Educational Review

ISSN: 0013-1911 (Print) 1465-3397 (Online) Journal homepage: http://www.tandfonline.com/loi/cedr20

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To cite this article: Brian M. Hughes (2005) Study, examinations, and stress: blood pressure assessments in college students , Educational Review, 57:1, 21-36, DOI: 10.1080/0013191042000274169

To link to this article: http://dx.doi.org/10.1080/0013191042000274169

Educational Review, Vol. 57, No. 1, February 2005

Routledge
Taylor & Francis Group

Study, examinations, and stress: blood pressure assessments in college students[1]

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The issue of stress associated with higher education and its impact on markers of student health is explored in three experiments looking at blood pressure levels in college students. All participants were full-time undergraduate students of psychology. In Experiment 1, academic fear of failure, assessed using psychometric testing, was found to be associated with depressed blood pressure responses among students who performed a stressful task on a computer. In Experiment 2, students were found to exhibit higher blood pressure before end-of-semester examinations than afterwards. In Experiment 3, students of relatively high academic ability were found to have demonstrated increased levels of pre-examination blood pressure responses to stress. Overall, the three experiments suggest ways in which the stressfulness of student life may have adverse consequences for student health and, moreover, ways in which the stressfulness of student life can be further explored. Factors such as fear of failure, impending examinations and academic ability must be taken into account when considering stress-related health consequences on campus.

Introduction

The topic of stress among students in higher education is an important one for psychologists and counsellors who work on college campuses, and is so for several reasons. The stress that arises from student life affects a large portion of the college-going population, perhaps contributing to the high levels of ill health, risk-taking behaviour and depression seen among student groups in many countries (e.g. Pledge *et al.*, 1998). Such stress may have multiple causes. The stressors that typically emerge in studies of students include concerns about grades, relationship problems, loneliness, money problems and parental problems (Furr *et al.*, 2001). However, one feature of college and university life is repeatedly implicated in student stress. Concern about grades was the most frequently reported precursor to a depressive episode among students who participated in a large multi-site North American survey in the late 1980s (Westefeld & Furr, 1987), and was again the most reported in a follow-on study conducted 10 years later (Furr *et al.*, 2001). Indeed,

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ISSN 0013-1911 (print)/ISSN 1465-3397 (online)/05/010021-16

DOI: 10.1080/0013191042000274169

concerns about academic performance have been highlighted as major stressors for students in studies conducted around the world (e.g. Rocha & Ortega-Soto, 1995; Tseng & Chang, 1998; Makaremi, 2000; Naito *et al.*, 2000).

Stress contributes to anxiety, which can in turn interfere with students' academic performance (by leading to the development of poor coping skills), mental health (by its association with depression, low self-esteem and burnout), physical health (by running down the immune system and heightening blood pressure), health behaviour (by rewarding short-term relief as opposed to long-term self-care), and interpersonal development (by impeding the development of intimate social relations). Much research has examined the impact of student stress on mental health. However, despite the fact that stress-related physical health is a significant target of research attention in its own right, little work has specifically aimed to assess stress-related health indices associated with student life. For example, from the perspective of health promotion, it would be important to establish what (if any) aspects of student life serve to elevate blood pressure levels among students, and what the extent of the impact might be. Blood pressure responses to psychological stress remain a significant indicator of the risk of future ill-health (particularly heart disease, e.g. Schwartz *et al.*, 2003) and provide useful insights into the mental states of participants who may not choose to identify themselves as 'stressed out' when filling in questionnaires.

This paper reports on three brief experiments that were designed to explore blood pressure responses to psychological stress among students in higher (third) level education. Each involves the assessment of 'cardiovascular reactivity', which is the term used to describe increases in blood pressure and pulse that result from stress (e.g. Pickering & Gerin, 1990). Psychologists normally study cardiovascular reactivity by inviting participants to perform psychologically challenging tasks under laboratory conditions. It is well established that those participants whose blood pressure and/or pulse increase by the greatest amounts are at a significantly higher risk of developing heart disease in later life (Treiber *et al.*, 2003). The first experiment examines the broad issue of students' academic self-concepts and how they relate to cardiovascular reactivity measures. The second experiment examines the issue of ambient stress at times in the semester where students might experience varying levels of performance anxiety, by comparing stress responses assessed before and after important academic examinations. The final experiment investigates the relationship between cardiovascular reactivity prior to examinations and subsequent examination performance. Such experiments contribute to our understanding of stress-related health indices in students, and provide useful information for health promotion initiatives seeking to reduce risk factors associated with cardiovascular disease in later life.

