language 1	321	73.6	115	26.4
foreign language 2	328	75.0	19	25.0
history	371	85.0	166	15.0
geography	345	79.0	92	21.0
mathematics	289	66.3	147	33.7
physics	293	67.0	144	33.0
chemistry	317	72.5	120	27.5
biology	327	74.8	110	25.2
Nine subjects	324	74.3	112	25.7
All subjects	244	55.8	193	44.2

Table 4

Mean differences between in SPM+ scores between students with equal or lower school grades and students with higher school grades, at the end of school year.

	Equal or lower school grades at the end of school year		Higher school grades at the end of school year			
Subject	*M*	*SD*	*M*	*SD*	*F*	*p*
mother tongue	38.94	5.65	39.38	5.10	.55	.46
foreign language 1	39.39	5.43	38.09	5.66	4.79	**.03**
foreign language 2	38.96	5.66	39.28	5.06	.24	.62
history	39.23	5.28	38.03	6.62	2.68	.10
geography	38.93	5.66	39.49	4.92	.74	.39
mathematics	39.41	5.16	38.37	6.10	3.49	.06
physics	38.99	5.40	39.17	5.73	.10	.76
chemistry	38.99	5.51	39.22	5.52	.15	.70
biology	39.07	5.62	38.99	5.17	.02	.90
nine marks	38.45	5.58	39.23	5.48	1.58	.21
all marks	39.33	5.38	38.70	5.66	1.40	.24

($df = 1/436$)

As the Table 3 shows, in most subjects approximately one fourth of students had lower grades at the half-term and higher grades at the end of the school year. The exceptions were found in history, where one fifth of the students has a higher final grade, and mathematics and physics where about one third of the students has a lower grade at the half-term, and a better one at the end of the school year. For a number of students (somewhat less than 50%) the average overall grades show some increase toward the end of the school year, which is probably the effect of cummulative grade changes in all subjects. One-way analysis of variance showed that the average SPM+ scores for these two groups did not show any statistically significant difference (see Table 4).

Table 4 shows that there were no significant differences in SPM+ scores between the two groups in any particular subject nor between average grades for nine or all subjects taken together. The only exception makes the first foreign language for which there was a statistically significant difference (p 3%), but not in the supposed direction: students with higher final grades have on average lower SPM+ scores. If Horn's hypothesis were right these students should have a higher average SPM+ result.

It seems that these results show quite clearly that even if teachers are trying to manipulate brighter students and motivate them to study harder by giving them lower grades (some of them are usually not inclined to study hard because they can pass by using their intelligence), this is not a very common phenomenon and it cannot be generalized.

Considering these results we should remind ourselves that school grades are more related to personality traits than to intelligence. We should not forget "persistance, interest in school and willingness to study. The encouragement for academic achievement that is received from peers, family and teachers may also be important" (Neisser et al., 1996, p. 81-82).

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APPENDIX A

Means and standard deviations of SPM+ results

	M	*SD*	*N*
Males	39.53	6.5	174
Females	38.73	4.73	263
Total	39.05	5.51	437

APPENDIX B

Individual SPM+ item difficulty on a sample of 437 students

SPMA 01	1.000	0.000	**SPMB** 01	0.991	0.095	**SPMC** 01	0.947	0.224
02	0.995	0.068	02	0.998	0.048	02	0.982	0.134
03	0.993	0.083	03	0.993	0.083	03	0.906	0.292
04	0.993	0.083	04	0.954	0.209	04	0.970	0.170
05	0.986	0.117	05	0.966	0.182	05	0.732	0.443
06	0.995	0.086	06	0.860	0.347	06	0.952	0.214
07	0.986	0.117	07	0.872	0.335	07	0.634	0.482
08	0.938	0.241	08	0.918	0.275	08	0.854	0.354
09	0.991	0.095	09	0.902	0.298	09	0.378	0.485
10	0.963	0.188	10	0.947	0.224	10	0.185	0.389
11	0.892	0.310	11	0.819	0.385	11	0.243	0.429
12	0.787	0.410	12	0.787	0.410	12	0.352	0.478
SPMD 01	0.941	0.237	**SPME** 01	0.666	0.472			
02	0.870	0.337	02	0.510	0.500			
03	0.794	0.405	03	0.547	0.498			
04	0.469	0.500	04	0.384	0.487			
05	0.355	0.479	05	0.167	0.373			
06	0.467	0.499	06	0.135	0.342			
07	0.375	0.485	07	0.105	0.307			
08	0.336	0.473	08	0.064	0.245			
09	0.284	0.451	09	0.085	0.279			
10	0.208	0.407	10	0.073	0.261			
11	0.309	0.463	11	0.071	0.257			
12	0.135	0.342	12	0.037	0.188			

