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Factors Influencing Medical Informatics Examination Grade – Can Biorhythm, Astrological Sign, Seasonal Aspect, or Bad Statistics Predict Outcome?

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Aim. To investigate whether and to what extent various parameters, such as individual characteristics, computer habits, situational factors, and pseudoscientific variables, influence Medical Informatics examination grade, and how inadequate statistical analysis can lead to wrong conclusions.

Methods. The study included a total of 382 second-year undergraduate students at the Rijeka University School of Medicine in the period from 1996/97 to 2000/01 academic year. After passing the Medical Informatics exam, students filled out an anonymous questionnaire about their attitude toward learning medical informatics. They were asked to grade the course organization and curriculum content, and provide their date of birth; sex; study year; high school grades; Medical Informatics examination grade, type, and term; and describe their computer habits. From these data, we determined their zodiac signs and biorhythm. Data were compared by the use of t-test, one-way ANOVA with Tukey's honest significance difference test, and randomized complete block design ANOVA.

Results. Out of 21 variables analyzed, only 10 correlated with the average grade. Students taking Medical Informatics examination in the 1998/99 academic year earned lower average grade than any other generation. Significantly higher Medical Informatics exam grade was earned by students who finished a grammar high school; owned and regularly used a computer, Internet, and e-mail (p 0.002 for all items); passed an oral exam without taking a written test ($p=0.004$), or did not repeat the exam ($p<0.001$). Better high-school students and students with better grades from high-school informatics course also scored significantly better ($p=0.032$ and $p<0.001$, respectively). Grade in high-school mathematics, student's sex, and time of year when the examination was taken were not related to the grade, and neither were pseudoscientific parameters, such as student zodiac sign, zodiac sign quality, or biorhythm cycles, except when intentionally inadequate statistics was used for data analysis.

Conclusion. Medical Informatics examination grades correlated with general learning capacity and computer habits of students, but showed no relation to other investigated parameters, such as examination term or pseudoscientific parameters. Inadequate statistical analysis can always confirm false conclusions.

Key words: *astrology; culture; data interpretation, statistical; education, medical, undergraduate; educational measurement; medical informatics; occultism; students, medical*

The Mind, like the sense of sight, has its illusions; and just as touch corrects those of the latter, so thought and calculations correct the former... One of the great advantages of probability calculus is that it teaches us to distrust our first impressions.

Pierre-Simon Laplace (1825)

It is very important for a physician today to have computer skills and knowledge on medical informatics. As both medical literature (1,2) and medical professional associations (3) emphasize, such skills and knowledge are almost indispensable in most facets of physician's professional life. There are suggestions that basic education in medical informatics should be introduced worldwide (3). Medical Informatics is a mandatory undergraduate course at all Croatian medical schools, although its organization slightly varies from school to school. At the Rijeka University School of Medicine, Medical Informatics is a 30-hour course which students attend in the fourth semester. Written exam has been introduced in 1998/99 academic year and consists of 22 multiple-choice questions with a single correct answer.

An anonymous questionnaire for students to evaluate Medical Informatics course was first applied in 1996. About 99% students at the time thought that a medical doctor had to be comfortable with the use of computer, 90% thought that he or she had to know basic principles on how computers work, and 94% agreed that basics knowledge on medical informatics had to be adopted during undergraduate studies. As far as the exam outcome was concerned, Medical Informatics grade was found more objective after a written test has been introduced (4).

Since the grade earned on a written examination is considered the most objective measure of student knowledge (5), we tried to determine if there was any other factor that could differentiate between students earning different grades on Medical Informatics examination. The incentive for investigation came in early 1996, when a student asked not to continue an oral examination, because "it was not the right day to take the exam." She said that she had learned hard and understood the matter, but according to an astrologic report, the timing was not right for any intellectual activity. The stars predicted that she would fail on the exam, irrespective of how much she had learned. Thus, we decided to investigate whether astrology or biorhythm ("bad days") might influence students' academic performance, in addition to other parameters, such as high-school grades or computer knowledge. The students were asked to provide their date of birth and were assured that this information would not be used for any personal tracking. We also investigated how inadequate statistical analysis could "prove" scientifically unfounded conclusions.