Experiment 1

Previous research has suggested that there is great heterogeneity in students' confidence about performance tasks (Schouwenburg, 1995). Thus, the first experiment sought to examine this relationship using an arithmetic task as a laboratory stressor and a standardised psychometric test designed to measure academic fear of failure. Considering fear of failure to be a somewhat counterproductive coping strategy or an indicator of low self-esteem, it was anticipated that a positive correlation would exist between it and cardiovascular reactivity. In other words, elevated fear was predicted to be associated with exaggerated stress responses.

Methodology

Participants. Participants were 30 students in higher education (19 females and 11 males), with a mean age of 20.53 years ($SD = 1.3$). The students were in the first year of a three-year undergraduate degree course in psychology.

Cardiovascular measures. Cardiovascular reactivity was assessed using an Omron R1 digital blood pressure monitor, an oscillometric sphygmomanometer with automatic, electric inflation and deflation of a wrist-mounted cuff. The Omron wrist-sphygmomanometer has been thoroughly evaluated using international standardisation protocols (Eckert *et al.*, 1997; Watson *et al.*, 1998).

Psychometric measures. Schouwenburg's (1995) version of the Study Problems Questionnaire (SPQ) was used to assess performance anxiety. The SPQ is a psychometric test that assesses personality factors underlying motivation-related study problems in higher-education students. It was first designed by Hermans (1977), but redrafted by Schouwenburg on the basis of factor analysis. The instrument is composed of 20 statements, to which respondents are required to record their agreement. Scores are allocated to three dimensions: Fear of Failure (representing the respondent's motivation to avoid the risk of being exposed as academically incompetent), Work Discipline (representing the respondent's perceived ability to resist procrastinating from study) and Study Interest (representing the respondent's depth of liking for their study area). The first dimension, Fear of Failure, is of most relevance to the present study in that it refers directly to the students' emotional responses to performance-based situations.

Procedure. Students were tested individually. Each student was instructed to rest in a waiting room for approximately 10 minutes before being led into a psychology laboratory and seated in a comfortable chair, with a computer and the blood pressure monitor on a table in front of them. The blood pressure cuff was attached to the wrist of the student's non-dominant arm, and the instructions for the experimental trial were explained. After an initial 10-minute period during which no cardiovascular readings were taken, the student was asked to sit quietly for a three-minute pre-test period. During this period, readings of systolic blood pressure (SBP), diastolic blood pressure (DBP) and pulse were taken at the end of minute one and again at the end of minute two. This was followed by another three-minute test period, where the student was asked to perform a mental arithmetic task presented on the computer. The mental arithmetic task was a standardised laboratory stressor, specifically designed for cardiovascular reactivity research (Hughes,

Table 1. Mean cardiovascular measurements (with Standard Deviations) for both periods of Experiment 1

	Period of experiment			
	Before task		During task	
	M	*SD*	*M*	*SD*
SBP[a]	120.03	11.63	124.52	11.58
DBP[a]	75.81	8.63	79.10	11.56
Pulse[b]	80.71	13.76	86.15	13.17

Note: [a]mmHg; [b]bpm

2001), and consisting of a series of subtraction problems involving large (i.e. three-to-five digit) numbers. During the task, two more sets of readings were taken, at the same intervals as in the pre-test period. The overall experimental sequence (ten-minute pre-lab rest, ten-minute in-lab rest, three-minute baseline and three-minute testing) was intended to provide a standardised measure of cardiovascular reactivity. It was typical of methodologies used in similar studies in the area, and was successful in eliciting strong increases in each cardiovascular parameter assessed. After the task, the student was asked to complete the SPQ, as well as provide relevant biographical information. The presentation of the SPQ was placed at the end of the experimental trial in order to prevent students from second-guessing the purpose of the experiment and so altering their behaviour accordingly.

Results

Descriptive statistics and manipulation checks. Mean baseline and elevated cardiovascular levels are presented in Table 1. Significant differences were assessed using Bonferroni-corrected *t*-tests for related samples, and were found to occur between baseline and elevated levels of SBP ($t = 3.09$, $df = 28$, $p = 0.012$) and pulse ($t = 3.29$, $df = 28$, $p = 0.009$), but not DBP ($t = 1.82$, $df = 28$, $p = 0.237$). This suggests that the laboratory task elicited largely useful measures of cardiovascular reactivity. Across the sample, the mean score derived from the SPQ for Fear of Failure was 2.87 ($SD = 0.7$), for Work Discipline was 3.42 ($SD = 0.7$) and for Study Interest was 3.39 ($SD = 0.6$). There were no significant gender differences in the SPQ dimensions or in any of the cardiovascular variables.

Fear of Failure and cardiovascular reactivity. Assessments of cardiovascular reactivity were made using partial correlation, by assessing the relationship between Fear of Failure and elevated cardiovascular levels while partialing out the influence of baseline cardiovascular levels. This method was used as the observed levels of reactivity may have been reflective of students' resting cardiovascular functioning, rather than of their individual responses to the laboratory stressor.

