Correlates of Performance in Biological Psychology: How Can We Help?

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Undergraduate students routinely rated science-related courses such as biopsychology as intimidating and very difficult. Identification of factors that may contribute to success in these types of courses is important in order to help increase performance and interest in these topics. To examine what variables are related to performance, we studied undergraduate students enrolled in biopsychology courses. We found grade point average and students' attitudes about science are the best predictors of performance. Level of perceived preparedness, science efficacy, test anxiety, and previous exposure to the course material were also associated. Contrary to previous data, we did not find a significant relationship between gender and race. It appears that to assist students in biopsychology, we need to focus on preparing them better for the course and stimulating a more positive attitude toward the material.

For over 30 years, comparative studies have chronicled the decline of performance in math and science test scores of American children. Internationally, high school seniors in the United States rank among the lowest in both mathematics and science general knowledge (Business Coalition for Education Reform, 2002). For example, an American high school senior's score in the 95th percentile would be equivalent to a score in the 30th percentile in Japan and the 50th percentile in England (Geary, 1996). During the years 1999-2000, of all bachelor's degrees conferred by United States degree-granting institutions, less than 6% were biological and life science degrees (National Center for Education Statistics, 2001a). From 1979 to 1999 the number of people receiving doctoral degrees in the life sciences increased more than 52%; however, the number awarded to American citizens had dropped by over 17% (NCES, 2001b). The proportion of freshmen intending to major in science and engineering fields fell more than 20% over the last 29 years, and the percentage of freshman intending to major in biological sciences has dropped more than 20 points (Higher Education Research Institute, 2002). This performance deficit progressively widens with successive years of schooling, and recent data revealed science majors average a 40% attrition rate, contributing to the United States ranking lower than several other industrialized countries in university degrees in science (Brand, 1995).

Identifying science performance predictors is essential to the exploration of possible reasons and justifications for this issue. Previous research has demonstrated strong correlations between levels of test anxiety and measures of performance (Everson, Tobias, Hartman, & Gourgey, 1993; Paulman & Kennelly, 1984; Tobias, 1979, 1985; Wigfield & Eccles, 1989; Wittmaier, 1972; Wolf & Smith, 1995). Students with higher test anxiety measures were found to be related to lower performance in the course. For instance, one study found relationships between test anxiety in college students, detriments in grade point average, and poor study skills (Culler & Holahan, 1980). This study showed that students with higher grade point averages had better study skills and lower test anxiety scores. Further, research has consistently shown correlations linking

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achievement to students' self-efficacy and attitude (Germann, 1994). Papanastasiou and Zembylas (2004) reviewed decades of research pertaining to attitudes, finding the attitudes of science students to be positively correlated with academic achievement and participation in advanced science courses. Zohar (1998), for example, found expected success measured with self-efficacy for grade attainment, three days before a test, predicted anxiety levels during an exam.

Quantitative and demographic variables reveal additional correlates of academic performance. Thomas and Schwenz (1998), in an undergraduate biochemistry class, showed that grade point averages and exams revealed the level of understanding of course material. However, in a college biology class, Johnson and Lawson (1998) found prior knowledge of biology had no significant effect on semester scores, quiz scores, or final examination scores.

Demographically, divergence between genders occurs in interest and achievement at the start of high school, growing more prominent as years of education increase (Brownlow, Jacobi, & Rogers, 2000), with United States men having more positive attitudes toward science than women (Czerniak & Chiarelott, 1984; Kahle & Lakes, 1983). However, recent data reveal the total number of women receiving a bachelor's degree in the biological or life sciences has surpassed men. Even more striking was the disparity between races of bachelor's degrees conferred by degree granting institutions. In the 1999-2000 school year, of the 63,532 bachelor's degrees conferred in the United States in the field of biological or life sciences, Black and Hispanic Americans combined received less than 13%, with over 71% issued to White, non-Hispanic Americans (NCES, 2000a). The same racial groups, in the National Center for Education Statistics High School Transcript Study (2000), had mean science and mathematics GPAs lower than all other subject fields. Showing little change from 1990 to 2000, these data forecast no significant levels of improvement. These trends in mathematics and science scores have added to the growing concern about how Americans will satisfy advancing technological professions, such as neuroscience, in the twenty-first century.

