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The interaction of statistics test anxiety and examination condition in statistics achievement of post-baccalaureate non-statistics majors

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THE INTERACTION OF STATISTICS TEST ANXIETY AND EXAMINATION CONDITION IN STATISTICS ACHIEVEMENT OF POST-BACCALAUREATE NON-STATISTICS MAJORS

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ABSTRACT

THE INTERACTION OF STATISTICS TEST ANXIETY
AND EXAMINATION CONDITION IN STATISTICS ACHIEVEMENT
OF POST-BACCALAUREATE NON-STATISTICS MAJORS

ANTHONY JOHN ONWUEGBUZIE

The problems which college students encounter in learning statistics was the focus of the present investigation. To this end, the effects of statistics test anxiety were investigated via an experimental study. The primary aim here was to contrast the effects on the statistics achievement of students who complete an examination under time limits with those who are not given any time limits, as a function of statistics test anxiety level. Twenty-six graduate students who were enrolled in an intermediate-level statistics course were randomly assigned to one of two examination groups: timed or untimed.

The results indicated that both low- and high-anxious students performed better under untimed conditions. However, high-anxious students showed a greater increment in performance than low-anxious students, in the untimed examination condition, with high-anxious students performing slightly better than low-anxious students (statistics test anxiety by examination condition interaction). In the timed examination condition, an interaction was found between examination completion time and statistics test anxiety. A positive correlation existed between completion rate and performance, for high-anxious students, while no such relationship was found for low-anxious students.

Additional analyses focused on the antecedent correlates of statistics anxiety and its components. Multiple regression models were used to build profiles of students with high levels of statistics anxiety and its components. Profiles were also constructed based on students' preferences for methods of assessment.

The results of this study are contrasted with findings of previous studies of mathematics and statistics anxiety. Recommendations for statistics instructors regarding instruction and assessment are given, based on the statistical analyses, student comments, observations and interviews. The educational implications of these findings for understanding statistics test anxiety, and for increasing statistics performance are discussed, as are suggestions for future research.

Major Professor: Michael A. Seaman, Ph.D.

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Chapter I

Introduction

As the need for the application of statistical techniques has increased over the years, so more college students are required to enroll in statistics courses as a necessary part of their degree program. Since many of these students come from diverse academic backgrounds, some of which appear far removed from the field of statistics, taking a statistics course is often a negative experience. Consequently, underachievement and disaffection often ensue in these courses. Indeed, some students change their academic majors and/or career choices as a direct result of their experiences in these classes (Feinberg & Halperin, 1978).

Many of the methods employed by students to attempt to increase their achievement in statistics, such as individual tutoring, peer group study sessions, and special review classes, have had mixed results (Feinberg & Halperin, 1978). This may be due to the fact that factors which debilitate their level of performance remain a threat, regardless of the remedial method employed.

Schacht and Stewart (1990) deemed statistics among the most anxiety-inducing course in any sociology department's curriculum. For many students, statistics is one of the most anxiety-inducing courses in their program of study (Zeidner, 1991). As such, statistics courses are viewed by many students as a major threat to the attainment of their degree. In fact, Robert and Bilderbach (1980) discovered that many students delay taking statistics courses for as long as possible, often enrolling in a class just prior to graduation.

To date, only a few studies have been undertaken specifically on the topic of statistics anxiety. Moreover, practically no research has been conducted on graduate students in relation to this construct. However, the fact that a very high percentage of graduate students in the behavioural sciences are required to take statistics courses, at least at an introductory level, justifies giving special attention to the phenomenon of statistics anxiety.

Statement of the Problem

A number of correlates of statistics performance can be found in the literature. However, statistics test anxiety, as opposed to general test anxiety, has received very little attention. Zeidner (1991) and Onwuegbuzie (1992) conceptualised statistics test anxiety as a major component of statistics anxiety, inasmuch as statistics test anxiety is related to indicators of statistics competence, self-efficacy, and attitude.

The question is, since statistics test anxiety often seriously debilitates statistics performance (Zeidner, 1991), is it possible to combat or decrease this anxiety in order to create an examination environment which affords a truer measurement of a student's level of competence in statistics?

Purpose of the Study

The major purpose of this study was to investigate the extent to which level of statistics test anxiety interacts with the length of time allocated to complete an examination in determining statistics achievement.

In addition, the study attempted to investigate the extent to which level of statistics test anxiety induces differential statistics achievement. Another question of interest was whether type of examination condition affects performance. It was also deemed important to examine whether there is a relationship between examination completion time and statistics performance, as a function of level of statistics test anxiety.

This study also attempted to ascertain whether a relationship exists between level of statistics anxiety and certain background variables, namely, level of study coping strategies, level of examination-taking coping strategies, amount of prior exposure to college mathematics and statistics courses, number of years which have elapsed since a student's last mathematics course, achievement level in previous statistics course, and attitude towards statistics.

Finally, the study sought to elicit students' opinions as to the most effective and anxiety-reducing method of evaluating statistics achievement.

Significance of the Study

The debilitative nature of test anxiety has been repeatedly demonstrated in the literature (Gaudry & Spielberger, 1971; Sarason, 1980; Tobias, 1985; Zeidner, 1990). In addition, mathematics anxiety has been shown to have a negative impact on mathematics achievement (Betz, 1978; Dew, Galassi, & Galassi, 1984; Richardson & Suinn, 1972). Of the handful of studies undertaken on statistics anxiety, there do not appear to be any studies of an experimental nature which investigate the effects of statistics test anxiety in evaluative settings.

If it can be demonstrated that graduate students with high levels of statistics test anxiety benefit from examination-taking conditions with minimal time constraints, as opposed to examination conditions where stringent time limits are imposed, then it can be inferred that performance of students under the treatment condition is more indicative of the original level of learning that took place in the course. This being the case, examination conditions could be employed which would lead to a more valid and accurate measure of a student's true statistics achievement.

On the other hand, if it can be demonstrated through this and subsequent studies, that a time limit imposed in statistics examinations does **not** impact upon achievement, regardless of anxiety level, then the use of timed examinations can be justified.

Many of the theories generated in the area of statistics anxiety have resulted from correlational studies. Predictions have been made regarding the causal link between cognitive and affective variables in statistics achievement (Maysick, 1984). However, it is very likely that such conceptualisations are an oversimplification of the relationships between statistics test anxiety and performance. In any case, causal inferences cannot be drawn from correlational studies.

An extensive review of the literature on statistics anxiety failed to locate any study which incorporated a true experimental design, that is, where an assignment of subjects to experimental conditions took place. Where no such design is employed, any relationships between statistics test anxiety and other variables are ambiguous, since causality cannot be established. It is the utilisation of randomisation which differentiates this study from any previous study of statistics anxiety found in the literature review.

Research Questions

The body of literature indicates that statistics courses are, for the most part, dreaded by students with non-statistics backgrounds (Benson, 1989; Feinberg & Halperin, 1978; Perney & Ravid, 1990; Roberts & Bilderback, 1980). Since many students appear to experience relatively high levels of test anxiety when taking statistics examinations (Onwuegbuzie, 1992), it was of interest to explore this phenomenon via a true experimental design. In particular, the main purpose of the current study was to explore the causal nature of the relationship between statistics test anxiety and examination performance.

Six general research questions were developed, which guided the research design. These were:

(1) To what extent does the level of statistics test anxiety interact with the length of time allocated to complete an examination in determining statistics achievement?

(2) To what extent does the level of a student's statistics test anxiety determine statistics achievement?

(3) To what extent does the length of time allocated to complete an examination determine statistics achievement?

(4) To what extent is the relationship between examination completion time and statistics performance a function of statistics test anxiety?

(5) What is the relationship between statistics test anxiety and selected endogenous and exogenous variables which are theoretically related to statistics anxiety?

(6) Which methods of assessing statistics achievement are most preferred by students?

Theoretical Basis of the Study

The choice of independent variables and the formulation of hypotheses in this study arose from theories of statistics anxiety, mathematics anxiety, general anxiety, and test anxiety. The theories presented and utilised in this study resulted from an extensive review of related literature, and from a pilot study undertaken on statistics anxiety (Onwuegbuzie, 1992).

One of the basic implicit assumptions of this study is that statistics anxiety is, per se, an anxiety. This implies that an understanding of anxiety in general is necessary to the understanding of statistics anxiety (Perney & Ravid, 1990). Indeed, the latter is defined with respect to the former. Another implicit assumption is that statistics anxiety is both real and observable, and as such, is both measurable and evaluative in nature (Cruise, Cash, & Bolton, 1985; Zeidner, 1991). Furthermore, statistics anxiety is deemed neither a fear nor a phobia. Rather, it is a reaction, as opposed to a notion, belief or predisposition (Onwuegbuzie, 1992). In this respect, statistics anxiety is, for the most part, a negative experience. Furthermore, it is assumed that statistics anxiety, unlike mathematics anxiety, occurs most often in academic or academic-related settings (Benson, 1989).

It is also assumed that statistics anxiety is, in some way, related to mathematics anxiety. This assumption stems from the fact that statistics involves aspects of mathematics, including those inherent in computation, suggesting that existing theories generated surrounding the construct of mathematics anxiety will aid the study of statistics anxiety.

A myriad of research indicates that students' attitudes towards mathematics are related to mathematics achievement, making it feasible that a similar relationship may be present in intermediate level statistics classes. Indeed, many instructors of introductory level statistics courses suspect the existence of such a relationship (Bendig & Hughes, 1954).

Cruise, Cash and Bolton (1985) suggested that statistics anxiety is related to, and yet distinct from, mathematics anxiety. In addition, Benson (1989) asserted that statistics test anxiety is different from general test anxiety. This finding is parallel to that of Richardson and Woolfolk (1980), who differentiate mathematics test anxiety from general test anxiety, inasmuch as the former includes a reaction to both subject matter and performance evaluation.

Consequently, it is also assumed that statistics test anxiety accounts for variation in statistics examination scores that cannot be accounted for by either mathematics anxiety or general test anxiety. Although there is evidence that statistics anxiety is positively correlated with mathematics anxiety as well as general test anxiety (Maysick, 1984), it is assumed that some of the cognitive processes involved in statistics anxiety differ from those involved in other anxieties. Indeed, Hunsley (1987) found a similar distinction between mathematics anxiety and test anxiety. As a result, this author believes that statistics anxiety is a better predictor than any other anxiety construct of the cognitive processes involved in statistical contexts.

Statistics test anxiety can be considered to be situation-specific, inasmuch as the symptoms only appear at a particular time and in a particular setting (i.e., statistics examinations). Indeed, many college students report that they experience higher levels of test anxiety in quantitative courses than in other courses (Richardson & Suinn, 1972). Another assumption, then, is that statistics test anxiety is an important component of statistics anxiety.