A significant negative Pearson correlation was observed between Fear of Failure and elevated levels of SBP ($r = -0.45$, $n = 30$, $p = 0.012$). This correlation remained significant when baseline SBP was controlled for ($r = -0.40$, $df = 27$, $p = 0.030$), indicating an association between Fear of Failure and SBP reactivity. The correlation between Fear of Failure and *baseline* SBP, when *elevated* SBP was controlled for, was not statistically significant ($p = 0.7$), suggesting that the relationship with elevated SBP was the stronger. Finally, the correlation with elevated SBP remained significant when gender was also partialed out (in addition to baseline SBP; $r = -0.39$, $df = 26$, $p = 0.039$).

A similar negative correlation was observed with respect to elevated DBP levels ($r = -0.40$, $n = 30$, $p = 0.031$), which remained significant when baselines were controlled for ($r = -0.45$, $df = 27$, $p = 0.014$). Once again, the correlation between Fear of Failure and baseline DBP, when controlling for elevated levels, was not statistically significant ($p = 0.2$); which suggested that the relationship with elevated DBP was the stronger. And once again, the relationship remained significant when partialing out *both* gender *and* baseline DBP ($r = -0.49$, $df = 26$, $p = 0.008$).

The correlation between Fear of Failure and elevated levels of pulse was not significant, even when controlling for baselines.

Work Discipline, Study Interest and cardiovascular reactivity. Analyses similar to those relating to Fear of Failure revealed no significant associations between cardiovascular measures and the other two dimensions of the SPQ (Work Discipline and Study Interest).

Discussion

The findings of this experiment were somewhat unexpected. The results suggest that students with high fear of failure manifested *lower* blood pressure responses to stress than those with low fear of failure. This was true even when baseline blood pressure levels, and gender, were partialed out of the analyses. At first glance, this pattern of results suggests that high fear is associated with a more subdued stress response than low fear, and so is counterintuitive. One explanation might be that the expression of fear represents what is referred to as a sensitising, rather than repression-oriented, coping strategy. In other words, students who report less fear may be engaging in a strategy of mental avoidance (i.e. ignoring the problem or pretending that the problem doesn't exist) in order to minimise their negative emotional responses, whereas students who reported more fear may simply be acknowledging the occurrence of stress in their lives in a psychologically healthy manner. Previous research has suggested that denial of fear is associated with lower verbal indications of stress, but exaggerated physiological responses (e.g. Newton & Contrada, 1992; King *et al.*, 1990). However, future research will need to incorporate assessments of repression or avoidant personality style in order to evaluate such an interpretation.

Experiment 2

The second experiment compared students' cardiovascular reactivity levels before and after important examinations. Previous research has tentatively suggested that background stress serves to increase levels of cardiovascular reactivity to laboratory-based stress, although only a slight majority of the research bears out this conclusion (Gump & Matthews, 1999). Campus-based research takes place at different times of the academic year. If levels of background stress directly influence students' cardiovascular reactivity to laboratory stress, then this needs to be borne in mind when comparing the results of different studies of stress that are conducted at different points in the academic calendar.

Methodology

Participants and environment. Participants were 13 psychology undergraduates (9 females and 4 males) with a mean age of 20.62 years ($SD = 1.4$). The students were in the second year of a three-year undergraduate degree course. Each year of the course is run over two 12-week terms. At the end of each term students undergo a weeklong examination period, during which they take six two-hour written examinations. The examinations are all equally weighted, and contribute directly to the students' grade averages. As such, each examination period is of crucial importance to a student's progress towards a degree in psychology.

The sample size reflected the voluntary nature of the students' participation in the research. Given that presenting for the experiment may have interfered with the students' examination preparations, they were assured that their participation was entirely voluntary and that they could withdraw from the study sample at any time without penalty or obligation to give a reason. All students in the class group ($n = 21$) were invited to participate in the experiment. The resulting sample of 13 participants yielded a participation rate of 62%. Although this rate is high, the low gross number of participants limited the possible extent of statistical analysis in the study. Nonetheless, self-selection motivation aside, the sample provided high ecological validity to the manipulation of academic stress.

Procedure. The procedure for each experimental trial was the same as that employed in Experiment 1, with two alterations. Firstly, immediately after the three-minute test period, students were asked to sit quietly for a further three-minute (post-test) period, during which two more sets of cardiovascular readings were taken (at the same intervals as before). These additional readings were intended to bolster the data collection regimen in the context of the small size of the sample under scrutiny. As such, the following sequence of three-minute periods resulted (each producing two sets of readings): pre-test, test and post-test. The second alteration was that, unlike in Experiment 1, the SPQ was not administered. Each student underwent the experimental trial twice: firstly, two weeks prior to the commencement of the end-of-semester examination period, and secondly, two weeks after its conclusion.