APPENDIX C

Correlation matrix of SPM+ series

	SPMA	SPMB	SPMC	SPMD
SPMB	.35			
SPMC	.32	.44		
SPMD	.26	.34	.44	
SPME	.14	.15	.28	.42

APPENDIX D

Main resutls of Principal component analysis of SPM+

Component	Initial Eigenvalues	% of variance	Cumulative %
1	2.28	45.60	45.60
2	.98	19.56	65.16
3	.69	13.74	78.90
4	.54	10.82	89.72
5	.51	10.28	100.00

APPENDIX E

Norms for the sample of secondary school students, with respect to gender, expressed in percentiles (n_M=174; n_F=263)

Percentile	Males	Females
5	27	31
10	32	33
20	35	35
25	36	36
30	37	36
40	39	38
50	40	39
60	42	40
70	43	40
75	44	42
80	45	42
90	46	44
95	48	46

APENDIX F

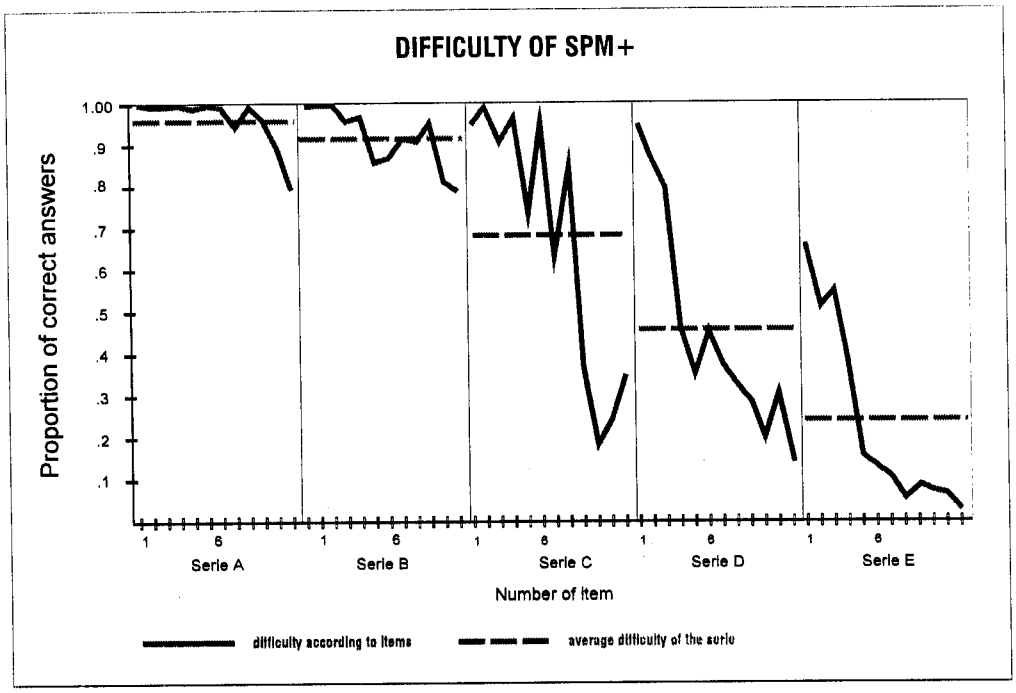

Figure 1. Graphic presentation of SPM+ individual item difficulty and average item difficulty by series from A to E on a sample of 437 secondary school students