Theorists have suggested that high anxious students experience more interfering responses during test-taking and, as such, tend to focus less of their energy and attention on the examination itself (Osterhouse, 1975; Wine, 1980). Therefore, it is postulated that high anxious students will perform significantly better in the untimed examination condition than in the timed examination condition, since it is possible that interfering responses are more apparent under time pressure. Low anxious students should also perform better in the untimed examination condition. However, it is expected that this difference in performance for the low-anxiety group will not be as large as the corresponding difference for high-anxious students, since the performance of low-anxious students during timed testing should closely reflect the amount of original learning. That is, it is expected that a timed test will not adversely affect the short-term retrieval of low-anxious students as much as that of high-anxious students. Covington and Omelich (1985) postulated this differential in the retrieval of information under evaluative settings. Indeed, the body of literature predicts that high-anxious students will profit to a greater degree from an untimed examination condition than their low-anxious counterparts (Hill, 1977, 1979, 1980, 1984; Hill & Eaton, 1977; Hill, Wigfield, & Plass, 1980).

Zollner and Ben-Chaim (1988) theorised that a more relaxed examination atmosphere will, on average, induce lower anxiety, and subsequently, higher achievement. If students are operating at a level of anxiety arousal which is higher or lower than the optimum for a particular task, then performance on that task will be detrimentally affected (Towle & Merrill, 1975).

Since very few studies on test anxiety utilise a covariance type approach to the analysis of data, in which treatment effects are adjusted for significant correlates, it is possible that much of the published literature reports misleading results.

Furthermore, it cannot be assumed that the effect of anxiety on concept and factual retrieval is independent of variations in student prior achievement in statistics. In other words, student prior achievement was believed to be a potential confounder in this study. Since the students' mid-term examination was considered to be the best single indicator of prior achievement in the statistics course under study, it was deemed an important covariate.

Burton and Russell (1979) found that an inadequate background in mathematics exacerbates mathematics test anxiety. Since some of the findings pertaining to mathematics anxiety seem to transfer to statistics anxiety, it is reasonable to expect that such background variables as amount of prior exposure to college mathematics and statistics courses, number of years which have elapsed since a student's last mathematics course, level of achievement in their previous statistics course, and attitude towards statistics, would facilitate explanation of statistics anxiety.

Definition of Terms

Anxiety: One definition of anxiety is "an emotional state with the subjectively experienced quality of fear or a closely related emotion" and "feelings of uncertainty and helplessness" (Endler & Edwards, 1982, p. 39). Anxiety can manifest in cognitive, affective, behavioural, and physiological ways.

Mathematics Anxiety: Stewart and Taylor (1978) describe mathematics anxiety as the feeling of tension and/or fear experienced by a person in the context of problem-solving, enrollment in mathematics courses, or the pursuit of fields and careers which require an appropriate level of mathematical competence. According to Richardson and Suinn (1972), a student who experiences mathematics anxiety usually undergoes either emotional or physical discomfort when faced with any mathematical task, be it a routine daily responsibility such as estimating the cost of shopping items, or a more complex task such as the solution of a mathematics problem in a classroom setting. Mathematics anxiety can manifest in cognitive, affective, behavioural, and physiological ways.

Statistics Anxiety: This is an anxiety which occurs when a student experiences anxiety as a result of encountering statistics in any form and at any level (Onwuegbuzie, 1992). Zeidner (1990) defines statistics anxiety as:

> a performance characterised by extensive worry, instrusive thoughts, mental disorganisation, tension, and physiological arousal ... when exposed to statistics content, problems, instructional situations, or evaluative contexts, and is commonly claimed to debilitate performance in a wide variety of academic situations by interfering with the manipulation of statistics data and solution of statistics problems. (p. 319)

Test Anxiety: "An unpleasant feeling or emotional state that has physiological and behavioral concomitants [and is] experienced in formal testing or other evaluative situations" (Dusek, 1980, p. 88).

Hypotheses

In accordance with the purpose of this study, the following research hypotheses were tested:

Primary Hypotheses:

1. There is an interaction between level of statistics test anxiety and the examination condition, after adjusting for statistics prior achievement.

2. There is a negative correlation between level of statistics test anxiety and statistics achievement, across examination conditions, after adjusting for statistics prior achievement.

3. The untimed examination condition leads to higher mean achievement scores in statistics than the timed examination condition, after adjusting for statistics prior achievement.

Secondary Hypotheses

4. Within each examination condition, There is an interaction between examination completion time and level of statistics test anxiety, after adjusting for statistics prior achievement.

5. There is a negative relationship between the level of study coping strategies and the level of statistics anxiety.

6. There is a negative relationship between the level of examination-taking coping strategies and the level of statistics anxiety.

7. There is a negative relationship between a student's attitude towards the field of statistics and the level of statistics anxiety.

8. There is a negative relationship between a student's attitude towards the course and the level of statistics anxiety.

9. There is a positive relationship between the number of years which have elapsed since a student's previous mathematics course and the level of statistics anxiety.

10. There is a negative relationship between the number of mathematics courses completed by a student and the level of statistics anxiety.

11. There is a negative relationship between the number of statistics courses completed by a student and the level of statistics anxiety.

12. There is a negative relationship between a student's level of achievement in a previous statistics course and the level of statistics anxiety.

In addition, the data were examined for interesting patterns which were not addressed by the above hypotheses.

Delimitations of the Study

The scope of this study was delimited by the investigator in a number of ways. First, the study was restricted to students enrolled in a graduate program. As a result, care should be exercised in generalising the results to undergraduate students.

Secondly, the study was delimited to examine only treatment effects of students from non-statistical majors. Hence, the results obtained in this study may not be generalisable to students enrolled in graduate programs with a heavy statistical content.

Limitations of the Study

This study was limited by several conditions which were beyond the control of the researcher. First, due to the fact that there were very few males in this study, any formal comparisons made between genders would be low in statistical power. Even if sex differentials were found in any area, the sample composition tends to limit generalisability. It should be noted, however, that the disproportionately low number of males in the class is typical of statistics courses taught by instructors from the college of education, in which this study took place.

Second, although it is possible to measure anxiety in a number of different ways, it was beyond the scope of the present study to gauge statistics anxiety via physiological measures. Statistics anxiety was assessed via a self-report instrument.

Third, participants in this study were volunteers. It is recognised that characteristics of volunteers may differ from those of non-volunteers (Scheier, 1959). Fourth, due to the fact that the participants were from non-statistical disciplines, it was likely that they represented a high test-anxious population.

Finally, since the size of the class was relatively small, care must be exercised when generalising these results to students enrolled in statistics courses whose class sizes are significantly different.

Organisation of the Remaining Chapters

Chapter 1, entitled "Introduction," includes a statement of the problem, the purpose and significance of the study, the theoretical basis of the study, the delimitations and limitations of the study, the hypotheses which were tested, and an outline of the study itself.

Chapter 2, entitled "Review of Related Literature," contains a review of the literature pertinent to this study. It includes literature pertaining to general anxiety, statistics anxiety, mathematics anxiety, and test anxiety, as well as a discussion of the relationships between the constructs. In addition, the literature on anxiety with respect to study coping and examination-taking coping strategies, and time pressure is presented.

Chapter 3, entitled "Methodology," outlines details of the methodology of this study, including a definition of the population and the sample, a delineation of the procedure used in selecting the sample, details of the instruments administered, as well as the statistical analyses to be utilised.

Chapter 4, entitled "Results," presents the data and findings from the analyses, in accordance with the procedures outlined in the preceding chapter.

Chapter 5, entitled "Summary, Implications, Recommendations and Conclusions," summarises the results and presents implications for future research, recommendations and conclusions.

A complete list of references and appendices containing the instruments administered follows the main body research report.

Chapter II

Review of the Related Literature

The following review of the literature is an attempt to further our understanding of the phenomenon of statistics anxiety within a theoretical framework, by combining the literature on general anxiety, general test anxiety, and mathematics anxiety.

The Construct of General Anxiety

General anxiety as a reaction to an event or situation has probably been in existence since the beginning of time. However, the study of anxiety as a psychological construct is, for the most part, a phenomenon which has only come to the fore this century. Indeed, the number of studies on anxiety, both experimental and correlational, increased steadily in the 1950's and 1960's. Spielberger (1972) estimated that approximately 5,000 anxiety-related publications appeared in the research literature between 1950 and 1970. The interest in studying anxiety seems to have continued to the present day (Edelmann, 1992). Anxiety has been described as an "emotional state with the subjectively experienced quality of fear or a closely related emotion" and "feelings of uncertainty and helplessness" (Endler & Edwards, 1982, p. 39).

Some authors believe that anxiety is a basic human characteristic (Spielberger, 1966, 1972). In any case, general anxiety is both subjective and experiential, and, as a result, has led to an array of definitions. There is a lack of consensus regarding the definition and characterisation of anxiety. However, there is basic agreement on three types of indicators of anxiety: behavioural, physiological, and phenomenological (Phillips, Martin, & Meyers, 1972).

Components of Anxiety

Many researchers agree that anxiety comprises two distinct but inter-related components, namely: state anxiety and trait anxiety (Cattell, 1966). Gaudry and Spielberger (1971) and Zuckerman (1972, 1976) defined trait anxiety as the relative stable proneness within each person to react with anxiety to situations which are perceived as being stressful. State anxiety is defined as the temporary emotional state of an individual. It is a construct which varies in intensity and which fluctuates over time.

Cattell and Scheier (1961) also defined anxiety within a two-component framework. They categorised anxiety as being either overt (a conscious state, related to specific events in a person's life), or covert (an unconscious stable measure of anxiety).

The Nature of General Anxiety

The consequences of anxiety are complex and interactional in nature and vary from one situation to another. Although these consequences are usually negative and debilitating, there are occasions when they can be facilitating. The latter is often the result of dealing with anxiety in a positive manner. In this instance, anxiety can act as a motivator (Philip, Martin & Meyers, 1972).

Anxiety has been shown to interfere with cognitive functioning (Grady, 1978). This interference seems to occur in a variety of educational settings and with a variety of instructional methods (Tobias, 1980). General anxiety has been shown to be negatively related to measures of intellectual and academic performance (Hill & Sarason, 1966; Spielberger, 1966), self-concept (Lipsett, 1958; Mitchell, 1959; Rosenberg, 1962) and peer relations (Grodner, 1977; Phillips, 1971).

Hollandsworth, Glezski, Kirkland, Jones, and Van Norman (1979) showed that students with low levels of anxiety were physiologically aroused during examinations but viewed their arousal as helpful. Highly anxious students, on the other hand, considered their state of anxiety debilitative. Fein (1963) postulated a curvilinear relationship between general anxiety and achievement.