Results

Descriptive statistics. Mean cardiovascular readings for the three experimental periods, and on both testing occasions, are illustrated in Figures 1, 2 and 3.

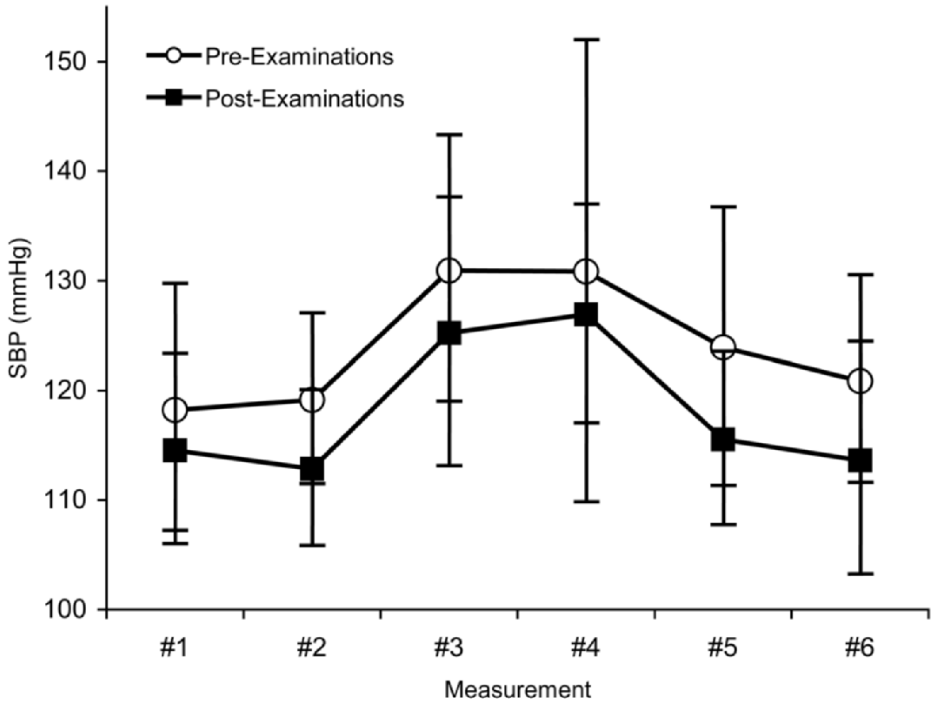

Figure 1. Mean levels of each measure of SBP taken in the experimental trials (#1, #2, #5 and #6 representing resting levels), before and after examinations. Error bars denote standard deviations

Pre-examination and post-examination comparisons. The data were statistically analysed as follows. For each cardiovascular parameter, data were entered into a three-way mixed analysis of variance (Anova). There were two independent variables. The first independent variable ('exam') was a within-participants variable, referred to the occasion of testing, and had two levels: two weeks pre-examination and two weeks post-examination. The second independent variable ('time') was also within-participants, and referred to the measurement points within each experimental trial, which resulted in six levels: first and second pre-test measurement (#1 and #2), first and second test measurement (#3 and #4), and first and second post-test measurement (#5 and #6). The third independent variable was gender (male or female), which was a between-participants variable. Where Mauchley's test of sphericity revealed that the assumption of sphericity was violated, degrees of freedom were adjusted using the Greenhouse-Geisser correction.

For SBP, the Anova revealed a significant main effect for 'time' (Mauchley's $W = 0.032$, $df = 14$, p of $W = 0.006$; $F_{2.2,23.9} = 8.58$, p of $F = 0.001$), indicating that the laboratory stressor was successful in eliciting SBP reactivity. A main effect for 'exam' was also revealed ($F_{1,11} = 8.32$, $p = 0.015$), indicating that there was a significant difference in participants' SBP levels before and after the examination period. A visual comparison of means depicted in Figure 1 shows that pre-examin-