This study examined potential educational and psychological factors that may influence and ultimately predict students' performance in a biological psychology course.

We explore how psychological, social and educational factors may predict performance in biological psychology. In addition, we made comparisons across gender, race, and choice of major.

Method

Participants

One hundred and forty-eight undergraduates enrolled in the biopsychology course at the University of San Diego comprised the sample for the current study. The same instructor collected the data over a period of three years. Participation in a research study was a requirement for the course. Alternative choices were given to those students who did not wish to participate in the current study.

Materials

Revised Spielberger State Anxiety questionnaire: (SA; Marteau & Bekker, 1992). This shortened version of the original questionnaire designed by Spielberger (1983) consists of 6 questions from the original scale. The study utilized a 5-point Likert scale with 5 = *the highest level of anxiety* and 1 = *the lowest level of anxiety.* We replaced the phrase used in the questionnaire from how you feel right now to how you feel right now about the course. Scores ranged from 6 to 24. The higher the score, the more anxiety about the course.

Scientific Attitude: (SAT; Moore & Foy, 1997). This is a 40-item test designed to measure the attitude of an individual toward science. A 5-point Likert scale was scored by assigning point values to each of the attitude items (5 = *strongly agree*, 4 = *mildly agree*, 3 = *neutral*, 2 = *mildly disagree*, 1 = *strongly agree*). The maximum possible score for this section was 140, with the minimum being 28. In addition, six positions are positive and six negative. Positive items: (POSSAT) (5 = *strongly agree* – 1 = *strongly disagree*). Negative items: (NEGSAT) (1 = *strongly agree* – 5 = *strongly disagree*). Scores may range from 12 to 60. The higher the score, the more negative the attitude toward science.

The Test Anxiety Inventory: (TTA; Spielberger, 1980). This is a self-report measure consisting of 20 items, employing a Likert scale from 1-4 (1 = *almost never*, to 4 = *almost always*). Scores may range from a high of 80 to a low of 20. The higher the score, the more test anxiety the person reported.

Science Efficacy: (SCIENCE). This survey was a modification of the math efficacy test designed by Betz and Hackett (1993). Various science courses (16 items) replaced items relating to math courses. The test measured the confidence of the individual in different areas of study, with scores ranging from 0 (*no confidence*), to 9 (*complete confidence*). Scores may range from a high of 135 to a low of 0, with higher scores, indicating greater confidence. The survey included one question (PSYCH) using the same scale to measure confidence in psychology-specific courses.

Biology Knowledge test: This is a 15-question test developed by the instructor to test students' knowledge of biology. Scores were are the total number correct out of 15. Scores could range from a high of 15 to a low of 0.

Background questionnaire: This questionnaire, developed by the researchers, included questions about year in school, age, sex, ethnic background, current GPA, major, number of science courses taken in college and high school (COLSCI and HSSCI, respectively), level of preparedness for course (1 – *not at all* to 10 – *very prepared*), as well as whether students had taken biopsychology or cognitive psychology previously.

Procedure

On the first day of class, students enrolled in the course took a biology knowledge test. The instructor explained the study and distributed packets to those who were interested in participating. Other equivalent options to earn their course credit were given to students who did not participate (20%). The analysis did not include the knowledge test scores of non-participating students.

Packets containing the following questionnaires were distributed to students who participated: the shortened version of the Spielberger State Anxiety questionnaire (SA), the Test Anxiety inventory (TTA), the Science Attitude inventory (SAT), a background questionnaire, and the science and psychology efficacy questionnaire. Students completed the packets and returned them to the instructor within two days.

For postcomparisons, another packet of questionnaires was given at the end of the semester. On the last day of class, all members of the course completed the biology knowledge posttest.