Participants and Methods

Participants

We surveyed 459 second-year students at the Rijeka University School of Medicine during a five-year study period, from 1996/97 to 2000/01. Immediately after passing Medical Informatics exam, students were asked to fill out an anonymous questionnaire on their attitude toward learning medical informatics and necessity of having computer skills for their future career. Data on the student's date of birth, date of exam, sex, and high-school mathematics and informatics grades were also collected.

Out of 459 students, 382 completed the questionnaire and were included in the analysis, whereas 77 left some questions unanswered and thus were excluded from the study. The sex distribution and Medical Informatics exam grade of the excluded students were compared with that of 382 students who completed the questionnaire to test whether the excluded students were biased in any way.

Computation and Statistics

All variables except the exam grade were considered categorical and were presented in absolute and relative frequencies. Data distributions were compared using chi-square test. One nominal variable with uniform distribution of four classes, random integers 1-4, was formed as a dummy to validate the statistical analysis and to be used for comparison with other variables where uniform distribution was expected (6). Before randomization, the number of classes in a dummy variable was set by means of a fair dice, where "one" was excluded as unacceptable event before the dice was thrown.

Pseudoscientific Parameters

Zodiac signs and biorhythm were pseudoscientific parameters analyzed in the study. The season when the student was born (spring, summer, fall, or winter) and his or her zodiac sign were calculated from the date of birth. For each students, we determined the main zodiac sign (according to usual zodiac dates; ref. 7), zodiac sign element (fire, earth, air, and water; ref. 7), and zodiac odd/even group sign (fire and air signs are odd-numbered and others are even-numbered, ref. 8).

Three biorhythm cycles – physical (23-day cycle), emotional (28-day cycle), and intellectual (33-day cycle) – were calculated on the basis of the following equation: sin 2 (life-length/period) , where life-length in days was calculated as the number of days between the student's birth date and the date of exam (9). Since curves range from -1 to +1, biorhythm values bellow -0.5 were considered unfavorable, above +0.5 were considered favorable, and between these two points were considered neutral (cut-off values included).

Grades

Exam grades (sufficient – 2, good – 3, very good – 4, and excellent – 5) were analyzed as numerical variables. Data were presented as a mean with standard deviation (±SD) and standard error of mean (±SEM). The last measure of dispersion was used to illustrate possible data misinterpretation.

Statistical Analysis

Exam grades were compared using t-test or one-way ANOVA for each group variable. Variables were analyzed as independent, with no adjustment. When three or more categories existed, Tukey's honest significance difference test was used after ANOVA for making pairs for post-hoc comparisons. P-values of both t-test and Tukey's honest significance difference test were assessed when homogenous subsets of categorical variables were defined, ie, when all existing categories were grouped into subsets that differed significantly among but not within themselves. Method revealed only two subsets of all variables tested, which were marked by capital letters A and B.

For all statistical analyses, significance level was set at $p<0.05$. Using t-test and one-way ANOVA, we found that average exam grades significantly differed in some variables. We further analyzed these variables, using randomized complete block design ANOVA, to determine which of the variables were mainly responsible for the observed effect (10). Since we had no intention to predict the value of dependant variable, ie, the exam grade, we did not analyze the combined interactions of factors in block design ANOVA (11).

SPSS software (SPSS® for Windows 7.5, SPSS Inc., Chicago, IL, USA) was used for all statistical analyses.

Results

Sex distribution and Medical Informatics exam grade of the excluded students were compared with that of 382 students who answered all the questions from the questionnaire, to test whether the excluded students were biased in any way (Table 1). Since no significant difference was found, we assumed that 382 students in the study group composed a representative sample of the second-year medical students.