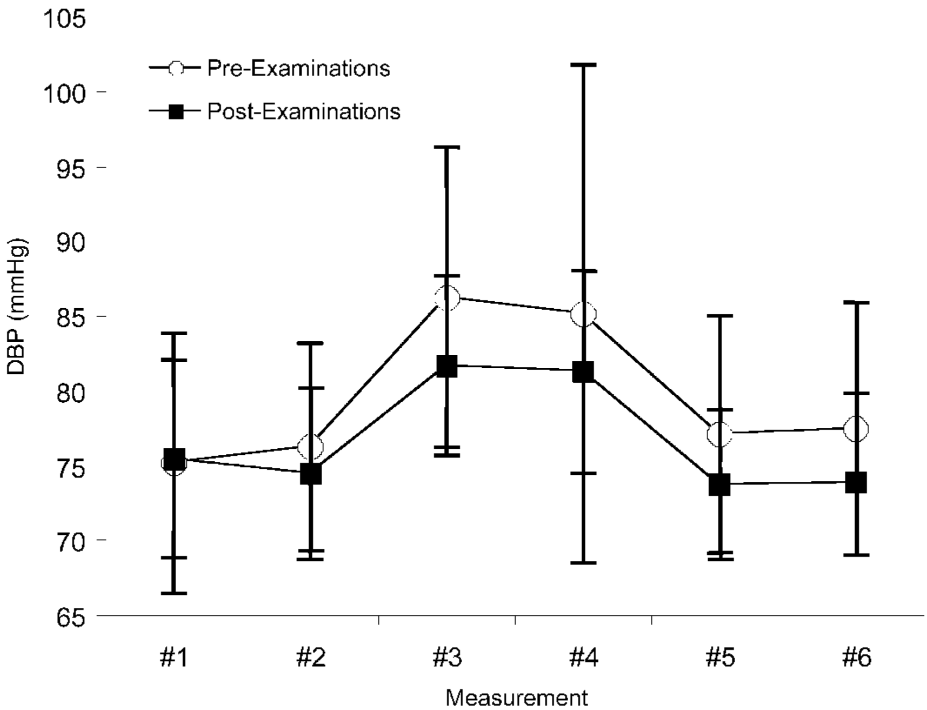

Figure 2. Mean levels of each measure of DBP taken in the experimental trials (#1, #2, #5 and #6 representing resting levels), before and after examinations. Error bars denote standard deviations

ation SBP levels were higher. No significant effects for gender or interaction effects were observed.

With respect to DBP and pulse, only effects for 'time' were revealed. In other words, the Anova revealed that DBP and pulse reactivity occurred during the laboratory stressor, but no differences emerged between these levels across the two testing occasions. The details of the Anova for SBP are given in Table 2.

Discussion

These results indicate that cardiovascular reactivity was not affected by levels of background stress. In other words, whereas baseline levels of blood pressure differed across the two testing occasions, measures of cardiovascular *reactivity* were the same (i.e. the increases observed were of a similar magnitude). This finding is in contrast to some previous studies, which found that cardiovascular reactivity is enhanced by background stress. However, such research has not been conclusive (Gump & Matthews, 1999), with the frequency and controllability of the background stress among many possible moderating variables (e.g. Matthews *et al.*, 1997). Some research has suggested that gender differences might be important, with men demonstrating some physiological reactivity increments in response to background stress to a greater extent than women (Matthews *et al.*, 2001). However, an

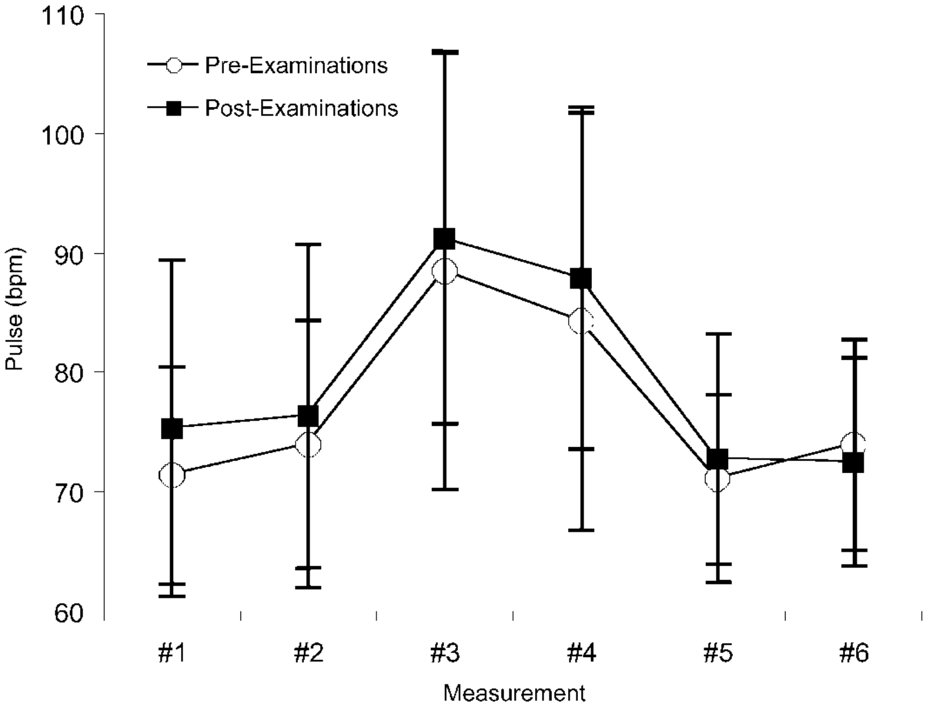

Figure 3. Mean levels of each measure of pulse taken in the experimental trials (#1, #2, #5 and #6 representing resting levels), before and after examinations. Error bars denote standard deviations

important difference between the present study and previous research might account for the varying findings. Unlike in the present study, previous studies have tended to operationalise background stress by relying on participants' self-reports, taking into account the subjective aspects of the experience of stress. In the present study,