Individuals who were not connected with the course scored questionnaires and entered all the data. Student id numbers were coded instead of names in all the questionnaires. Coded under the student identification numbers, average grades and test scores of the course were matched with final grades of the semester.

Statistical Analysis

SPSS completed all the analyses. One-way ANOVA analyzed comparisons between groups. Repeated measures ANOVA compared pre and post data, including the state anxiety measures, knowledge test, and attitude toward science. Spearman correlation coefficients calculated correlations, and simple regression methods provided all the regression analysis. Calculations also yielded means and standard deviations. All missing data were either ignored or if part of a questionnaire, averaged across the other responses in the questionnaire. The analysis did not include the score, if more than 10% of the data was missing within a questionnaire.

Scores on tests, test average, and overall average grade in the course defined performance. The regression analysis used test average as the dependent variable because overall grade in the course included some variables that were subjective in nature.

Results

Sample Description

The majority of our sample was women (64.2%), senior year (59.5%) and Caucasians (67.6%). The rest of the sample included 14.2% Hispanics, 7.4% Asians, followed by 9.4% who listed themselves as other. Psychology majors were the majority of participants with 89.9%. Only 14.9% of the participants stated they had taken a similar course before. The average age of the sample was 21.25 years of age.

The sample reported an overall GPA of 3.12 (*SD* = 0.46) and an average number of science courses taken during college as 4.59 as compared to 3.97 for high school. On a scale of 1 – 10 (*most prepared*), the sample reported they felt moderately prepared (*M* = 6.21, *SD* = 2.04) for the course. Of the sample, 14.9 % stated that they have taken a similar course before.

Anxiety levels for the course were relatively low (M = 13.21, *SD* = 4.18) at the beginning of the course and significantly increased by the end of the course to 15.31 (*SD* = 5.48), [$F(1, 88) = 167.17$, $p < .007$□ Attitude toward science scores started out fairly negative (M = 132.02, *SD* = 21.99) and became significantly more positive by the end of the semester (*M* = 118.25, *SD* = 19.76), [$F(1, 76) = 40.07$, $p < .00001$□

Knowledge of the course material significantly improved over time from a pretest score of 8.48 (*SD* = 2.12) to a posttest score of 11.61 (*SD* = 1.87), [$F(1, 88) = 158.04$, $p < .0001$□ Finally, efficacy scores for psychology were fairly high whereas scores for science were relatively low (*M* = 7.73, *SD* = 2.10) and (*M* = 42.08, *SD* = 14.49) respectively.

Correlation

Table 2 shows the correlations between variables. Test average was significantly correlated with all of the variables measured with the exception of number of high school science courses, psychology efficacy, anxiety levels (both pre and post), and negative attitude subscale scores.

Regression Analysis

The dependent variable entered in the analysis was test average. A simple regression analysis was implemented to enter the variables GPA, pretest scores, science efficacy, how prepared for the course, test anxiety, state anxiety, and science attitude scores. The results showed an R square of 0.55; $F(8, 72) = 9.85$, $p < .0001$. GPA (Beta = .66, $p < .0001$) and SAT (Beta = -.16, $p < .06$) were significant predictors of test average. No other significant factors were found.

Sex Differences

Few significant sex differences were reported in the current study, as shown in Table 3. Women reported feeling less prepared for the course, had lower scores on the pretest and more negative attitudes about science both before and after the course. However, although not statistically significant, women did perform better in the course compared to men.