Brett and Kernaleguen (1975), Butterfield (1964), Feather (1967), Joe (1971), Ray and Katahn (1968), and Watson (1967) found that college students who were assessed as having an external locus-of-control were more anxious than those who were assessed as having an internal locus-of-control.

However, Gold (1968) and Procicuk and Breen (1973) did not find a significant relationship between locus of control and test anxiety.

With regard to the relationship between sex and general anxiety, research findings have been mixed. Whilst some authors found that females score higher on measures of general anxiety than their male counterparts (Biaggio & Nielsen, 1976; Gall, 1969; Sarason, 1963; Sarason, Davidson, Lighthall, & Waite, 1958), others have found no sex differences (Dunn, 1965; Feld & Lewis, 1967).

Symptoms of General Anxiety

Cattell (1966), Duffy (1962), Janisse (1976), May (1950), and Rule and Nesdale (1976) derived lists of physiological reactions associated with high levels of anxiety. These include: an increase in heart rate, respiration rate, and blood pressure, overall muscle tension, a contraction of the smooth muscles of the internal genital organs, a decrease in skin temperature, a decrease in skin resistance, an increase in metabolic rate, pupils dilating, body hair standing on end, digestive activity being suspended, dry mouth, and palmar sweating. Anxiety has also been shown to induce some psychosomatic symptoms such as asthma, migraine and hypertension (Edelmann, 1992; Wolpe, 1973).

McReynolds (1976) highlighted behavioural signs of anxiety which include: biting one's nails, restlessness, crying, stuttering, and voice tremors. Fear, frustration, and learned-helplessness are often symptoms of anxiety (Mandler, 1972). High levels of anxiety can manifest in excessive smoking, alcoholism, and eating disorders (Hall, 1972; Koenig & Masters, 1965; Seixas, 1977), as well as sexual dysfunctions (Razani, 1972).

Affective symptoms of anxiety include apprehension and emotional instability (Krug, Scheier, & Cattell, 1976). Severe anxiety, according to Spielberger (1972), is associated with an unrealistic and disproportionate perception of ego threat which often has debilitating consequences. Every individual develops methods of trying to control or reduce their level of anxiety. These methods include the defense mechanisms described by Sigmund Freud, such as repression, denial, and projection (Spielberger, 1972).

Antecedents of General Anxiety

Epstein (1972) conceptualised three basic antecedents of anxiety: (1) primary overstimulation, (2) cognitive incongruity, and (3) response unavailability. Primary overstimulation involves frantic feelings of being overwhelmed with stimulation which exceeds the level of tolerance. Cognitive incongruity pertains to situations in which there is a discrepancy between an individual's expectation and reality, coupled with a failure to cope with this predicament. Anxiety states which are associated with cognitive incongruity include: confusion, despondency, and disorientation. Response unavailability is an anxiety state which occurs when a waiting period is required before a response can be made.

As mentioned above, trait anxiety can be defined as a relatively stable and permanent personality characteristic. That is, trait anxiety is neither time- nor situation-specific. On the other hand, state anxiety can be conceptualised as a temporary condition which fluctuates over time. That is, state anxiety is time- and situation-specific. Gauldry and Spielberger (1971) reported that students with high levels of trait anxiety exhibit state anxiety elevations more frequently than those with low levels of trait anxiety, because they tend to interpret a wider range of situations as being threatening.

According to Lazarus and Averill (1972), the antecedents of general anxiety can be divided into two components; namely, situational and dispositional. Situational antecedents are those in the immediate environment which surround the stimulus, whilst dispositional antecedents are factors which an individual brings to the setting. Dispositional and situational antecedents interact to determine overall level of anxiety.

Research has consistently shown that state anxiety adversely affects learning and achievement (Joesting & Whitehead, 1977; Waid, Kanoy, Blick, & Walker, 1978; Ward & Salter, 1974). In addition, some studies have shown that individuals with high levels of trait anxiety are more susceptible to performance-related events than those with high levels of state anxiety (Johnson & Spielberger, 1968;

Shedletsky & Endler, 1974).

The Treatment of General Anxiety

The treatment of anxiety has taken many forms. These include behavioural, cognitive and psychotherapeutic approaches (Suinn, 1975), as well as the administering of drugs (Gray, 1976).

Some approaches use social learning theories as their base (Bandura, 1977). Bernstein and Borkovec (1973), Chang-Liang and Denny (1976), Connor (1974), and Sherman and Plummer (1973) have demonstrated that relaxation techniques can be successful in reducing anxiety in an academic setting. Similarly, Wolpe (1973) showed that a combination of relaxation and desensitisation techniques can also lead to anxiety reduction. Yorde (1977) reported a reduction in performance-related anxiety levels by using biofeedback techniques which concentrate on the physiological signs of anxiety, and cognitive-restructuring methods which focus on self-control. Success using cognitive-restructuring techniques has also been reported by other researchers (Beck & Rush, 1975; Goldfried, Decenteceo, & Weinberg, 1974; Goldfried & Trier, 1974; Lazarus, 1977; Meichenbaum, 1972, 1977; Meichenbaum & Turk, 1976). There is also evidence that Anxiety Management Training, which combines relaxation and cognitive-restructuring, can reduce anxiety levels (Edie, 1973; King, 1974; Mendonca & Siess, 1976; Nicolleti, 1973; Suinn, 1975, 1977a; Suinn & Richardson, 1971; Richardson, 1976).

Summary

A major trend in the literature on general anxiety has been the conceptualisation of general anxiety as a two-dimensional phenomenon. According to this view, general anxiety comprises trait and state anxiety. State, or overt anxiety is a temporal- and situation-specific form of anxiety, whilst trait, or covert anxiety is a relatively stable and permanent personality characteristic. High levels of state anxiety have been found to have an adverse effect on performance. At the same time, people with high levels of trait anxiety are more affected by performance-related events than are high state anxious persons.

Antecedents of general anxiety have been categorised as: primary overstimulation, cognitive incongruity, and response unavailability, or as dispositional and situational factors.

General anxiety was described as having a variety of physiological, behavioural, and phenomenological manifestations. These can include asthma, migraine, hypertension, fear, frustration, learned-helplessness and emotional instability.

Several treatment methods for general anxiety were mentioned, including: psychotherapy, relaxation, desensitisation, biofeedback techniques, and cognitive-restructuring methods. With respect to their relative effectiveness in anxiety reduction, results are inconclusive.

The Construct of General Test Anxiety

General test anxiety is a phenomenon which seems to affect most students (Everson, Millsap, & Rodriguez, 1991; Hill, 1984). General test anxiety has been described as a "fear of taking examinations; unpleasant emotional reaction elicited by anticipation of a testing situation; may have an affect on the test performance of the subject" (Good, 1973, p. 595). Some researchers believe that test anxiety originates from unrealistic parental expectations, commencing in the elementary school years or earlier (Hill, 1972; Hill & Wigfield, 1984). Once set in motion, test anxiety can continue through a student's elementary and secondary school life (Hill & Wigfield, 1984), as well as through college life (Spielberger, Anton, & Bedell, 1976).

The Effect of Test Anxiety on Performance

Mandler and Sarason (1952) proposed the first widely accepted conceptualisation of test anxiety. They theorised that students who are affected by interfering responses focus some of their attention on task irrelevant responses, culminating in a reduced level of performance. On the other hand, they believed that for students who are unaffected by interfering responses, test anxiety elicits task-relevant responses, facilitating task completion. Alpert and Haber (1960) separated facilitating effects of test anxiety (task-relevant responses) from debilitating effects (task-irrelevant responses). Wine (1971) derived an attentional hypothesis similar to Mandler and Sarason, whereby he postulated that the difference between high and low test-anxious students manifests itself in the amount of attention focused on task-relevant behaviour, with the latter group displaying more attention.

Tobias (1977, 1980) suggests that anxiety interferes with learning and performance on three fundamental levels. Firstly, anxiety inhibits the efficient preprocessing of new information. For example, the student may have difficulty organising study material. Secondly, anxiety interferes with processing, which Tobias describes as the application of new understanding to the solution of a problem. The student may understand the new material, but is unable to retrieve the information or apply the new knowledge to a specific problem. Thirdly, Tobias suggests that anxiety interferes with the output of a response. The correct answer may be grasped and then lost before the student verbalises or records it.

Tobias (1985) proposed a deficits model whereby lower examination scores of high test-anxious students are attributed to inadequate study habits coupled with deficient test-taking skills. As a result, the deficits model predicts that an awareness of previous under-achievement causes test anxiety. On the other hand, Hembree (1990) proposed an interference model, in which test anxiety affects the recall capacity of the student which, in turn, lowers the level of performance. Hembree's model is similar to the attentional model of Wine (1971), in which high anxious students divide their attention between task-relevant and task-irrelevant cognitive activities.

The effects of test anxiety on performance have been extensively documented. Using various types of aptitude and achievement measures in different educational settings, many studies have found a negative correlation between test anxiety and academic performance (Alpert & Haber, 1960; Culler & Holahan, 1980; Deffenbacher, 1977; Dusek, 1980; Hill & Sarason, 1966; Johnson, 1979; Mandler & Sarason, 1952; Myers, 1976; Sarason & Mandler, 1952; Spielberger, Anton, & Bedell, 1976; Spielberger & Sarason, 1978; Tyron, 1980).

One continuing debate revolves around the question of whether the relationship between test anxiety and examination performance is linear or curvilinear (Grooms & Endler, 1960; Munz & Smouse, 1968). Cox (1960) refuted both of these relationships, claiming that the relationship between test anxiety and performance is not monotonic. In addition, some researchers have postulated that the relationship between test anxiety and achievement is stronger for one sex than for the other, although results have been contradictory (Cotler & Palmer, 1971; Dember, Nairne, & Miller, 1962; Russell & Sarason, 1965).

Some theorists have postulated that the examination performance of high test-anxious students improves when examination items are presented in a non-random fashion with respect to item difficulty (Munz & Smouse, 1968; Spielberger

& Smith, 1966), when test items call upon generalisation as opposed to rote memorisation (Carron, 1963; Ray, Katahn, & Snyder, 1971), when some of the items are of a humorous nature (Smith, 1971), and when examinations are held on a regular basis (Dustin, 1971).