Table 2. Anova summary table, with respect to SBP responses before and after examinations

Source	*SS*	*df*	*MS*	*F*	*p*
EXAM[a]	1088.10	1	1088.10	8.32	0.015
EXAM × GENDER	5.03	1	5.03	0.038	N.S.
Error (EXAM)	1437.83	11	130.71		
TIME[b]	3807.02	2.2*	1751.47	8.58	0.001
TIME × GENDER	372.87	2.2*	171.54	0.84	N.S.
Error (TIME)	4881.43	23.9*	204.16		
EXAM × TIME	98.37	5	19.68	0.36	N.S.
EXAM × TIME × GENDER	149.14	5	29.83	0.54	N.S.
Error (EXAM × TIME)	3171.449	60	52.857		

Note: [a]Two levels (Pre-examination, Post-examination); [b]Six levels (Measurements #1–6); degrees of freedom marked with an asterisk have been adjusted using the Greenhouse-Geisser correction on account of the assumption of sphericity having been shown to be violated.

background stress was objectively inferred from the fact that important examinations were looming. It may be that subjective judgments of stressfulness are required from participants in order to demonstrate effects on cardiovascular reactivity.

On the other hand, there may be grounds to suspect that background stress directly impinged on the students' *overall* cardiovascular levels, independently of *reactivity* to laboratory stress. In the analyses, a main effect for 'exam' was found. This means that students had significantly higher blood pressure prior to their examinations than afterwards. A similar finding was reported by Matthews *et al.* (2001), for men but not for women. In their study, male participants categorised as the high (background) stress group demonstrated significantly higher baseline DBP than male, low (background) stress participants. The results were similar for baseline SBP but were marginally non-significant statistically.

The present experiment was of a test-retest design in which time was an important independent variable. As such, it was impossible to control for ordering effects through counterbalancing. It may be that the observed differences in cardiovascular parameters before and after examinations were the result of participants' practice effects or their habituation to the laboratory paradigm. It is widely believed that cardiovascular profiles should prove generally stable over time (Hinz *et al.*, 2001; Rutledge *et al.*, 2001), especially short periods of time (e.g. Swain & Suls, 1996). Nonetheless, the effects of repeat performance would best be established using a between-groups design in future studies. This, however, will necessitate the recruitment of larger numbers of student participants at a time when willingness to volunteer is likely to be low.

In research into the health status of students in higher education, the effects of background stress associated with examinations could be a contaminant in studies that employ test-retest designs at various points of the academic year. Unless background stress can be controlled for, some studies may end up with relatively high-stress time-1 occasions and relatively low-stress time-2 occasions, whereas other studies may end up with the opposite sequence. As well as increasing the likelihood of erroneous interpretations of the causes of inter-test blood pressure differences in individual studies, this factor also confuses the comparison of different test-retest studies conducted in different institutions.

Experiment 3

The ability to perform laboratory tasks such as mental arithmetic might be related to academic ability. Therefore, studies conducted on high-ability samples may generate findings that are not generalisable to other members of the population. This experiment investigated the association between pre-examination cardiovascular reactivity and subsequent examination performance.

Methodology

Participants. The sample consisted of 19 psychology undergraduates (13 females and 6 males), with a mean age of 20.47 years ($SD = 1.6$), which included all the participants from Experiment 2. As in Experiment 2, the students were in the second year of a three-year degree course, about to undertake a weeklong set of written examinations. The sample is larger than in Experiment 2 due to a level of dropout across that experiment's pre-post design.

Procedure. The procedure was the same as that employed in the pre-test stage of Experiment 2. In brief, all participants underwent an assessment of cardiovascular reactivity two weeks prior to the commencement of the examination period (incorporating those measures used in Experiment 2). After the examinations themselves, a record was made of each student's academic performance, which represented their performance across their six written examinations. Participants were asked for their consent to use their examination marks for research purposes.

Results

Descriptive statistics. Across the sample, the mean level of SBP reactivity was 13.79 mmHg (SE = 2.9), mean DBP reactivity was 8.89 mmHg (SE = 2.2), and mean pulse reactivity was 14.84 bpm (SE = 3.9). The academic performance across the group was average, with marks ranging across the various pass and honours ranges. There were no failing students.