Racial Differences

Because our sample contained such a small percentage of other races with the

Table 1
Frequency Data of Sample Description Variables

Variable		Percentage
Gender	Male	34.50
	Female	64.20
Race*	Caucasian	67.60
	Hispanic	14.20
	Asian	7.40
	Other	9.50
Year in School*	Senior	59.50
	Junior	32.40
	Sophomore	7.40
Major*	Psychology	89.90
	Biology	2.00
	Other	6.20
Taken Course Before	Yes	14.90
	No	84.50

* = Data missing from sample

Table 2
Spearman Correlation Coefficients and N in Parentheses

	GPA	ColSci	Prepared	Pre test	Post Test	Efficacy	Test Anx	Pre SAT
Test Avg	.61 (116)**	.18 (120)*	.25 (118)*	.25 (117)**	.48 (109)**	.27 (111)**	-.18 (120)*	-.24 (106)*
Grade	.58 (116)**	.21 (120)*	.21 (118)*	.19 (117)*	.48 (109)**	.30 (111)**	-.21 (120)*	-.19 (106)

** $p < .001$
* $p < .05$
ColSci - number of college science courses
Prepared – how prepared for the course
Efficacy – score on science efficacy scale
Test Anx – Test Anxiety Inventory
PreSAT – scores of science attitude before the course

Table 3

Means and Standard Deviations Across Gender and Choice of Major

	Prepared	Pre- Test	Post-Test	Pre SAT	Post SAT	NEG SAT	POS SAT	Grade
Male	6.67 (1.64)	9.27 (2.13)	11.86 (1.58)	143.90 (19.22)	132.97 (23.14)	21.21 (3.49)	14.00 (3.2)	77.92 (8.28)
Female	5.94 (2.23)*	8.07(2.03)*	11.57 (1.93)	126.44 (21.14)*	117.15 (18.06)	20.31 (4.36)	13.83 (3.5)	80.54 (7.09)
Major	6.12 (2.03)	8.51 (2.05)	11.45 (1.88)	133.04 (21.96)	119.42 (20.30)	21.13 (3.61)	14.00 (3.4)	78.94 (7.59)
Non Major	7.67 (1.37)*	9.00 (2.59)	13.12 (0.99)*	119.45 (18.90)	108.50 (10.83)*	15.27 (5.25)*	12.25 (2.5)	81.27 (10.6)

p < .05
SAT = science attitude questionnaire
NEG = negative and POS = Positive

exception of Caucasian, one group included all individuals who identified themselves as non-Caucasian. ANOVA showed that only efficacy levels for the field of psychology differed between groups with non-Caucasians reporting higher levels of efficacy than Caucasians ($M = 8.31$, $SD = 1.29$) and ($M = 7.54$, $SD = 2.24$) respectively; $F(1, 139) = 4.51$, $p < .03$)

Major vs. Nonmajors

Of the entire sample, only 12 people reported being a major other than psychology. As shown on Table 3, statistically significant differences were found on a number of variables across these groups. Non-majors believed they were more prepared for the course, [$F(1, 141) = 6.62$, $p < .01$□reported taking more science courses in college; [$F(1, 143) = 11.28$, $p < .001$□had higher posttest scores, [$F(1, 87) = 6.06$, $p < .02$□higher post-anxiety scores, [$F(1, 87) = 16.95$, $p < .0001$□ and started with more positive attitudes toward science (NegSAT = $F(1, 132) = 24.48$, $p < .0001$; SAT = $F(1, 128) = 3.93$, $p < .05$). Non-majors also had significantly different post-positive science attitude scores, [$F(1, 85) = 16.35$, $p < .0001$□Although not significant, the trend of the data was a higher average for the course for non-majors.

In addition, comparisons between those who had previously taken the course with those who had not taken such a course, showed no differences across any of the variables.

Discussion

Data from our study show that GPA and attitude about science were the best predictors of performance. Those students with better GPAs and a more positive attitude about science did better in the course. As seen in previous studies, these variables are related to performance across a variety of courses (Culler & Holahan, 1980; Germann, 1994; Papanastasiou & Zembylas, 2004; Thomas & Schwenz, 1998; Wolf & Smith, 1995). Furthermore, course performance in biopsychology was related to several other variables such as level of perceived preparedness, science efficacy, test anxiety, and prior knowledge of material. Therefore, students who came into the course feeling better about their ability to do well in the course, as well as those who had some basic knowledge of the course material, were at an advantage to do better in the class.