Components of Test Anxiety

Liebert and Morris (1967) theorised that test anxiety comprises two distinct but correlated components, namely, worry and emotionality. They conceptualised worry as a cognitive element, and emotionality as being behavioural in nature. This conceptualisation was supported by Desiderato and Koskinen (1969a), Mandler and Watson (1966), Morris, and Liebert (1969, 1970), and Spiegler, Morris and Liebert (1968). However, although Hembree (1988) accepted this two-factor definition of anxiety, he contended that test anxiety is more behavioural than cognitive in nature, implying that high test anxiety debilitates performance. Deffenbacher (1977), Morris, Davis, and Hutchings (1981), Morris and Liebert (1969), Sarason (1986), and Wine (1971, 1980) believed that worry is more closely related to under-achievement than is emotionality. This is confirmed by the studies of Doctor and Altman (1969)t Liebert and Morris (1967), and Morris and Liebert (1970), who found that worry is negatively related to performance. On the other hand, several studies have demonstrated empirical evidence that the relationship between emotionality and performance is unclear, and, at best, varies according to the level of worry (Deffenbacher, 1977, 1978, 1980; Doctor & Altman, 1969; Liebert & Morris, 1967; Morris & Liebert, 1970). Spielberger and Sarason (1978) also reported that worry and emotionality differentially affect examination performance.

Antecedents of General Test Anxiety

According to Byrd (1982), the antecedents of test anxiety can be situational, dispositional, or environmental in nature. As expressed earlier, situational antecedents refer to factors which surround the stimulus, whilst dispositional antecedents refer to factors which an individual brings to the setting. Environmental antecedents refer to events which occurred in the past. The major difference between a dispositional and an environmental antecedent is that the former is internal to the person, whilst the latter is external (Byrd, 1982).

Situational Antecedents of General Test Anxiety

Factors which influence the level of anxiety in evaluative settings are classed as situational antecedents. These include: the amount of time afforded the student to prepare for the examination (Sarason, 1972), the need or desire for achievement (Spielberger, 1978), the stage of the learning process (Phillips et al., 1972), the degree to which examinees are penalised for dependency and cautiousness, the amount of instructions given for each test item, the personality of the examiner, and the difficulty of the test item (Sarason et al., 1960).

By administering a self-constructed questionnaire, Sarason and Stoops (1978) found that high test-anxious students were more preoccupied with how poorly they were doing and how their peers were managing.

Dispositional Antecedents of General Test Anxiety

Dispositional antecedents include self-esteem and self-concept. Both these antecedents have been found to relate negatively to test anxiety (Sarason et al., 1960). High levels of test anxiety have been found to have an adverse effect on students' appraisals of their own performance in evaluative situations (Hunsley, 1987), and to decrease self-esteem (Many & Many, 1975; Sarason, 1960). Arkin, Detchon, and Maruyama (1982), Doris and Sarason (1955), Meichenbaum (1972), and Wine (1971) hypothesised that high test-anxious students tend to engage in more negative self-centred thoughts, disrupting effective use of their time, and consequently, impairing performance.

Locus of control is also classed as a dispositional antecedent. Lusk (1983) found that psychology students with high levels of test anxiety tended to perform better if they had an internal locus-of-control. On the other hand, psychology students with low levels of test anxiety performed better if they had an external locus-of-control. Galassi, Frierson, and Sharer (1981) found that high test-anxious students interpreted the evaluation experience as a situation which was beyond their control and which might result in failure, whilst low test-anxious students interpreted the evaluation experience in such a way as to predict their own success.

Environmental Antecedents of General Test Anxiety

Environmental antecedents include age, gender, socio-economic factors, geographical location, number of severe illnesses, parental separations, and parenting styles (Byrd, 1982). Nijhawan (1972) and Sarason, Davidson, Lighthall, Waite, and Ruebush (1960) found evidence to support the hypotheses that test anxiety increases with age, females are more anxious than males, students from the lower classes are the most anxious, rural children are more anxious than urban children, test anxiety is positively related to the number of serious illnesses, high test-anxious students are less able to cope with parental separation, and the parents of high test-anxious children are more authoritative than their counterparts. Sex differences have been found in levels of test anxiety, with females reporting higher levels than males (Everson, Millsap, & Rodriguez, 1991; Hembree, 1988).

Measures of General Test Anxiety

Most researchers have relied upon self-report scales to assess general test anxiety. Measures of test anxiety include: scales developed to measure global test anxiety (Mandler & Sarason, 1952; Sarason, 1972), scales constructed to assess emotionality and worry (Liebert & Morris, 1967; Osterhouse, 1972), scales which assess interfering thoughts during examinations (Sarason & Stoops, 1978), scales appropriate for elementary school children (Sarason, Davidson, Lighthall, Waite, & Ruebush, 1960), scales appropriate for secondary school children (Spielberger, Gonzales, Taylor, Anton, Algaze, Ross, & Westberry, 1980; Morris & Liebert, 1970), scales which measure test anxiety in conjunction with behaviour therapy research (Suinn, 1969), and scales for physiological measures of test anxiety (Barabasz, 1973, 1975; Kondas, 1967).

The Treatment of General Test Anxiety

The importance of treating general test anxiety has led to an array of studies. Several procedures have been developed to reduce test anxiety. These include psychotherapy (Goldstein & Dean, 1966), counselling (Feder, 1967), cognitive treatments (Allen, 1972; Bistline, Jaremko, & Sobelman, 1980; Horne & Matson, 1977; Kaplan, McCordick, & Twitchell, 1979; Leal, Baxter, Martin, & Marx, 1981; Lent & Russell, 1978; Reister, Stockton, & Maultsby, 1977; Ricketts & Galloway, 1984), self-instructional training (Holroyd, 1976; McCordick, Kaplan, Finn, & Smith, 1979; Meichenbaum, 1972), stress inoculation training (Deffenbacher & Hahnloser, 1981; Hussian & Lawrence, 1978), implosive therapy (Cornish & Dilley, 1973), hypnosis (Melnick and Russell, 1976), covert reinforcement (Kostka & Galassi, 1972), biofeedback (Romano & Cabianca, 1978), psychodrama (Kipper & Giladi, 1978), systematic desensitisation (Allen & Desaulniers, 1974; Allen, Elias, & Zlotlow, 1980; Anton, 1976; Bedell, 1976; Chang-Liang & Denney, 1976; Cohen, 1969; Cornish & Dilley, 1973; Crighton & Jehu, 1969; Dawley & Wenrich, 1973; Deffenbacher, 1974; Doctor & Altman, 1969; Donner & Guerney, 1969; Emery & Krumboltz, 1967; Freeling & Shemberg, 1970; Garlington & Cotler, 1968; Horne & Matson, 1977; Ihli & Garlington, 1969; Johnson & Sechrest, 1968; Laxer & Walker, 1970; Lomont & Sherman, 1971; McMillan & Osterhouse, 1972; Mitchell & Ingram, 1970; Myers, 1976; Schaer & Isom, 1988; Scissons & Njaa, 1973; Smith & Nye, 1973; Spielberger, Anton, & Bedell, 1976; Suinn, 1968; Tyron, 1980), anxiety management training (Deffenbacher & Shelton, 1978), automated treatment delivery systems (Biglan, Villwock, & Wick, 1979; Chandler, Burck, & Sampson, 1986; Donner & Guerney, 1969) relaxation (Barrios, Ginter, Scalise, & Miller, 1980; Deffenbacher, 1976; Harris & Johnson, 1983; Levin & Gross, 1985; Russell, Wise, & Stratoudakis, 1976), and assertiveness training (Wehr & Kaufman, 1987).

The results of the above studies have been mixed, with some researchers indicating that particular treatments do have an impact on test anxiety, whilst other researchers report no impact. In a review of the large body of literature on test anxiety reduction techniques, Overton (1982) surmised that there is no one method which is consistently shown to be superior, although he felt that anxiety management training and study skills training appear to be somewhat effective.

Allen, Elias, and Zlotlow (1980), Denney (1980), and Tyron (1980), independently reviewed all studies in which systematic desensitisation or cognitive treatments for test anxiety were used to treat undergraduate students. Each concluded that, although most authors report decreases in self-reported test anxiety, very few report significant improvements in academic performance. Results concerning the effectiveness of anxiety reduction treatments for children are not so lucid. At the present time, conclusive generalisations are not possible, due to various methodological and design flaws such as inappropriate control groups and small sample sizes (Tyron, 1980).

Summary

General test anxiety has been repeatedly studied as a specific manifestation of general anxiety, beginning with the research of Mandler and Sarason in 1952. Several researchers have suggested that test anxiety consists of two components: worry and emotionality. Worry is conceptualised as a cognitive element, whilst emotionality has been conceptualised as being behavioural in nature. Many researchers have shown that worry is inversely related to academic performance. Emotionality does seem to affect performance, but it is not so consistently related. Emotional arousal may facilitate or debilitate performance, depending on the corresponding level of cognitive response. Emotionality appears to be more debilitating when associated with high levels of worry.

Although some researchers have failed to find a relationship between test anxiety and performance, the bulk of the available evidence supports the tentative conclusion that high levels of test anxiety bring about a reduction in performance levels.

Test anxiety seems to be an experience which is influenced by situational, dispositional, and environmental antecedents. These antecedents include: age, sex, parental expectations, self-esteem, self-concept, desire to achieve, stage of the learning process, and difficulty of the test item.

Various measures of test anxiety have been constructed. The majority of these are self-report scales. Choice of scale depends on various factors, such as the age of the subject, the educational level, and the component of anxiety which needs to be assessed.

There is a growing body of literature which suggests that test anxiety can be effectively treated. Interventions which have been shown to reduce test anxiety include: psychotherapy, counselling, cognitive restructuring, self-instructional training, covert reinforcement, biofeedback, psychodrama, systematic desensitisation, anxiety management training, and assertiveness training. However, while test anxiety has been successfully modified by some of these methods, to date there is no consistent evidence to indicate the superiority of any one approach over the others. Too few comparative studies exist to make overall conclusions. Conclusions are also invalidated by various weaknesses in research design, such as small sample size and inappropriate dependent measures. It is clear that comparative studies, which are both internally and externally valid, are necessary before the construct of test anxiety can be effectively addressed.

The Construct of Mathematics Anxiety

Mathematics anxiety has been described as "an irrational dread of mathematics that interferes with manipulating numbers and solving mathematical problems within a variety of everyday life and academic situations" (Buckley & Ribordy, 1982, p. 1). Level of discomfort varies in intensity, depending on the individual in question. Tobias (1978) discovered that students who have high levels of mathematics anxiety, express debilitating feelings of panic. She also found that students rated their anxiety as being a negative experience. Thus, mathematics anxiety may be a critical factor in influencing and attaining a student's academic and vocational goals (Betz, 1978).

Kogelman and Warren (1979) postulated that mathematics anxiety is a response which is learned from peers, teachers, and parents. Bander and Betz (1981) reported that mathematics anxiety comes to the fore around adolescence, as a result of peer pressure and sexual stereotyping. Meece (1981) found that some school children, in an attempt to reduce their level of anxiety, tend to devalue mathematics. Betz (1978) reported the prevalence of mathematics anxiety amongst college students.