Examination results and cardiovascular reactivity. A series of Pearson bivariate correlations revealed significant positive associations between academic performance and SBP ($r = +0.45$, $n = 19$, $p = 0.017$) and DBP ($r = +0.46$, $n = 19$, $p = 0.047$) reactivity. To control for gender, partial correlations were computed. These confirmed the significant positive association between academic performance and SBP reactivity ($r = +0.536$, $df = 16$, $p = 0.022$), but the association between academic performance and DBP reactivity became marginally non-significant ($r = +0.319$, $df = 16$, $p = 0.058$). Given the similarity between the bivariate and partial correlation involving DBP reactivity, it is likely that this loss of significance was the result of the reduced degrees of freedom associated with the partial correlation, rather than of a gender effect per se. The data for SBP reactivity are illustrated in Figure 4.

As a precaution against both the small sample size and the possibility of a violation of the parametric assumption of an interval scale of measurement, a series of equivalent nonparametric bivariate (Spearman) correlations were computed. These revealed, again, a significant positive association between academic performance and SBP reactivity ($\rho = +0.59$, $n = 19$, $p = 0.008$), as well as a significant positive association between academic performance and pulse reactivity ($\rho = +0.47$, $n = 19$, $p = 0.041$).

The data-set for SBP reactivity included a score for one participant whose blood pressure *decreased* during the laboratory stressor rather than increased (see Figure 4). As this participant may therefore conceptually be considered an outlier, her data were removed from the data-set and the correlations were recomputed. The correlation between academic performance and SBP reactivity remained significant, using either parametric ($r = +0.48$, $n = 18$, $p = 0.042$) or nonparametric ($\rho = +0.53$, $n = 18$, $p = 0.025$) analyses, and when using partial correlation to control for gender

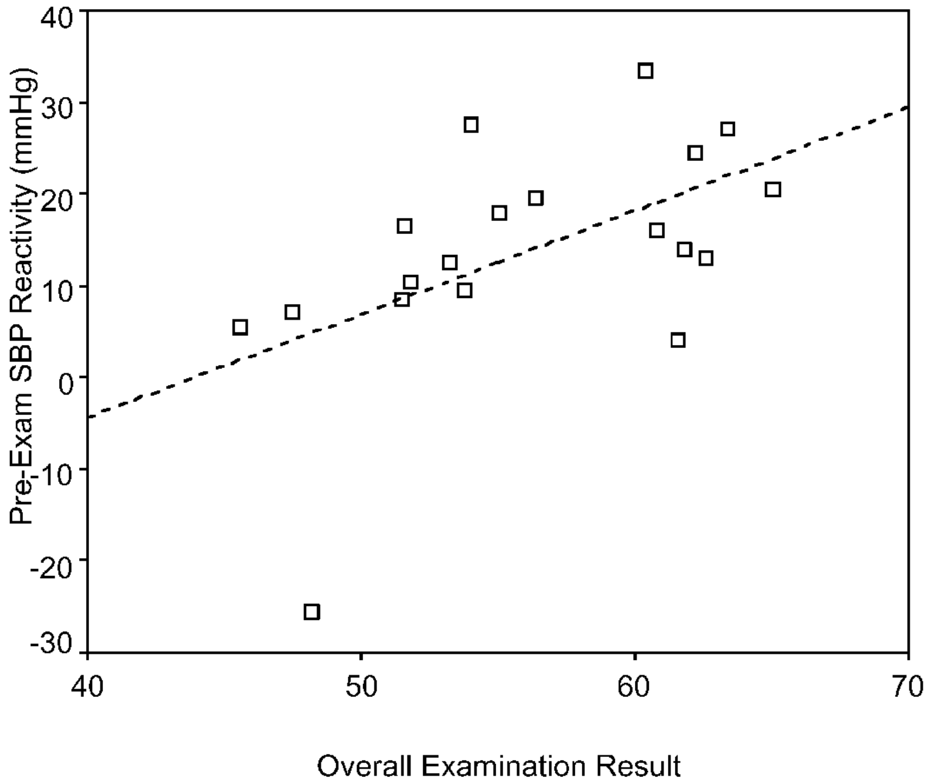

Figure 4. Scattergram (with line-of-best-fit) illustrating the significant positive correlation ($r = +0.54$, $p = 0.017$) between pre-examination SBP reactivity and subsequent examination performance ($n = 19$)

($r = +0.49$, $df = 15$, $p = 0.048$). Overall, these results point to a trend for students' pre-examination cardiovascular reactivity to be positively associated with their subsequent examination performance.

To consider the potential comparison between these relationships and the equivalent relationships between academic performance and *post*-examination cardiovascular reactivity, the equivalent set of analyses were conducted using those variables. None of the associations was statistically significant in the context of the parametric bivariate correlations, nonparametric bivariate correlations or the partial correlations. However, given the fact that only 13 participants yielded post-examination cardiovascular measurements, it is unclear whether the non-significance of these associations is the result of the absence of a relationship or a lack of statistical power.