Demographically, sex differences in attitudes toward science were consistent with previous research (Czerniak & Chiarelott, 1984; Kahle & Lakes, 1983). Interestingly, although women scored higher on the negative attitudes subscale, they did perform slightly better in the course than men. However, these differences in performance were not statistically significant and may reflect the larger number of female participants in the current study. Moreover, race did not seem to be a factor in performance. Although not reported in this study, performance and grade point average disparities across race have been consistently reaffirmed through a number of research studies (NCES, 2000). One explanation for the discrepancy in our data may be due to the small number of non-Caucasian participates, prohibiting a meaningful analysis. The combining of groups labeled non-Caucasian was necessary to increase numbers in this group but may have eliminated any existing differences in a specific racial group.

Unlike the demographic variables, choice of major seemed to be important. There were many disparities reported when comparing psychology majors with non-majors. Non-majors reported taking more science courses, feeling more prepared and having a better attitude toward the sciences. In addition, although not statistically significant, they earned higher grades in the course than psychology majors. However, these results should be interpreted carefully, particularly in view of the fact that many psychology majors may have underreported the number of college science courses they had previously taken, neglecting to consider psychology courses as a science, and very few non-majors participated. Future studies should examine performance and attitude levels in a broader population of students, including more men and individuals of color. Finally, the results may not generalize to other science or psychology courses but may be specific to this area of psychology and this course in particular.

In summary, our results point to the importance of addressing attitudes and knowledge for students to perform better in the biopsychology course. By focusing our efforts early on providing a better background for subjects related to biopsychology and giving extra help for those students with lower GPAs, we may impart an adequate foundation to perform better in science-based coursework. Additionally, by focusing on students' beliefs about their abilities and their preparedness for the course, we may help students to come in with more positive feelings about the course in general. Many unforeseen benefits may follow from addressing these key factors that influence science performance. For example, at the end of the twentieth century, one-third of all science and engineering Ph.D.-holders working in U.S. industry were foreign born (NSF, 2002). Growing political debates about the importing of talent from other countries have raised the issue of the need for more qualified workers within the United States. Future studies need to address possible programs that can increase interest and perceived efficacy for science and math-related careers to help fill the gap in the current employment market.

References

Betz, N. E., & Hackett, G. (1993). *Mathematics Self-Efficacy Scale.* Palo Alto, CA: Mind Garden.

Brand, D. L. (1995). Those students who could have but didn't—Early attrition from college science. *Research & Teaching*, 180-183.

Brownlow, S., Jacobi, T., & Rogers, M. (2000). Science anxiety as a function of gender and experience. *Journal of Science Education and Technology*, *42*, 119-131.

Business Coalition for Education Reform. (2002). "What happened to first in the world?" *The Formula for Success.* Retrieved August 9, 2004, from http://www.bcer.org/timss/p5.cfm

Culler, R. E., & Holahan, C. J. (1980). Test anxiety and academic performance: The effects of study-related behaviors. *Journal of Educational Psychology*, *72*, 16-20.

Czerniak, C. & Chiarelott, L. (1984). *Science anxiety: An investigation of science achievement, sex and grade level factors.* ERIC: No. ED 243 672.

Everson, H. T., Tobias, S., Hartman, H., & Gourgey, A. (1993). *Test anxiety and the curriculum: The subject matters.* ERIC: No. ED 366 598.

Geary, D. C. (1996). International differences in mathematical achievement: Their nature, causes, and consequences. *Current Directions in Psychological Science*, *5*, 133-137.

Germann, P. J. (1994). Testing a model of science process skills acquisition: An interaction with parents' education, preferred language, gender, science attitude, cognitive development, academic ability, and biology knowledge. *Journal of Research in Science Teaching*, *31*, 749-783.

