Improving Academic Performance and Working Memory in Health Science Graduate Students Using Progressive Muscle Relaxation Training

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Research involving working memory has indicated that stress and anxiety compete for attentional resources when a person engages in attention-dependent cognitive processing. The purpose of this study was to investigate the impact of perceived stress and state anxiety on working memory and academic performance among health science students and to explore whether the reduction of stress and anxiety was achieved through progressive muscle relaxation (PMR) training. A convenience sample of 128 graduate students participated in this study. Using an experimental pretest–posttest design, we randomly assigned participants to a PMR group or a control group. Results indicated that PMR reduced state anxiety, $F(1, 126) = 15.58, p < .001$, thereby freeing up working memory and leading to improved academic performance in the treatment group. The results of this study contribute to the literature on Attentional Control Theory by clarifying the process through which working memory and anxiety affect cognitive performance.


The impact that stress and anxiety have on working memory and academic performance among college students is a significant concern in academic settings because being overstressed inhibits students’ learning and performance (Eysenck, Derakshan, Santos, & Calvo, 2007). Academic performance in graduate school has been related to one’s ability to develop higher level cognitive function, which relies heavily on working memory (Beilock & DeCaro, 2007). Strategies that have optimized working memory and performance in stressful environments have been researched by both health and cognitive psychologists (Ashcraft & Krause, 2007; Walkenhorst & Crowe, 2009).

In high-level performance, the central role of working memory has had a significant impact on attentional control in people (Unsworth & Engle, 2007). To this end, Eysenck, Payne, and Derakshan (2005) developed Attentional Control Theory to explain the relationship that accounts for individual differences in task performance in stressful conditions and the effect that state anxiety has on performance in these situations. This theory postulates that stress-related cognition (i.e., worry, self-preoccupation, concern over evaluation) occupies attentional resources and thereby produces deficits in information processing. This negative impact on attention is related to hypersensitivity toward task-irrelevant information being exacerbated under stressful situations (Broadway, Redick, & Engle, 2010).

College students undergo a significant amount of stress because of several factors, including multiple choice and essay exams, term papers, and...
progressive muscle relaxation (PMR) has demonstrated several populations to perform well in stressful situations (Agee, Danoff-Burg, & Grant, 2009). These techniques have also demonstrated effectiveness in various academic settings but with mixed results (Fernandez, 2007; Oman, Shapiro, Thoresen, Planté, & Flinders, 2008). The use of progressive muscle relaxation (PMR) has demonstrated particularly positive results in controlling stress and anxiety (Conrad & Roth, 2007; Poorman, Mastorovich, Molcan, & Webb, 2009).

It has appeared that at high enough levels, stress has adverse effects on cognition and cognitive performance. The literature has pointed out that elements of working memory, a key component in high-level cognitive performance, are negatively affected by stress (Beilock & DeCaro, 2007; Eysenck et al., 2007). Although the relationship among stress, anxiety, and working memory has not been fully understood, it appears likely that the crux of the impairment has resided in attentional issues reducing the person’s resources to encode or retrieve task-appropriate information (Eysenck et al., 2007).

Several researchers (e.g., Green, 2011; Poorman et al., 2009) demonstrated that relaxation techniques have a significant positive impact on the reduction of stress and anxiety among university students. Specifically, PMR has shown promising results as a means of reducing stress levels. PMR is a technique that involves tensing and relaxing specific muscle groups in a specific order to decrease the physiological aspects of anxiety while distracting people from their awareness of anxious feelings, suggesting a cognitive component to the technique (Conrad & Roth, 2007; Nassau, 2007). However, researchers have not extensively studied the role that working memory has played in the relationship among stress, anxiety, and academic performance, and whether stress management techniques, such as PMR, can sufficiently reduce stress and anxiety to improve working memory capacity, leading to improved academic performance.