Table 1. Comparison of students included in and excluded from the study according to their sex and Medical Informatics grades

	No. (%) of students			
Parameter	included (n=382)	excluded (n=77)*	Statistics	p
Sex:				
men	151 (35.0)	22 (5.1)	^{2}=0.52	0.470
women	231 (53.6)	27 (6.3)		
Grade:				
number of grades	382	74	t=-1.28	0.202
mean±SD	3.48±1.04	3.31±1.03		

*Out of 77 students excluded, 28 did not provide the information on their sex and 3 did not provide grades (no overlap).

Variables

Out of 21 variables analyzed, 10 significantly differed in average grade in their categories (Table 2). Students had lower average grade in the 1998/99 academic year than in other academic years ($p<0.001$). Students who finished grammar high school ("gymnasium") had significantly higher Medical Informatics exam grades than those who finished medical or other types of vocational high schools ($p<0.001$).

Table 2. Medical Informatics exam grade (mean SD) in student groups according to 21 variables analyzed independently (t-test or one-way ANOVA) and as multivariate (block design ANOVA)*

				Difference in grades between groups					
				T-test/one-way ANOVA†		Block design ANOVA		Homogenous subsets‡	
Variable	Variable group values	No. of students	Grade (mean SD)	t/F	p	F	p	No. of subsets	subset
Academic study year	1996/97	80	3.48 1.16	9.72	<0.001	5.45	<0.001	2	A
	1997/98	87	3.71 1.06						A
	1998/99	77	2.87 0.96						B
	1999/00	69	3.70 0.85						A
	2000/01	69	3.64 0.86						A
Student sex	female	231	3.42 1.02	1.64	0.202	–	–	1	–
	male	151	3.56 1.06						
High school type	gymnasium	292	3.61 1.01	10.27	<0.001	3.97	0.020	2	A
	medical	84	3.10 1.01						B
	other vocational	6	2.67 1.21						B
Own computer	no	197	3.32 1.03	9.83	0.002	2.46	0.117	2	A
	yes	185	3.65 1.02						B
Routine use of computer	no	112	3.18 1.07	13.76	<0.001	0.10	0.748	2	A
	yes	270	3.60 0.99						B
Internet use	no	156	3.21 1.00	19.30	<0.001	2.05	0.154	2	A
	yes	226	3.67 1.02						B
E-mail communication	no	271	3.34 1.02	17.65	<0.001	4.07	0.044	2	A
	yes	111	3.82 1.00						B
Exam type	oral	149	3.67 1.09	8.56	0.004	4.17	0.042	2	A
	written (test)	233	3.36 0.98						B
Exam repeating	no (first-time pass)	325	3.57 1.01	18.43	<0.001	3.08	0.080	2	A
	yes (2 or 3 try)	57	2.95 1.00						B
Exam period	summer	189	3.51 1.02	2.18	0.114	–	–	1	-
	fall	149	3.37 1.00						
	other	44	3.73 1.19						
Average final high school grade	sufficient and good	18	2.89 0.76	3.47	0.032	3.00	0.052	2	A
	very good	126	3.44 1.08						B
	excellent	238	3.54 1.02						B
Average high school Informatics grade	sufficient and good	39	3.10 0.99	7.41	0.001	4.24	0.015	2	A
	very good	131	3.31 1.02						B
	excellent	212	3.65 1.02						B
Average high school Mathematics grade	sufficient and good	113	3.31 1.04	2.62	0.074	–	–	1	–
	very good	142	3.49 1.02						
	excellent	27	3.61 1.03						
Season of birth	Spring	87	3.55 1.05	1.16	0.326	–	–	1	–
	Summer	104	3.40 0.95						
	Fall	93	3.37 1.08						
	Winter	98	3.60 1.06						
Zodiac sign	Aries	27	3.56 1.12	1.32	0.215	–	–	1	–
	Taurus	32	3.50 0.98						
	Gemini	28	3.61 1.10						
	Cancer	35	3.29 0.83						
	Leo	32	3.31 1.06						
	Virgo	37	3.59 0.96						
	Libra	24	3.29 1.12						
	Scorpio	33	3.52 1.09						
	Sagittarius	38	3.29 1.09						
	Capricorn	33	3.24 0.94						
	Aquarius	33	3.64 1.08						
	Pisces	30	3.97 1.03						
Zodiac sign element	Fire	97	3.37 1.08	0.70	0.552	–	–	1	–
	Earth	102	3.45 0.96						
	Air	85	3.53 1.10						
	Water	98	3.57 1.02						
Zodiac sign group	Odd	182	3.45 1.09	0.37	0.541	–	–	1	–
	Even	200	3.51 0.99						
Intellectual biorhythm	unfavorable	108	3.38 1.06	0.92	0.402	–	–	1	–
	neutral	148	3.48 1.04						
	favorable	126	3.56 1.02						
Emotional biorhythm	unfavorable	111	3.45 1.07	0.23	0.798	–	–	1	–
	neutral	151	3.52 1.00						
	favorable	120	3.46 1.06						
Physical biorhythm	unfavorable	126	3.42 1.05	1.17	0.311	–	–	1	–
	neutral	120	3.42 1.02						
	favorable	136	3.59 1.04						
Random number 1-4	1	96	3.42 1.01	0.72	0.541	–	–	1	–
	2	92	3.61 1.08						
	3	101	3.42 1.03						
	4	93	3.48 1.03						