Some researchers believe that mathematics anxiety is no more than subject-specific test anxiety (Brush, 1981). Others define mathematics anxiety more broadly, incorporating an anxiety component associated with taking mathematics examinations (Richardson & Woolfork, 1980). Some authors have described mathematics anxiety as an attitude (Aiken, 1976). On the other hand, mathematics anxiety has also been described as a fear, coined as mathophobia (Lazarus, 1974).

Mathematics Anxiety and Educational Achievement

Using the number of semesters of high school mathematics completed at high school as an index of mathematics participation, Betz (1977) and Hendel (1977) independently found a significant positive correlation with mathematics achievement. Furthermore, studies have shown that high mathematics anxiety may induce future mathematics avoidance (Ernest, 1976; Fennema & Sherman, 1976; Frary & Ling, 1983; Hackett, 1985; Hendel, 1980; Sells, 1973, 1978). Since evidence exists that under-achievement in mathematics can negatively affect academic and career choices and goals (Rounds & Hendel, 1980; Tobias & Weissbrod, 1980), it is conceivable that mathematics anxiety is a moderating factor in the relationship between mathematics avoidance and mathematics achievement.

Many studies have shown that high levels of mathematics anxiety are associated with poor performance and under-achievement in mathematics (Aiken, 1970, 1976; Alexander & Cobb, 1984; Austin-Martin, Waddell, & Kincaid, 1980; Betz, 1977, 1978; Brush, 1978; Buckley & Ribordy, 1982; Callahan & Glennon, 1975; Clute, 1984; Crosswhite, 1972; Feinberg & Halperin, 1978; Fennema & Sherman, 1977; Frary & Ling, 1983; Gaudry & Spielberger, 1971; Gliner, 1987; Hackett, 1985; Hendel, 1980; Hutton & Levitt, 1987; Jacobs, 1973; Morris, Kellaway, & Smith, 1978; Reyes, 1984; Richardson & Suinn, 1972; Richardson & Woolfork, 1980; Sarason, Davidson, Lighthall, Waite, & Ruebush, 1960; Sepie & Keeling, 1978; Siegel, Galassi, & Ware, 1985; Skemp, 1971; Skypeck, 1980; Suinn, 1972; Suinn, Edie, Nicolleti, & Spinelli, 1972; Suinn & Edwards, 1982; Szetela, 1971; Tobias & Weissbrod, 1980).

In a study of 700 college freshmen, Dreger and Aiken (1957) found a negative correlation between number anxiety and mathematics achievement. Similarly, Gottfredson (1980) found a negative relationship between mathematics anxiety and mathematics achievement.

However, some conflicting findings have been reported regarding the relationship between mathematics anxiety and performance (Fulkerson, Galassi, & Galassi, 1984; Resnick, Viehe, & Segal, 1982; Siegel & Galassi, 1983; Siegel, Galassi, & Ware, 1985). Some researchers have found that the relationship between mathematics anxiety and performance is not significant, after controlling for previous mathematics performance (Dew, Galassi, & Galassi, 1984; Llabre & Suarez, 1985).

Conflicting evidence also exists on the explanatory power of mathematics anxiety in predicting mathematics performance. Some researchers believe that the predictability of mathematics anxiety is dependent on sample characteristics (Reyes, 1984). Indeed, no study has conclusively demonstrated a clear cause-effect relationship between mathematics anxiety and performance. This is due to the use of correlational research designs. Causal inference has therefore not been possible.

Some researchers have asserted that mathematics anxiety is not related to general intelligence, since students who experience high levels of mathematics anxiety may be very successful in other courses (Kogelman & Warren, 1979; Lazarus, 1974; Morris, 1981; Tobias, 1978).

Significant correlations between mathematics anxiety and test anxiety have been reported in the literature (Betz, 1977; Brush, 1978; Dew, Galassi, & Galassi, 1983, 1984; Hendel, 1977; Morris, Kellaway, & Smith, 1978; Resnick, Viehe, & Segal, 1982; Richardson & Suinn, 1972; Rounds & Hendel, 1980). However, Dew, Galassi, and Galassi (1983, 1984) argue that although test anxiety and mathematics anxiety are related, they are distinct constructs.

Components of Mathematics Anxiety

Several studies have demonstrated that mathematics anxiety is a multidimensional construct. Finger and Galassi (1977) postulated that mathematics anxiety has two components: an emotionality factor and a cognitive factor. Rounds and Hendel (1980) identified two components of mathematics anxiety which they named Mathematics Test Anxiety, involving the anticipation and completion of a task, and Numerical Anxiety, involving everyday manipulations of numbers. Other researchers have also described mathematics anxiety as a two-dimensional construct (Alexander & Cobb, 1984; Brush, 1981; Plake & Parker, 1982). Wigfield and Meece (1988) identified two components of mathematics anxiety, similar to the components of test anxiety found by Liebert and Morris (1967). They found that the affective component relates more strongly to performance than does the cognitive component.

In a similar study, Resnick, Viehe, and Segal (1982) identified three factors; namely, Evaluation Anxiety, Arithmetic Computation, and Social Responsibility Anxiety. Ferguson (1986) also identified three factors. In addition to Rounds and Hendel's Numerical Anxiety and Mathematics Test Anxiety, Ferguson found a factor he named Abstraction Anxiety, an anxiety which stems from mathematics relating to abstract topics, which are first introduced in the middle grades.

Symptoms of Mathematics Anxiety

Dew, Galassi, and Galassi (1984) found that mathematics anxiety is associated with physiological arousal. Sovchik, Meconi, and Steiner (1981) presented symptoms experienced by students with high levels of mathematics anxiety. These include cautiousness, learned-helplessness, low self-esteem and compulsive behaviours. Tobias (1978) has also stressed the dysfunctional effects of severe mathematics anxiety. For extremely anxious students, a mathematics classroom is seen as frightening, threatening, bewildering, and guilt- and shame-inducing.

Antecedents of Mathematics Anxiety

Harris and Harris (1987) identified eight major causes of mathematics anxiety. They divided these causes into three categories: student-related anxieties, comprising lack of confidence and negative student attitudes; teacher-related anxieties, comprising teacher bias and authoritarian teaching styles; and teaching-related anxieties, comprising lack of variety, lack of relationship with the real world, and emphasis on memorisation and on speed.

As in the case of test anxiety, the antecedents of mathematics anxiety can be considered to be situational, dispositional, and environmental (Byrd, 1982).

Situational Antecedents of Mathematics Anxiety

Situational antecedents relate either to the nature of mathematics or to the mode of teaching. There are many situational antecedents of mathematics anxiety. Calvert (1981) found that previous level attained in mathematics is a factor in determining mathematics anxiety. Burton and Russell (1979) and Calvert (1981) found that students most prone to mathematics anxiety were those whose prior mathematics backgrounds and achievements were inadequate. Betz (1977, 1978) found mathematics anxiety to be related to sex, prior mathematics exposure, mathematics achievement, trait anxiety, test anxiety, and attitudes of students, parents, and teachers towards mathematics. In addition, Brush (1978) discovered a negative relationship between mathematics anxiety and the number of years of high school mathematics and grades in high school mathematics courses. Gressard and Loyd (1986) found a moderate relationship between mathematics anxiety and computer anxiety.

In a study of high school graduates who were about to enroll in college, Shanklin (1978) found that those who chose majors which required low levels of mathematics knowledge and skills tended to be more anxious about mathematics than their counterparts.

Some researchers have contended that the way mathematics is taught can be a source of mathematics anxiety (Burton, 1984; Clute, 1984; Downie, Slesnick, Stenmark, & Hall, 1983; Greenwood, 1984). Williams (1988) agreed, adding that since mathematics learning appears to be largely a function of mathematics teaching (Greenwood, 1984; Lazarus, 1974; Peterson and Fennema, 1985), it may follow that mathematics anxiety is a function of mathematics teaching. Crawford (1980) found that poor mathematics instruction at some point in a student's background may have contributed to increased levels of anxiety surrounding the subject. Poor mathematics instruction includes: an undue emphasis on precision, inadequate explanation, disorganised presentation, and excessive material covered (Kogelman & Warren, 1979; Tobias, 1978). Morris (1981) found that mathematics anxiety may stem from negative experiences with mathematics during early school years.

In addition, Bulmahn and Young (1982), Kelly and Tomhave (1985), Larson (1983), Lazarus (1974), and Walker (1978) have argued that mathematics anxiety is transferred from teachers to students. Several studies have found high levels of mathematics anxiety in pre-service elementary teachers (Battista, 1986; Kelly & Tomhave, 1985; Sovchik, Meconi, & Steiner, 1981). On the other hand, Chavez and Widmer (1982) found that most elementary school teachers do not have high levels of mathematics anxiety.

Both Crawford (1980) and Kogelman and Warren (1979) discovered that inappropriate mathematics textbooks play a role in inducing anxiety. Many mathematics textbooks are too complex for students who do not possess a strong background in mathematics. As a consequence, students are compelled to learn mathematical formulas and definitions by rote because they do not fully comprehend them. Such strategies may be somewhat effective for lower-level mathematics courses. However, at higher levels, this system begins to break down (Kogelman and Warren, 1979). The formal style of most mathematics textbooks may give many students the impression that mathematics is a rigid, authoritative, and mysterious discipline (Kogelman and Warren, 1979). Such a portrayal may induce anxiety, as can an authoritarian classroom setting (Tobias, 1978).

The terminology, notation, and language of mathematics may contribute to mathematics anxiety (Tobias, 1978; Wagner, 1980; Walker, 1978). This may result, in part, from the fact that some people have a lower tolerance of ambiguity in mathematics than they do in other subjects.

Many myths surrounding mathematics tend to exacerbate anxiety. For example, it is often believed that there is only one way to solve a mathematical problem, that one must be able to solve problems at a fast rate, and that mathematics is a male domain. These types of false belief systems help to create, maintain, and elevate levels of mathematics anxiety.

Mathematics is perceived by many as a rigid discipline in which success is guaranteed only if the correct answer is arrived at, regardless of how much effort is expended in obtaining an answer. This incongruity between effort and "success" also promotes anxiety (Tobias, 1978).

Mathematics learning is essentially cumulative and progressive in nature. This cumulative nature implies that what is taught in one grade must be learned, otherwise acquisition of knowledge cannot continue in subsequent grades. In addition, as a student's knowledge of mathematics increases, the material gets more difficult, at least in absolute terms. This expectation of increasing mathematical complexity can bring about higher anxiety levels, which can be detrimental to the student (Smith, 1979).

There appears to be agreement in the literature that it is disadvantageous, with respect to achievement in mathematics, to experience a fragmented or discontinuous mathematics education (Lazarus, 1974). Consequently, those returning to study mathematics after a long break often experience high levels of anxiety (Lazarus, 1974).