Therefore, in the current study, we examined the negative impact that stress and anxiety have on working memory capacity, and we investigated how this result affected academic performance in health science graduate students. Prior studies in this population have shown that significant stress is negatively associated with problem solving, grade point average, and overall academic performance (Ansari et al., 2008). As such, working memory has played an important role in the context of students’ academic success in graduate school (e.g., passing practical examinations; Liston, McEwen, & Casey, 2009). However, the extent to which stress and anxiety have affected working memory and how they are related to one another in an “at-risk” environment (e.g., graduate students taking practical examinations) warrant further examination to more fully understand their effects on cognitive performance. Although the existing literature has demonstrated the effectiveness of PMR in reducing stress and anxiety in college students (Poorman et al., 2009), it is not clear whether stress management techniques, such as PMR, can sufficiently reduce stress and anxiety to improve working memory capacity, leading to improved academic performance.

Of particular interest in this study was the fact that attentional inhibition affects the ability of people to momentarily consider what information is irrelevant to task completion and what information is relevant. The effective control of attentional inhibition as it relates to working memory has been demonstrated to affect cognitive processing (Conway, Jarrold, Kane, Miyake, & Towse, 2007). Given that cognitive processing has been directly related to problem solving and decision making (Ilkowska & Engle, 2010), the regulation of individual attention has demonstrated an impact on what task relevant stimuli one attends to and what irrelevant stimuli one does not attend to. Stress and anxiety have been the most researched factors influencing cognitive functioning (Rausch, Gramling, & Auerbach, 2006).

Conrad and Roth (2007) indicated that PMR training is an effective technique for the reduction of tension, anxiety, and physiological arousal that are associated with
cognitive functioning. Using a cognitive–behavioral theoretical framework and on the basis of the prior findings in PMR research, we used this technique with graduate students to determine whether this approach could result in a measurable decrease in an inherently stressful environment relating to their practical examinations.

Method

Participants

In this quantitative study, we used the pretest–posttest design with a convenience sample of 128 health science graduate students at the University of St. Augustine. Participants were randomly assigned to the training group (PMR) or the control group. A main source identified as contributing to academic stressors included performance in practical examinations (Kumar & Jejurkar, 2005).

Measures

Data in this study were collected from well-established instruments, including the Perceived Stress Scale (PSS; Cohen, Kamarck, & Mermelstein, 1983); the State-Trait Anxiety Inventory (STAI; Spielberger, 1983); the Trail Making Test, Part B (TMTB; King & Bird, 1965); and practical examination scores. The collection of pretest data took place in the 4th wk of the semester before any practical examinations had been given (a typical semester is 15 wk in duration, with three scheduled practical examinations in Weeks 5, 9, and 13). Before random assignment into groups, participants participated in a measure of academic performance pretest (practical examination). Data were collected on all measures of interest (PSS, STAI, and TMTB) on the day of the academic performance pretest. After the initial collection of data (pretest), participants were randomly assigned to either a training group (PMR) or a control group.

The four-session PMR training took place in a quiet room after the skills and procedure class and lasted approximately 20 min each time. The control group met when the PMR group met, mirroring the conditions, except the control group was asked to read an article on general health and fill out a question-and-answer worksheet relating to the reading in the classroom during the sessions. These groups took place in Weeks 5–8. The number of sessions was based on previous research demonstrating that between two and eight sessions of PMR are needed (four being optimal) to achieve statistically significant effects when investigating the relationship between PMR and academic performance (Fernandez, 2007). Four sessions were identified to be the minimal time period for a person to gain mastery of PMR.

Analysis

The pretest–posttest control group design has been considered the scientific standard in clinical research for establishing a cause-and-effect relationship (Creswell, 2009). This design was used to analyze change in scores from pretest to posttest between the training group (PMR) and the control group. Data were analyzed with a Pearson product–moment correlation coefficient to assess the relationship among the study variables (PSS, STAI, TMTB, and practical examination scores). The effects of PMR on perceived stress, state anxiety, working memory, and academic performance were assessed with repeated-measures analysis of variance (ANOVA) comparing the mean score changes from pretest to posttest between the treatment and the control groups. Using working memory posttest score as a covariate, we tested the interaction among the effects of PMR intervention, working memory capacity, and academic performance between the two groups with an analysis of covariance. We hypothesized that PMR would reduce perceived stress and state anxiety, thereby freeing up working memory capacity and leading to improved scores on academic performance in the training group (PMR) as compared with the control group.