*Both statistics are presented with test distribution values t and F, and level of probability.

†T-test (t-values) was used in analyzing variables with two groups, whereas one-way ANOVA (F values) was used for the analysis of other variables consisting of three or more groups.

‡When three or more variable categories existed, Tukey's honest significance difference test was used after ANOVA for making all pairs of post-hoc comparisons. P-values of t-test or post-hoc tests (data not shown) were examined when existing categories were grouped into subsets, with significant difference among and insignificant difference within them (ie, homogenous subsets). Data analysis revealed maximum of two subsets in all variables, denoted with capital letters A and B. For each variable, it means that there is a significant difference in average Medical Informatics grade between groups A and B, but there is no difference in average grade within categories clustered as subset A or subset B. For example, analysis of homogenous subsets of the first variable revealed that grades in academic years 1996/97, 1997/98, 1999/00, and 2000/01 did not differ significantly (subset A), but all of them differed from 1998/99 academic year. Subsets were used only to compare categories within each variable, not between them.

Significantly better grades were obtained by students who owned and regularly used a computer, Internet, and e-mail (p 0.002 for all four items), those who passed the oral exam without taking a written test ($p = 0.004$), and those who passed the exam on the first try ($p < 0.001$). Students who were excellent and very good high school students (A and B students) obtained significantly better exam grades ($p = 0.032$), as well as those who had excellent grades in high school informatics ($p = 0.001$). Grades in high-school mathematics showed no relation with Medical Informatics exam grade ($p = 0.074$). Also, no significant difference in Medical Informatics exam grade was found between male and female students ($p = 0.202$). Examination terms also did not show any correlation with grades ($p = 0.114$ for summer terms immediately after classes vs fall terms after summer break vs terms during the academic year).

Pseudoscientific Parameters

No significant difference in average Medical Informatics exam grades was found between students born in different time of year (summer, fall, winter, or spring), under different signs, and different zodiac “temper”, or according to odd/even groups of signs (p 0.215 for all). There was no significant difference in exam grades between unfavorable, neutral, and favorable groups of intellectual, emotional, and physical biorhythm cycles (p 0.311 for all). As expected, no significant difference in exam grades between four random groups was found either ($p = 0.541$).

Multivariate Approach

When we analyzed the 10 variables that significantly differed in average grade in their categories with variable adjustment using block design ANOVA (Table 2), we found 5 of them to be mutually independent factors. These 5 variables were academic study year ($p < 0.001$), type of high school finished before medical school ($p = 0.020$), student’s habit to use e-mail ($p = 0.044$), oral/written type of exam ($p = 0.042$), and average high-school informatics grade ($p = 0.015$). Other variables found significant by one-way ANOVA may be considered dependent upon these five.