Dispositional Antecedents of Mathematics Anxiety

Low levels of confidence and self-esteem with respect to problem-solving capacity can be regarded as dispositional antecedents of mathematics anxiety (Betz, 1977; Docking & Thronton, 1979; Kogelman, Nigro, & Warren, 1978; Sherman, 1980; Tobias, 1978). Ernest (1976) postulated that questions posed and remarks made by a teacher can leave a student feeling inadequate, resulting in a reduction in self-esteem and, consequently, increased levels of anxiety. Smith (1981) found, in her study of women, that low mathematics self-esteem was a significant factor in predicting mathematics anxiety. According to this study, women have a higher incidence of negative attitudes towards mathematics than do men. Similarly, Gourgey (1985), Kogelman et al. (1978), Lipsett (1958), Tobias (1978), and Wolfe (1978) found that self-concept was negatively related to mathematics anxiety.

Hadfield and Maddux (1988) found that field independent learners (students who take a primarily global approach to learning) tend to have higher levels of mathematics anxiety than field dependent learners (students who take a primarily analytical approach to learning). Giangrasso (1981) found that students with high levels of mathematics anxiety tend to make more conceptual errors when solving problems.

Two attitudes which can be regarded as dispositional antecedents of mathematics anxiety are stereotyping and perceived usefulness (Burton, 1979; Hilton, 1980a). With respect to the former, Sherman (1980) found that women with college preparatory mathematics often experienced a conflict between sex role and mathematics achievement. Bander and Betz (1981) and Tobias (1978) theorised that higher mathematics anxiety levels among females are partly attributable to their being socialised to believe that mathematics is a male domain. The majority of mathematics teachers are male. In addition, mathematics instructors often reserve higher expectations for males than for females. Females are often encouraged to specialise in fields which do not require a strong mathematical background (Betz, 1978). Bander and Betz (1981) and Tobias (1976) reported that cultural and peer pressure has culminated in the perception of mathematics as a male domain.

Environmental Antecedents of Mathematics Anxiety

Environmental antecedents include sex, age (Sherman, 1980) and parental attitudes towards mathematics (Lazarus, 1974). Hackett (1985) reported that the causes of mathematics anxiety include socioeconomic status, parental background, and the influence of teachers. Age has also been considered a possible environmental antecedent to mathematics anxiety (Brush, 1979).

Sex has been extensively studied as an antecedent correlate of mathematics anxiety and achievement. The body of literature suggests that females report higher levels of mathematics anxiety than males (Bander & Betz, 1981; Betz, 1978; Brush, 1980; Burton, 1979; Dew, Galassi, & Galassi, 1983; Fennema, 1977; Fox, 1977, 1981; Fox, Fennema, & Sherman, 1977; Levitt & Hutton, 1983; Llabre & Suarez, 1985; Meece, 1981; Osen, 1974; Ramirez & Dockweiler, 1987; Stent, 1977; Tobias, 1976, 1979, 1980; Tobias & Weissbrod, 1980). This leads to fewer women enrolling in mathematics-related courses at both high school and college levels (Meece, Parsons, Kaczala, Goff, & Futterman, 1982; Tobias, 1978, 1980).

At the college level, older women have been found to experience higher levels of mathematics anxiety than younger women (Betz, 1978; Dew, Galassi, & Galassi, 1984; Lent, Brown, & Larkin, 1984; Resnick, Viehe, & Segal, 1982; Richardson & Suinn, 1972).

Bander and Betz (1981) claimed that sex differences are more apparent in relation to mathematics anxiety than any other anxiety construct. However, some studies have not found evidence of a sex difference in mathematics anxiety (Brush, 1978; Dreger & Aiken, 1957; Frary & Ling, 1983; Hackett, 1985; Resnick, Viehe, & Segal, 1982; Singer & Stake, 1986; Tsai & Walberg, 1983). Hunsley and Flessati (1988) argued that any differences between gender with respect to mathematics anxiety may be the result of gender-linked self-reporting biases. Since males on average enroll in more mathematics courses than females, any gender differences may be confounding differences due to mathematics background (Llabre & Suarez, 1985). Moreover, Fox (1977) and Sherman (1982) demonstrated that after adjusting for prior mathematics background, no sex differences in mathematics anxiety prevail. In addition, Hyde, Fennema, Ryan, Frost, and Hopp (1990) performed a meta-analysis of seventy studies and found little evidence to support the view that females experience more mathematics anxiety than males.

Measures of Mathematics Anxiety

Numerous instruments have been developed to measure mathematics anxiety. Most of these self-report measures focus on affective reactions towards mathematics (Bergin & Lambert, 1978; Bulmahn & Young, 1982; Dreger & Aiken, 1957; Fennema & Sherman, 1976; Livingston & Cobb, 1984; Richardson & Suinn, 1972; Richardson & Woolfork, 1980; Sandman, 1973; Sudweeks, Stoler, & Crocker, 1980; Suinn & Edwards, 1982; Turner, 1981). The instrument developed by Meece (1981) measures both cognitive and affective components of mathematics anxiety.

The Mathematics Anxiety Rating Scale (MARS), developed by Richardson and Suinn (1972), is currently the most popular self-report instrument used to assess mathematics anxiety because of its sound psychometric, reliability, and validity data (Brush, 1978; Dew, Galassi, & Galassi, 1983; Plake & Parker, 1982; Richardson & Suinn, 1972; Richardson & Woolfork, 1980; Rounds & Hendel, 1980; Suinn, 1968, 1972; Suinn, Edie, Nicoletti, & Spinelli, 1972).

The Treatment of Mathematics Anxiety

Various intervention strategies for the reduction of mathematics anxiety have been developed. These include: systematic desensitisation (Addleman, 1972; Brombach, 1980; Crumpton, 1978; Goldfried, 1971; Hyman, 1973; Nash, 1970; Olson & Gillingham, 1980; Smith, 1979; Suinn, Edie & Spinelli, 1970), behaviour modification (Crouch, 1971; DeBronac-Meade, 1982; Genshaft, 1982), counselling (Hendel & Davis, 1978), cognitive restructuring (Matheson, 1977; Natkin, 1967), study skills counselling (Bander, Russell, & Zamostny, 1982; Dellens, 1979), personal journals (Barrow, 1984; Shodahl & Diers, 1984), relaxation (Bander, Russell, & Zamostny, 1982; Kogelman, Forman, & Asch, 1981), anxiety management training (Streim, 1979; Suinn, 1977b; Suinn & Richardson, 1971), classical conditioning (Tobias & Weissbrod, 1980), and computer-assisted instruction (Harris & Harris, 1987; Kulik, Bangert, & Williams, 1984; Mevarech & Ben-Artzi, 1987).

Trent (1985) found that hypnotherapeutic restructuring, expectancy control, and systematic desensitisation reduced mathematics anxiety. Reyes (1984) linked mathematics anxiety to the quality of feedback received from the teacher. Morris (1981) emphasised peer tutoring, stressing the importance of understanding the thought processes involved in problem-solving, giving positive feedback, providing positive mathematics experiences, using explicit materials to teach mathematical content, and reducing tension and pressure in mathematics classes. Hendel and Davis (1978) met with success in reducing mathematics anxiety in women by employing counselling intervention procedures.

Burton (1979), Hilton (1980b), Morris (1981), and Sherard (1981) presented suggestions for the reduction of mathematics anxiety to teachers. These could be summed up as establishing a creative, positive, and supportive classroom atmosphere.

Dueball and Clowes (1982) reported studies which attempted to compare some of these treatments. However, they were unable to reach any clearcut conclusions, due to incomparable data.

Summary

The most consistent general finding noted, with respect to mathematics anxiety, is that high mathematics anxiety is associated with relatively low performance at both school and university levels. This conclusion is based on the negative correlations which were found in a number of different studies between measures of mathematics anxiety and a variety of measures of academic aptitude and achievement.

The major features which have been shown to influence mathematics anxiety include: attitudes towards mathematics, societal components, sex-role socialisation, students' negative experiences, inappropriate teaching, and attributional patterns. Antecedents to mathematics anxiety can be either situational, dispositional, or environmental.

Various instruments have been constructed to measure mathematics anxiety. By far the most used instrument is the MARS, primarily because it appears to have the best normative, reliability, and validity data.

A number of intervention procedures aimed at reducing mathematics anxiety were mentioned. These include: psychotherapy, counselling, cognitive restructuring, self-instructional training, systematic desensitisation, and anxiety management training. Some procedures have been shown to be effective in the reduction of mathematics anxiety, but very few have been effective in raising performance levels. On account of the fact that each incidence of mathematics anxiety may involve many variables, it appears difficult to recommend one treatment over the others.

The Construct of Statistics Anxiety

Statistics anxiety has been described as "a performance characterised by extensive worry, intrusive thoughts, mental disorganisation, tension and physiological arousal ... when exposed to statistics content, problems, instructional situations or evaluative contexts" (Zeidner, 1990, p. 319). Although an extensive base of theory and research exists on general anxiety, test anxiety, and mathematics anxiety, relatively little research has been undertaken on statistics anxiety (Schacht & Stewart, 1990).

Feinberg and Halperin (1978) found that level of state anxiety was more predictive of statistics achievement than level of trait anxiety. They contended that affective variables such as state anxiety are more closely related to students' expectation of statistics achievement than are cognitive variables.

Blalock (1987) asserted that students with high levels of mathematics anxiety tend to try to memorise statistics facts, formulas, and procedures instead of focusing their attention on endeavouring to understand fully the concepts and general principles involved.

Zeidner (1991) theorised that statistics anxiety comprises two factors, similar to the two-component model of mathematics anxiety discussed above (Alexander & Cobb, 1984; Brush, 1981; Plake & Parker, 1982; Rounds & Hendel, 1980). These components are: content-related and assessment-related anxiety.

Antecedents of Statistics Anxiety

Some of the findings with respect to the correlational antecedents of statistics anxiety are expected to conform to previous mathematics anxiety and test anxiety research.

Indeed, Perney and Ravid (1990) contended that mathematics anxiety is transferred to statistics courses. Both Bendig and Hughes (1954), who studied the relationship between student attitude and statistics achievement, and Fisch (1971), who studied the effects of a variety of cognitive and affective variables on statistics achievement in a German University, found a relationship between situational anxiety and performance. Thus, it seems reasonable to assume that the antecedents of statistics anxiety can be categorised as situational, dispositional, and environmental.