Results

Descriptive Statistics

Descriptive statistics of PSS, STAI, TMTB, and practical examination scores of participants from the two groups are summarized in Table 1. Across the groups (control, experimental, and total sample) and across time (pre- and post-PMR training), the deviations of the scores from the mean (quantified by the standard deviation) were similar. Correlations among the study variables are summarized in Table 2.

Repeated-Measures Analysis of Variance

A repeated-measures ANOVA was used to determine the effect of PMR training on the differences between the pretest and posttest scores on all of the study variables. Because a pretest–posttest design involving repeated measures was used in this research and because there was no training at the pretest phase, the interaction \( F \) ratio (and corresponding \( p \) value) was used for testing the main effect of PMR rather than the actual main effect \( F \) ratio (Dimitrov & Rumrill, 2003). As presented in Table 1, the PSS mean scores for pretest and posttest were 17.31
and 17.40, respectively. The findings presented in Table 3 indicate that the mean scores on PSS before and after the PMR training were not significantly different, $F(1, 126) = 3.52, p = .063$. Thus, PMR training did not have a significant effect on perceived stress among the students, so no further comparisons between the experimental group and the control group were made.

The means of STAI scores in the pretest and posttest were 41.34 and 37.91, respectively (see Table 1). A significant difference in means, $t(126) = 5.83, p < .001$, was observed between these means, which suggested a strong nonequality of the means (see Table 3). PMR training accounted for the difference (see Table 3).

In addition, outcomes of repeated-measures ANOVA indicated that PMR training had a significant effect on the academic performance of the students. A significant difference in means, $F(1, 126) = 13.48, p < .001$, between the pretest and posttest scores of the experimental group is 39.80 and 33.17, respectively; see Table 1). Significant differences were observed, which suggested a strong nonequality of the means accounted for by PMR training.

Among the dependent variables observed, state anxiety, working memory capacity, and academic performance were significantly affected by PMR training. Thus, the significant effects of PMR training were further investigated by comparing the pretest and posttest scores of the experimental and control groups. Because a statistical significance of PMR’s effect was observed, pairwise comparisons of the control group’s pretest and posttest STAI scores were investigated. The results indicated that there were no significant differences between these means ($t = 0.17, p = .868$). This finding suggests that the effects were primarily from the changes in the experimental group. However, the pretest scores of the experimental group were related to the posttest scores. This relationship was significant ($p < .001$) in this group (39.80 and 33.17, respectively; see Table 1). A significant difference ($t = -5.83, p < .001$) between the means in the posttest and the pretest was observed.

A significant linear association ($p < .001$) between the pretest and posttest scores of the control group with respect to the variable TMTB was found. Descriptive statistics presented in Table 1 indicate that the pretest mean TMTB score was 44.83, whereas the posttest mean score was 41.34. Results implied that these means

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**Table 1. Mean Perceived Stress (PSS), State Anxiety (STAI), Working Memory Capacity (TMTB), and Academic Performance (PRACT) Scores**

<table>
<thead>
<tr>
<th>Assessment and Group</th>
<th>Pretest Score, M</th>
<th>Posttest Score, M</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSS</td>
<td>Control group</td>
<td>17.41</td>
</tr>
<tr>
<td></td>
<td>Experimental group</td>
<td>17.22</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>17.31</td>
</tr>
<tr>
<td>STAI</td>
<td>Control group</td>
<td>40.66</td>
</tr>
<tr>
<td></td>
<td>Experimental group</td>
<td>39.80</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>40.23</td>
</tr>
<tr>
<td>TMTB</td>
<td>Control group</td>
<td>44.83</td>
</tr>
<tr>
<td></td>
<td>Experimental group</td>
<td>47.45</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>46.14</td>
</tr>
<tr>
<td>PRAC</td>
<td>Control group</td>
<td>85.94</td>
</tr>
<tr>
<td></td>
<td>Experimental group</td>
<td>83.95</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>84.95</td>
</tr>
</tbody>
</table>