Statistical Analysis

In addition, we searched for at least one simple case of inappropriate statistical analysis that proved an “obvious” finding or hypothesis. We analyzed students grouped according to their zodiac signs again and found no significant difference among 12 zodiac signs in their exam grades (ANOVA’s $F = 1.32$, $p = 0.215$; Table 2). Data presented in the table 2 were analyzed as mean SD (Fig. 1) and mean SEM (Fig. 2) to show the difference in finding according to statistical analysis applied. Pisces with the highest average exam grade (3.97 0.16) could significantly differ from Capricorn with the lowest average grade (3.24 0.19) (Fig. 2). Their intervals did not overlap and comparison of these two groups yielded $t = 2.92$ and $p = 0.005$, which proved that students born under the sign of Pisces were significantly better in medical informatics than students born under the sign of Capricorn.

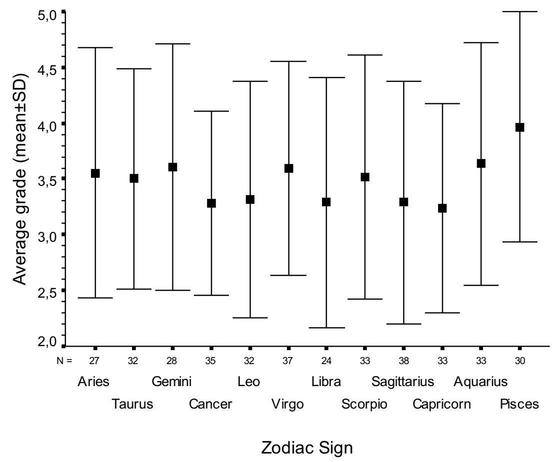

Figure 1. Medical Informatics exam grades of 12 zodiac sign clusters presented as mean with standard deviation (mean ± SD). Number of students per cluster (N) is indicated above zodiac sign on x-axis.

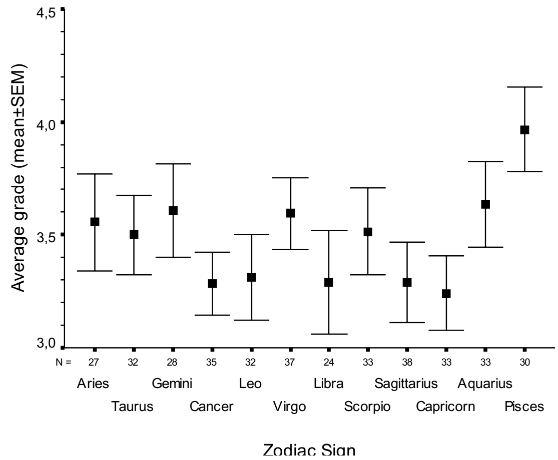

Figure 2. Medical Informatics exam grades of 12 zodiac sign clusters presented as mean with standard error of the mean (mean ± SEM). Number of students per cluster (N) is indicated above zodiac sign on x-axis.

Discussion

Variables

Our study showed that the shift from an oral exam to a written test immediately decreased the average grade from 3.48 and 3.71 in 1996/97 and 1997/98 academic years, respectively, to 2.87, probably because more knowledge was needed to answer the test questions. Furthermore, by the introduction of a written examination, possible subjectivity of an oral examiner in assessing student knowledge was avoided. This finding was statistically corroborated by comparing oral and written test grades for the whole study period. The same was shown in a pilot study carried out in 1999, the results of which were presented to students at the beginning of Medical Informatics course in the following 1999/00 and 2000/01 academic years. In these academic years, students earned better average grades, 3.70 and 3.64, respectively, which did not differ significantly from the grades at the beginning of the study period. It is possible that the finding od the 1999 pilot study provided an impetus for students to learn harder and thereby earn better grades. Moreover, better grades obtained by those who passed the exam on their first try is consistent with the incentive to learn.