Discussion

These findings suggest a positive association between academic ability and cardiovascular reactivity, in particular relating to SBP. In short, high-ability students were more responsive to laboratory stress prior to their examinations, than low-ability students. This might arise from an enhanced state of pre-performance arousal or anticipatory anxiety in students who have much to gain (or lose) from their examinations. Students of lesser ability, who may feel that they have less to gain or lose, may not achieve such heightened states of pre-performance arousal. The direction of causation implicit in this correlation is unclear. It could be the result of underlying factors such as 'engagement-involvement' (Singer, 1974). For example, previous studies have found participants who see themselves as highly involved in their environments exhibit more variable blood pressure responses than do lowly engaged participants (e.g. Sparacino *et al.*, 1982). It is also unclear whether the effect identified in the present study is time-specific with regard to pre-examination arousal. Larger samples will be needed for a thorough examination of post-examination cardiovascular reactivity.

This type of effect raises the question of the generalisability of findings of health-status research on students, when it is based on participants of a particular level of aptitude. In such studies, external validity might be threatened if varying levels of academic ability emerge in samples that result from the selection paradigms employed by different researchers. Previous research has suggested that unrewarded students (those who participate for the 'love of science') are more sociable, attentive and perform better on tasks than students who are provided with tangible incentives for their participation in research (e.g. MacDonald, 1972; Rush *et al.*, 1978), and may represent a relatively high level of academic ability. Research has also suggested that differences in reactions of the autonomic nervous system (measured as either pulse or skin conductance levels) emerge among participants recruited using different systems (Kotses *et al.*, 1974). However, there is little consistency in such research, with many authors reporting the opposite state of affairs (e.g. Dixon, 1978; Tomporowski *et al.*, 1993).

Generalisation from volunteer participants to the general population has been a longstanding concern in psychology (e.g. Smart, 1966). It seems likely that, in college-based research, students who perform well in their academic work will be more interested in participating in psychology experiments. If this is the case then the present data suggest that they may demonstrate different cardiovascular stress response profiles to those students who do not participate.

Overall discussion

These three experiments shed light on a number of features of the levels of stress faced by students in higher education, and the potential knock-on effects on their cardiovascular health. Firstly, students possess expectations about performance that are not necessarily held by the general population. Such expectations appear to impact on blood pressure reactivity in a systematic fashion (Experiment 1). Students also encounter varying levels of background stress in their academic lives while participating in research studies. This background stress also affects overall cardiovascular measures (but not reactivity; Experiment 2). Furthermore, students vary in their academic ability, which means that they bring different levels of skill and task motivation into the cardiovascular stress laboratory. This may well impact directly on their stress responses to tasks imposed by researchers (Experiment 3).

The experiments reported here warrant replication on larger samples. In general, sample sizes were depressed as a result of attempts to maximise the validity of the types of stress under review (particularly in the cases of Experiments 2 and 3). Nonetheless, the associations observed in these experiments were striking and, given the sample sizes, highly statistically significant. It appears at first glance that there are strong and observable effects at play, which, if verified, will be of considerable importance to continuing work on cardiovascular health in students. Further enhancements to the present experiments could include the assessment of constructs related to fear of failure but applicable to the general population (thereby allowing for student–non-student comparisons), cross-cultural comparisons to allow for variations in academic cultures across different countries and educational systems, and prospective designs that would more closely assess the emergence and dissipation of stress responses before and after examinations.

As is often the case with research that focuses on participants' experiences of stress and anxiety, consideration must be given to the volunteer nature of the study sample when drawing conclusions. It is clearly likely that differences existed between those participants who volunteered to participate and those who did not, and that these differences bore some relation to the major constructs that were evaluated in the research (e.g. the manner with which individuals habitually cope with pressure). Reliance on volunteer participants is often necessary in order to enhance ecological validity, and allows for real-life situations to come under scientific scrutiny. Alternative methods of sample selection often pose ethical problems, and research that seeks to avoid participant reluctance by creating artificially stressful situations just leads to alternative problems of generalisability. In the social sciences, the onus is on researchers to consider the implications of their designs for the interpretation of their data. Accordingly, care must be taken when seeking to generalise the findings reported here to those students who did not choose to participate.

Overall, it was demonstrated that a number of aspects of college life influence the extent to which stress impacts on students. The consideration of how stress impacts on people in different occupations is a field of research that continues to expand. Given the sheer numbers of students in higher education, it is appropriate that the livelihoods experienced by college students be incorporated into the study of occupational stress and health. The habits and experiences formed in higher education usually last a lifetime. It is hoped that the damaging effects of stress on public health can one day be tackled via the college campus.

Note

1. The data for this study were collected while the author was based at the Department of Psychology, LSB College, Dublin.

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