*Note. N = 126 participants. M = mean; PRACT = practical examination; PSS = Perceived Stress Scale; STAI = State-Trait Anxiety Inventory; TMTB = Trail Making Test, Part B.*

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**Table 2. Correlations Among the Study Variables**

<table>
<thead>
<tr>
<th>Variable</th>
<th>PSS</th>
<th>STAI</th>
<th>TMTB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson correlation</td>
<td>.42</td>
<td>.17</td>
<td>-.14</td>
</tr>
<tr>
<td>Significance, 2-tailed</td>
<td>&lt;.001</td>
<td>.054</td>
<td>-.22</td>
</tr>
</tbody>
</table>

*Note. PRACT = practical examination; PSS = Perceived Stress Scale; STAI = State-Trait Anxiety Inventory; TMTB = Trail Making Test, Part B.*
were significantly different \( t = -2.88, p = .005 \). Hence, there was a decrease by 3.42 in mean from pretest to posttest in the control group. However, a significantly high correlation \( (p < .001) \) between the pretest and posttest scores of the experimental group was found. The pretest and posttest means (47.45 and 37.91, respectively) were significantly different \( t = 8.53, p < .001 \). This paired-sample comparison suggests a statistically significant decrease of mean by 9.54 from pretest to posttest.

**Analysis of Covariance**

Descriptive statistics from Table 1 specified 85.94 and 83.59 as the mean academic performance of the students in the control group at pretest and posttest. The performance before and after was linearly related, and there was a significant decrease of 2.35 observed \( t = -2.71, p = .009 \) in the academic performance, pretest and posttest, of participants in the control group. In addition, in Table 1 the means of the academic performance of the students in the experimental group were 83.95 and 90.64 before and after the intervention. Therefore, a significant difference \( t = 8.97, p < .001 \) between these means existed, and there was an increase of 6.69 in the mean performance from pretest to posttest.

The intervention through PMR training was found to be significant, \( F(1, 127) = 37.52, p < .001 \), in the academic performance of the students, as indicated by a univariate analysis in which intervention was set as a fixed variable, and postacademic performance was the dependent variable. To determine the role of working memory capacity in the academic performance of the students, we used working memory capacity as a covariate, and corresponding effects were observed. An analysis of covariance suggested that working memory capacity of the students as a covariate had no significant effect, \( F(1, 127) = 3.16, p = .78 \). Thus, the working memory capacity of the students could not account for the association between PMR training and academic performance of students.

**Discussion**

After the posttest practical examination, the correlation between perceived stress (PSS) and working memory was not significant. However, there was a statistically significant correlation between state anxiety (STAI) and academic performance (practical examinations). It appeared that when stress was experienced or perceived at a more extreme level (state anxiety), it affected participants’ cognitive performance more negatively. There could be many reasons for this conclusion, relating to a complex interaction of cognitive, behavioral, emotional, and physiological elements. Anxiety specifically relating to cognitive performance has been theorized to consist of at least two distinct components—worry and emotionality (Everson, Millsap, & Rodriguez, 1991)—with interference as an additional defining aspect of the experience (Stober, 2004). Unique to the graduate student experience, the anxiety that surrounds test taking has remained pertinent to this population, given the setting of time pressures, intensive examinations, and continuous coursework throughout the semester. Students consistently cite exams and grade-related worries as their greatest sources of anxiety. Therefore, it would be reasonable to conclude that situation-specific anxiety, as observed in this study, co-occurs with other stressful life experiences, to the detriment of performance. The stressful life experiences individually, as measured by the PSS, did not appear to affect the other variables in a significant way. It made logical sense that the correlation between STAI and practical examinations in this study was similar to that of the TMTB, given that practical examinations also rely on a dual-task procedure, focusing on the relevant aspects of the given task while filtering out the nonrelevant aspects.