Having interest in the subject of medical informatics could explain why students who routinely used or had their own computer, who used Internet and/or e-mail obtained better grades. Actually, multivariate analysis found the use of e-mail the only independent significant variable characterizing students who might generally be proficient in informational science. Furthermore, it seems that a combination of general learning capacity and interest in informatics could at least partly explain the association between Medical Informatics exam grade, average final high-school grade, and grade in high-school informatics course (5). Although high-school informatics course is considered to be related to mathematics, grade in Medical Informatics did not significantly correlate with high-school mathematics grade in our study. It proves that Medical Informatics teaches something else rather than basics of mathematics and informatics (1,3).

Neither examination term nor student sex was associated with Medical Informatics grade in our study. Lynch et al (12) found that women generally show less interest than men in computer science. When they tested the preparedness of medical students for computer-based testing for the United States Medical Licensing Examination, sex proved to be a significant variable (12). Our results, on the other hand, show that both men and women can learn medical informatics equally well, regardless of their interest in the subject. This is important especially in view of the growing feminization of medical profession (13,14).

Pseudoscientific Parameters – Zodiac Signs and Biorhythm

Pseudoscientific parameters are based on hypotheses that can neither be scientifically verified or tested, nor supported by rational thinking or evidence, and their validity holds no evidence compatible with any well-supported scientific theory (15,16).

Our study revealed no association between the season of birth, zodiac sign, or biorhythm with the students' examination grades, which is in accordance with other studies (9,17). Moreover, statistical analysis of pseudoscientific variables gave almost identical results to the analysis of variables when students were randomized by chance into four clusters, ie, there was no difference in average grades between student groups.

Poor Statistics

In the analysis of pseudoscientific variables and exam grades, we first tested mean values of exam grades of 12 zodiac signs (Figs. 1 and 2). The only difference was that the data dispersion was presented with SD in Figure 1 and with SEM in Figure 2. By definition, mean 1 SEM interval presents about 68% of means of samples, not original measurements. Therefore, we cannot assume that Pisces get better grades than Capricorns just because their intervals do not overlap (Fig. 2); they do overlap when data presentation is correct (Fig. 1). Using SEM instead of SD is one of ten most frequent statistical errors in biomedical literature (18). In our data analysis with t-test, we found that Pisces with highest average grade differ from Capricorn with lowest average grade, but only because we excluded other zodiac signs from the analysis (19), which is incorrect. The only correct statistical method here is analysis of variance (global method).

Instead of using a global method, one may perform a sequence of t-tests to make eleven comparisons between Pisces and all other signs. Each comparison is characterized by -level or type I error, which is interpreted as the probability of rejecting a true null-hypothesis (10). If each comparison is made by 5% chance to assume it falsely significant (ie, p 0.05), than type I error will occur eleven times and make overall a 55% chance to declare incorrectly one of the comparisons significant. Therefore, we may conclude that significant difference in Medical Informatics grades between Pisces and Capricorn does not exist at all.

Hines (9) analyzed 136 empirical studies on biorhythm theory published in the 1970-1997 period and found "proof" of the theory of biorhythm cycles in 24. However, he also found at least one error in data processing and analysis per study. He concluded that either there were no rational grounds for biorhythm theory or, if there was, it was based on improper statistical analysis.

In conclusion, the only possible way in which these pseudoscientific parameters might influence grades is by building on student positive attitude before examination, which can help them earn better grade but only if they have sufficient knowledge (5). The report by Nguyen and Swenson (20) on significantly more births and marriages in Vietnam in astrologically good years is an illustration of how beliefs can impact behavior, which later, in retrospective exploration, can be found as scientifically unexplainable fact. The frequency of infant deaths, which they also analyzed for the same period, had a uniform distribution; this finding only indicated that marriages and births coinciding with astrologically ideal times were at least partly planned.

Obviously, zodiac signs, biorhythm, horoscope, and other pseudoscientific parameters have no scientific grounds at all and can serve only as a form of amusement for general public or lame excuse for unprepared students.

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