Situational Antecedents of Statistics Anxiety

The situational antecedents of statistics anxiety appear to be somewhat similar to those pertaining to mathematics anxiety. Using an instrument called the Statistics Attitude Survey (Roberts & Bilderback, 1980), Roberts and Saxe (1982) found significant correlations between statistics anxiety and basic mathematics skills, statistics prior knowledge, statistics course grade, number of prior mathematics courses completed, the status of the course (i.e., required or elective), attitudes towards calculators, course and instructor evaluation, satisfaction with the statistics course, and sex. Zeidner (1991) also found that amount of prior exposure to mathematics, and poor prior achievement in mathematics influenced the level of statistics anxiety.

Morris, Kellaway, and Smith (1978) found that non-statistics majors who were enrolled in an introductory statistics class had significantly higher levels of mathematics anxiety than did mathematics students enrolled in mathematics classes. They also found an inverse relationship between mathematics anxiety and statistics achievement. Hunsley (1987) also discovered a negative relationship between mathematics anxiety and statistics achievement, mathematics anxiety and self-reported level of examination preparedness. Benson (1989) found that statistics test anxiety is negatively related to both mathematics self-concept and statistics achievement. Harvey, Plake, and Wise (1985) and Sime, Ansorge, Olson, Parker, and Lukin (1987) reported a negative correlation between mathematics anxiety and academic performance in a statistics examination. However, they were unable to establish a causal link.

Sells (1978) asserted that mathematics anxiety is largely responsible for the negative attitudes which are inherent in most sociological statistics courses. Topf (1976) noted that graduate nursing students attributed their lack of knowledge of statistical concepts to anxiety about quantitative subject matter.

Dispositional Antecedents of Statistics Anxiety

Zeidner (1991) found that perceived level of mathematics self-concept and level of self-esteem are important factors of statistics anxiety.

Environmental Antecedents of Statistics Anxiety

Some of the environmental antecedents of mathematics anxiety appear to transfer to statistics anxiety. Benson (1989) and Benson and Bandalos (1989) found that females reported higher levels of statistical test anxiety than did males. Demaria-Mitton (1987) studied statistics anxiety in an introductory statistics course. She found that statistics anxiety was experienced by both sexes. However, female subjects reported more statistics anxiety than did males. Statistics anxiety was related to age, with students of more than twenty years of age experiencing more anxiety than their younger counterparts. However, the results of Demaria-Mitton may not be valid since she used a modified version of the MARS (Richardson & Suinn, 1972) to measure statistics anxiety.

Measures of Statistics Anxiety

The vast majority of research studies undertaken on statistics anxiety have used measures of mathematics anxiety, in particular the MARS (Richardson & Suinn, 1972). Indeed, in an extensive review of the literature, only two scales which directly measure statistics anxiety were found. These were the Statistics Anxiety Rating Scale (STARS; Cruise, Cash, & Bolton, 1985) and the Statistics Anxiety Inventory (STAI; Zeidner, 1991).

The Treatment of Statistics Anxiety

In the only study found which addressed the treatment of statistics anxiety, Schacht and Stewart (1990) reported that students in statistics classes where humorous cartoon examples were incorporated, perceived a reduction in their level of mathematics anxiety. For these same students, a reduction in the actual level of their mathematics anxiety was confirmed, although the exact causal nature of this reduction could not be established, since an experimental design was not employed.

It is highly likely that interventions for different presentations of statistics anxiety may be different, depending on the manner in which it is manifested by each individual. For example, a student who has unpleasant physiological reactions in examination situations may benefit from a different type of intervention to a student who has a negative view of their propensity or ability to succeed. The former may benefit from biofeedback training, whilst the latter may benefit from some form of cognitive intervention.

Findings from Pilot Study on Statistics Anxiety

As a pilot to the current investigation, Onwuegbuzie (1992) used an ethnographic paradigm, in an attempt to build a theory of statistics anxiety. Data were collected via direct observations, structured and semi-structured interviews, self-report questionnaires, and personal journals. The major purpose of this study was to develop a detailed description of the nature and etiology of statistics anxiety, as experienced by graduate students.

It was found that statistics anxiety is a complex subjective and experiential phenomenon, which manifests itself in many ways and which occurs both in evaluative and non-evaluative settings. High levels of statistics anxiety were deemed debilitative. Statistics anxiety was found to be a conglomeration of expectations, beliefs, attitudes, experiences, and behaviours, with regard to statistics learning and achievement. Many of the antecedents and indicators of mathematics anxiety and test anxiety were apparent in the study.

In developing and validating the Statistical Anxiety Rating Scale, Cruise, Cash, and Bolton (1985) found six components using principal component factor analysis. These components were: (1) Worth of Statistics, (2) Interpretation Anxiety, (3) Test and Class Anxiety, (4) Computational Self-Concept, (5) Fear of Asking for Help, and (6) Fear of Statistics Teachers (Cruise, Cash, & Bolton, 1985, p.92).

In the ethnographic study undertaken by Onwuegbuzie (1992), ten components of statistics anxiety emerged from the data. These were: (1) Perceived Usefulness of Statistics (equivalent to the "Worth of Statistics" of Cruise et al.), (2) Computation Self-concept, (3) Application of Statistics knowledge (equivalent to the "Interpretation Anxiety" of Cruise et al.), (4) Fear of Asking for Help, (5) Fear of Statistics Teachers, (6) Class Anxiety, (7) Test Anxiety, (8) Fear of Statistical Language, (9) Statistical Computing Anxiety, and (10) Grade Anxiety. The last three components listed, namely: fear of statistics language, statistical computing anxiety and grade anxiety were not found by Cruise, Cash, and Bolton (1985). The ten components of statistics anxiety found in the pilot study are as follows:

<u>(1) Perceived Usefulness of Statistics</u>

This component pertains to how useful students believe statistics to be for their future development, in terms of academic or career aspirations. Students who displayed the highest levels of anxiety tended to view statistics as being irrelevant. One student expressed, "I don't think that this is being taught in a way that will be useful to us" (p. 50).

<u>(2) Computation Self-Concept</u>

This component refers to the level of anxiety experienced by a student who is endeavouring to solve a statistics problem which requires computation. Individuals with low self-perception with regard to their aptitude for statistics are likely to experience anxiety. This could occur in any setting. This dimension is captured by the following account:

> I wish the hand calculation of things was done more. We rely on the computer and when asked to calculate something by hand I don't know what to do. It's like doing long division on a calculator on homework, and on a test having to do it by hand. You of course will not know where to begin. (p. 51)

(3) Application of Statistics Knowledge

This component relates to the level of anxiety experienced by a student when analysing data. A student with high levels of this anxiety component finds it very difficult to decide which procedure to use and how to interpret the data. Part of this anxiety is induced by a student's misconception of statistics. The statistics project, which was assigned by the instructor, was particularly anxiety-provoking for many students. In particular, writing a statistics report seemed to be overwhelming for many students.

(4) Fear of asking for help

When some students ask for help from a peer or an instructor, they experience high levels of anxiety. Many of these students are afraid that they will be seen in a bad light. They are constantly afraid of asking questions which may be deemed stupid. One student admitted:

> Another interesting factor is that I became instantly withdrawn and "shy" in this class. I am afraid to ask questions and offer answers. I am always sure that I have the wrong answer. I am normally an assertive, confident individual. I am a certified principal and special education teacher, constantly supervising and monitoring adolescents with behaviour and emotional problems, as well as heading the B/EH Program. I am actively interviewing for administrative positions that I feel I would successfully take on .... yet I turn into

a mouse with a "pea brain" during Applied Statistics. I am hopeful, though, that my statistical self-image will improve with time. (p. 51)

<u>(5) Fear of Statistics Teachers</u>

Students who are afraid of statistics teachers may not be able to relate to them. They may not view statistics teachers the same way as they view most other professors. Some students are wary of a statistics professor even before the statistics course begins. One student admitted that after the first lesson a lot of her anxiety was eased because the professor "not only showed that he had a sense of humor, but he also let the class know that he is aware of our fear of statistics" (p. 52).

In referring to a previous statistics instructor, one student noted, "Dr. I. is so forbidding looking to me. He has a kind-looking face, but his eyes are cold and distant. Anyway, I feel anxious just in his presence, so I will avoid having him judge me on anything if I can avoid it" (p. 52).

<u>(6) Class Anxiety</u>

This component refers to the anxiety experienced when a student is in a classroom setting. It also includes any anxiety-provoking thoughts and perceptions which students may have before or after a statistics class session. For example, one student admitted to feeling constantly "overwhelmed by the amount of information given in class" (p. 53).

(7) Test Anxiety

This component refers to the anxiety experienced during preparation for a test, taking a test, or waiting for the results of a test. It is captured in the words of one student who, after a statistics test, reported:

> I was very nervous about the test when I went in, but I felt fairly well prepared and thought I could make an "A", but the test really was not what I expected. During the test, I reached the highest level of test anxiety I ever experienced. After the test, I experienced a great deal of anxiety about having probably failed the test and thought about how to get out of taking the course. However, there really was no way to get out of it without extreme measures, so I decided to resign myself to surviving the course. (p. 55)

(8) Fear of Statistics Language

Anxiety may also be induced by an intrinsic fear of the overall structure which governs statistics. This includes formulas, symbols, notations, and conventions. Such anxiety can manifest both within and without the classroom, and is situational, environmental, and dispositional. For example, one student revealed, "The only factor that keeps me going through the class, and instantly helps reduce my anxieties is that I will be able to have the information 'translated' into regular English after the class" (p. 57).

(9) Statistical Computing Anxiety

Statistical computing anxiety is a situational manifestation of statistics anxiety. It is a fear which relates to the use of computers. Computer anxiety may occur even when a situation poses no real or immediate threat as far as the use of computers is concerned. Anxiety reactions may be activated merely by contemplating the use of a computer, as well as by interacting with it. One of the students "experienced much fear and frustration in using the (computer) mainframe." A classic account of an anxious session spent at the computer was:

> If I keep messing up with no results (!), I feel a sense of despair and a big knot in my chest. I can hardly keep from crying, and I would just quit and go off by myself and cry - and then drop the course - if Linda and Eve weren't there (classmates).
>
> If I drop the course, I would lose my teaching assistantship and that would really screw everything up! Finally, I get the stupid problem done, but I really don't feel much satisfaction because I feel I have wasted at least two hours and a lot of energy! My cute, "upbeat" password almost got changed to an obscenity. (p. 58)

(10) Grade Anxiety

This factor can induce situational, environmental, and dispositional anxiety. It refers to the anxiety which arises from a student's expectation of their final grade. This expectation is often incongruent with reality. The expectation may be too high or too low. In either case, it can be anxiety-provoking. There was abundant evidence of grade anxiety in the ethnographic study. Indeed, this was probably the most prevalent theme arising from the study. Grade anxiety is exemplified in the following commentary:

> I will be lucky if I can squeak out a C in this class....I am in a panic that I will not be able to grasp the material in time for the tests, that I will have to repeat the class and become humiliated as well as not graduate on time. I MUST PASS THIS CLASS!!! I will have to make extra efforts and allow more time to study. (p. 59)

There was plenty of evidence arising from this study to suggest that negative experiences in previous mathematics courses increase levels of statistics anxiety. Many students find statistics classes threatening to their self-esteem, due to the fact that failure, for them, is a realistic possibility. This reduction in self-esteem results in elevated anxiety levels.