Higher Education Research Institute. (2002). Freshman intending to major in selected S&E fields, by reace/ethnicity: 1971-2000. *University of California at Los Angeles*. Retrieved July 15, 2004, from http://www.cnc.ac.cn/gb/others/nsf/200201/pdf/c02.pdf

Johnson, M. A., & Lawson, A. E. (1998). What are the relative effects of reasoning ability and prior knowledge on biology achievement in expository and inquiry classes? *Journal of Research in Science Teaching*, *35*, 89-103.

Kahle, J. B. & Lakes, M. K. (1983). The myth of equality in science classrooms. *Journal of Research in Science Teaching*, *20*. 131-140.

Marteau, T. M. & Bekker, H. (1992). The development of a six-item short-form of the state scale of the Spielberger State-Trait Anxiety Inventory (STAI). *British Journal of Clinical Psychology*, *31*, 301-306.

Moore, R. W. & Foy, R. L. (1997). The Scientific Attitude Inventory: A Revision (SAIII). *Journal of Research in Science Teaching*, *34*, 327 – 336.

National Center for Education Statistics. (2001a). Bachelor's degrees conferred by degree-granting institutions, by racial/ethnic group, major field of study, and sex of student: 1999-2000. *United States Department of Education, National Center System*. Retrieved July 15, 2004, from http://nces.ed.gov/programs/digest/d01/dt269.asp

National Center for Education Statistics. (2001b). Statistical profile of persons receiving doctor's degrees in the life sciences: 1979-80 to 1998-99. *United States Department of Education, Integrated Postsecondary Education Data System*. Retrieved July 15, 2004, from http://nces.ed.gov/programs/digest/d01/dt306.asp

National Center for Education Statistics. (2002). Comparative indicators of education in the United States and other G-8 countries. *United States Department of Education*. Retrieved July 15, 2004, from http://nces.ed.gov/pubs2003/2003026.pdf

National Center for Education Statistics, High School Transcript Study. (2000). Mean grade point average of high school graduates, by course subject: 1990, 1994, 1998, and 2000. *United States Department of Education, Institution of Education Sciences*. Retrieved October 7, 2004, from http://nces.ed.gov/nationsreportcard/hsts/results/gpa.asp

Papanastasiou, E. C., & Zembylas, M. (2004). Differential effects of science attitudes and science achievement in Australia, Cyprus, and the USA. *International Journal of Science Education*, *26*, 259-280.

Paulman, R. G., & Kennelly, K. J. (1984). Test anxiety and ineffective test taking: Different names, same construct? *Journal of Educational Psychology*, *76*, 279-288.

Science & Engineering Indicators (2002). Foreign-Born Scientists and Engineers in the U.S. Workforce. *National Science Foundation*. Retrieved November 30, 2004, from http://www.nsf.gov/sbe/srs/seind02/pdf/overview.pdf

Spielberger, C. D. (1980). *Test Anxiety Inventory*. Palo Alto, CA: Mind Garden, Inc.

Spielberger, C. D. (1983). *State-Trait Anxiety Inventory*. Palo Alto, CA: Mind Garden, Inc.

Thomas, P. L., & Schwenz, R. W. (1998). College physical chemistry students' conceptions of equilibrium and fundamental thermodynamics. *Journal of Research in Science Teaching*, *35*, 1151-1160.

Tobias, S. (1979). Anxiety research in educational psychology. *Journal of Educational Psychology*, *71*, 573-582.

Tobias, S. (1985). Test anxiety: Interference, defective skills, and cognitive capacity. *Educational Psychologist*, *20*, 135-142.

Wigfield, A., & Eccles, J. S. (1989). Test anxiety in elementary and secondary school students. *Educational Psychologist*, *24*, 159-183.

Wittmaier, B. C. (1972). Test anxiety and study habits. *Journal of Educational Research*, *65*, 352-354.

Wolf, L. F., & Smith, J. K. (1995). The consequence of consequence: Motivation, anxiety, and test performance. *Applied Measurement in Education*, *8*, 227-242.

Zohar, D. (1998). An addictive model of test anxiety: Role of exam-specific expectations. *Journal of Educational Psychology*, *90*, 330-340.