As previously mentioned, a repeated-measures ANOVA was used to determine whether PMR training had a
significant effect on perceived stress, state anxiety, working memory capacity, and academic performance. The findings indicated that there were no significant differences in PSS scores before and after the PMR training. However, PMR training did have a significant effect on state anxiety (STAI), working memory (TMTB), and academic performance (practical examinations). As mentioned previously, an explanation for these findings with regard to PSS may be that participants were not experiencing enough stress to have a significant impact. However, when stress was experienced to the point of significant anxiety reflected in elevated scores on the STAI, the positive impact of the PMR training was realized. Many researchers have specifically reached the conclusion that anxiety was especially debilitating when concerns about academic success and failure were paramount in school (Oman et al., 2008; Poorman et al., 2009).

Test anxiety refers to the conceptual, physiological, and behavioral responses that occur when there is concern about possible failure and when there is a reaction to being evaluated in a given situation (Andrews & Wilding, 2004), especially in clinical situations. Neuromuscular hypertension is a physical state produced by anxiety. The premise of PMR is that if muscles are relaxed, the mind, thoughts, and emotions are relaxed. PMR teaches people to tense muscle groups so that they learn to recognize when they are tense, and then to relax those same muscle groups (Conrad & Roth, 2007). With practice, people can learn to inhibit or control their anxiety by recognizing the triggers that produce anxiety. People learn to focus on different muscle groups for tension and relaxation. Then, at the first sign of anxiety, the person can apply those relaxation skills (Conrad & Roth, 2007). Therefore, it appeared that the PMR training in this study benefited participants by giving them exposure to an effective coping technique.

Students with elevated levels of state anxiety were more likely to have difficulty performing difficult dual-task tests (TMTB and practical examinations). For graduate students (especially in health science education settings where practicals are performed) in clinical situations, test anxiety transforms to performance anxiety. As the anxiety increases, the ability to perform practical examinations under evaluative conditions decreases. The implications drawn from this result are that the participants may make the connection between a poor learning experience (practical examinations) and the increased possibility of failing the program, making the experience even more anxiety provoking. As anxiety increases, students’ focus becomes more and more narrow. When performing clinically or on practical examinations, anxious students may become so focused on one aspect that they do not have time to complete the examination or miss critical parts, resulting in a decreased grade or failure of the practical entirely (Gregor, 2005). Anxiety during practicals seems to affect participants’ ability to concentrate on the task at hand, affecting the ability to focus on salient aspects of problem solving and decision making needed to cognitively perform.

Therefore, not only did the PMR training reduce anxiety, but it also correlated with increased working memory and practical examination scores. These results coincide with those of other researchers who have demonstrated that PMR can reduce anxiety and increase cognitive performance in school (Gregor, 2005). Elimination of all anxiety is not possible, and it is not even desirable, but it can be personally controlled. As other researchers have found, PMR is an effective means of relieving performance anxiety related to cognitive performance (Poorman et al., 2009).

The PMR training was found to be significant in improving academic performance of the participants when intervention was set as a fixed variable, and postacademic performance was the dependent variable. To further clarify the role that working memory had in academic performance, we used working memory as a covariate. The ensuing analysis led to the conclusion that when working memory capacity was a covariate, there was no significant effect. Therefore, working memory capacity of the students could not account for the association between PMR training and academic performance of participants in this study. Although statistical significance was not found, there was a trend in the data that suggests that there may be an important relationship in which working memory capacity does play a role. One logical explanation as to why statistical significance was not achieved was that the TMTB was not a sensitive enough test of working memory.

Implications for Occupational Therapy Education

The findings of this study suggest that occupational therapy educators could assist students by discussing the following topics with them:

- How anxiety and stress affect academic performance, including cognitive mechanisms that are impaired during practical tests
- How and why PMR could improve academic performance along with the mechanisms involved
- How participating in relaxation techniques while enrolled in occupational therapy school could have a positive effect on quality of life.
In addition, program directors should consider how the implementation of PMR during graduate school orientation could facilitate on-time graduation, information retention, and reduced dropout rates.

References