The fact that many graduate students put off enrollment in statistics courses for as long as possible, seems to culminate in more anxiety. Increased levels of anxiety, in this instance, appear to stem from the fact that by the time many graduate students take statistics they are so far advanced in their own programs that these courses become obstacles to graduating.

Levels of statistics anxiety appeared to be higher in those students who had been away from school for a long period of time, or who had not taken a mathematics or mathematics-related courses for a long time. Another important finding was that level of self-concept and self-esteem was a factor in determining the level of statistics anxiety.

Constant themes which arose from the study relating to the reasons why some students had higher anxiety levels in statistics than in other subjects, included: "lack of prior knowledge", and "overwhelming material". In addition, students with high levels of statistics anxiety regarded statistics as being "abstract"; they "did not have the aptitude for this type of thinking"; they "found the statistical symbols confusing"; they "didn't understand the concepts"; they "could not relate to statistics"; and, for them, "statistics did not seem real."

Statistics anxiety was a function of the perceived difficulty in understanding the assumptions and approaches which form an integral part of statistics. Students who were highly anxious about statistics often seemed to relate their anxiety to a feeling of loss due to a misunderstanding of a pre-requisite topic.

The data from this study strongly suggest that statistics anxiety is a learned response. It appears that at least one of the ten dimensions of statistics anxiety highlighted in this chapter was experienced by every student in the study.

Summary

Comparatively little research has been undertaken on statistics anxiety. In these studies, the major features which have been shown to influence statistics anxiety include: basic mathematics skills, statistics prior knowledge, number of prior mathematics courses completed, attitudes towards calculators, satisfaction with the statistics course, mathematics self-concept, and self-esteem. Antecedents to statistics anxiety can be either situational, dispositional, or environmental. In am ethnographic study undertaken by the author, ten components of statistics anxiety were identified. These were: (1) Perceived Usefulness of Statistics, (2) Computation Self-concept, (3) Application of Statistics knowledge, (4) Fear of Asking for Help, (5) Fear of Statistics Teachers, (6) Class Anxiety, (7) Test Anxiety, (8) Fear of Statistical Language, (9) Statistical Computing Anxiety, and (10) Grade Anxiety.

Most of the instruments used to measure statistics anxiety tend to be measures of mathematics anxiety. Only two scales appear to have been constructed specifically to measure statistics anxiety.

Only one study was found which addressed the treatment of statistics anxiety. In this study, humorous cartoon examples were used by the statistics instructor. It appears that much more research is needed in this area.

The Relationships Among Statistics Anxiety, Mathematics Anxiety, Test Anxiety and General Anxiety

General anxiety can be described as a psychological construct from which an array of sub-constructs stem. These sub-constructs are apparent in specific situations. In a graduate school setting, test anxiety, statistics anxiety, and mathematics anxiety seem to be common among students. A multitude of physiological, behavioural, phenomenological, cognitive, and affective symptoms result from anxiety, be it general anxiety or academic-related anxiety. Many of these symptoms are debilitative.

Studies have found moderate correlations among mathematics anxiety, test anxiety, and trait anxiety (Bander & Betz, 1981; Betz, 1977, 1978; Dew, Galassi, & Galassi, 1983, 1984; Plake & Parker, 1982), although the association between mathematics anxiety and trait anxiety was refuted by Docking and Thornton (1979). Betz (1978) found moderate correlations among mathematics anxiety, test anxiety, and general anxiety.

Maysick (1984) reported that statistics anxiety was positively related to trait anxiety, number anxiety, and mathematics test anxiety, and negatively related to mathematics background and type of major. Spielberger (1980) and Trent and Maxwell (1980) independently found a positive relationship between test anxiety and trait anxiety.

Morris (1981) pointed out that mathematics anxiety is not necessarily related to general anxiety, inasmuch as a person with high levels of mathematics anxiety may not be characterised by high anxiety in general, and vice versa. Benson (1989), Hunsley (1987), and Richardson and Woolfork (1980) asserted that mathematics test anxiety comprises more than just test anxiety, inasmuch as the former relates to a reaction to both course content and evaluation, whilst the latter pertains only to evaluation. As a result, it seems reasonable to assume that statistics test anxiety is also distinct from test anxiety.

Just as Hadfield and Maddux (1988) asserted that mathematics anxiety is a unique construct which only has a slight relationship to general anxiety and test anxiety, so too it will be assumed in the present study that statistics anxiety is a unique construct. Similarly, just as Morris, Kellaway, and Smith (1978) contended that MARS is a better predictor of mathematics anxiety than other general test anxiety scales, so too it will be assumed that STARS is the most appropriate measure of statistics anxiety. Indeed, the differentiation of general anxiety and situational anxiety in mathematics performance (Aiken, 1970; Feinberg & Halperin, 1978) is no less important with respect to statistics achievement.

Anxiety and Attributional Style

Academic-related anxiety is often associated with cognitions about causes of failure. Many highly anxious students tend to attribute failure to internal deficiencies, to believe that failure is likely to recur in the future, and to view their situation as unchangeable (internal-global-stable attributions.)

One of the earliest studies on test anxiety and attributions found that students with high test anxiety tended to blame themselves more for failure than students with low anxiety (Dorris & Sarason, 1955). Similarly, Arkin and Schumann (1984) found that high anxious students perceived themselves to be less able (internal locus-of-control), and the task more difficult (external locus-of-control).

On the other hand, Holroyd, Westbrook, Wolf, and Badhorn (1978), found that test anxiety was not influenced by any of Weiner's four achievement attributions (i.e. ability, effort, task difficulty, or luck).

Anxiety and Attributional Styles in Children

Kramer (1988) reported that both gifted and non-gifted seventh, eighth, and ninth graders who exhibited self-blaming attributional styles, were more anxious and/or perfectionistic than were students with self-enhancing attributional styles. In addition, anxiety and perfectionism were found to be significantly positively related. Finally, females were found to be more anxious and perfectionistic than males. Reidy (1985) discovered that learning-disabled boys (grades 3-5) who make more internal-global-stable attributions for failure are likely to be more anxious than their counterparts.

Anxiety and Attributional Styles in Adults

At the college level, Kammen (1989) analysed the causal attributions and state anxiety of optimists and pessimists. He found no difference between optimists and pessimists with respect to initial performance expectations or anxiety levels. However, after receiving success feedback and being told that a second task would be moderately difficult, both the performance expectations and anxiety levels of pessimists tended to be consistent with their causal attributions, with "difficult-to-moderate" pessimists having high anxiety and lowered performance expectations, whilst "easy-to-moderate" pessimists were associated with lowered anxiety and increased expectations.

Rothblum, Solomon, and Murakami (1986) found that high procrastinators, particularly women, had higher levels of test anxiety, state anxiety, and anxiety-related physical symptoms than low procrastinators. Furthermore, high procrastinators were significantly more likely than low procrastinators to attribute success in examinations to external and unstable factors.

Sappington (1987) found that students returning to non-traditional degree programs attributed their feelings of anxiety more often to external rather than to internal sources. These external sources included lack of time to accomplish their learning goals, failure to realise the high expectations they had of themselves, and fear concerning the impact that returning to school would have on their interpersonal relationships.

Wilding (1987) found that adult students with high levels of mathematics anxiety showed significant changes in their causal attributions for mathematics failure, reporting a significant increase in the importance of their own efforts in the mathematics learning environment.

Hunsley (1985) reported that test and mathematics anxiety tended to influence students' cognitive processes, including their appraisals, thought content during examinations, and several types of causal attributions.

Arkin, Kolditz, and Kolditz (1983) contended that unsuccessful, highly test anxious students blamed their personality, as opposed to their behaviour or the environment, for their failure. In other words, they made internal, global, and stable attributions for their lack of success. In addition, Rapaport (1984) found that students with high test anxiety held the belief that when they failed they did so due to lack of ability.

It has also been found that there is a "pervading asymmetry" (Geen, 1980, p.43) in the contrasting effects of success and failure on the performance of students with high and low test anxiety. Research indicates that, following failure, students with high test anxiety have a tendency to perform less well, while low test anxious students tend to increase their performance levels. Following success, the reverse is likely to occur. That is, students with high test anxiety perform better, while their counterparts perform worse (Wine, 1980). Attribution theory suggests that low test anxious students may attribute failure to an unstable internal factor (i.e. lack of effort, e.g. "I'm not trying hard enough"), causing them to work harder to increase performance. Conversely, it is suggested that high test anxious students, attributing their failure to a stable internal factor (i.e. lack of ability, e.g. "I'm not good enough"), consequently give up and disengage from the task. Similarly, Wahl and Besag (1986) found that, with respect to mathematics anxiety, low anxious students attributed their success to their own effort and ability (internal), while attributing failure to characteristics of the task (external).

Research indicates that both success and failure have greater impact on the subsequent performance of high test anxious subjects than on that of subjects with low test anxiety (Weiner, 1966; Weiner & Schneider, 1971). Hill (1972) has suggested that low-anxious children are less concerned with and influenced by external evaluation, and are consequently more task oriented than high-anxious children, who are more preoccupied with being evaluated.

Coping Strategies and Anxiety

Hunsley (1985, p.3) defined coping as a "transactional process which is continually modified and adapted to meet the demands of a stressful situation." According to Hunsley, changes in coping can occur via a process of cognitive evaluation. This evaluation comprises two components, namely, primary and secondary appraisal. Primary appraisal determines how relevant the situation is to the individual (i.e. irrelevant, benign-positive, or stressful). Secondary appraisal involves an assessment of the resources an individual has at their disposal for dealing with the situation, as perceived through the primary appraisal. Choice of coping strategies may be made at either a conscious or an unconscious level. Whatever the level, it appears that both poor study coping strategies and inadequate test coping skills can debilitate performance. Indeed, Mechanic (1962) found that approximately one-third of students believed that the ability to cope with anxiety is a factor which is imperative for success.

Meichenbaum and Butler (1980) contended that poor study habits and test-taking skills and inadequate coping skills are important aspects of test anxiety. The research on anxiety and achievement documented above provides evidence that anxiety interferes with performance. There is also strong evidence to suggest that anxiety interferes with learning, inasmuch as students who are highly anxious have difficulty learning new material (Tobias, 1977, 1980).

Some authors have found that students with poor study skills tend to be more test-anxious than their counterparts (Alpert & Haber, 1960; Benjamin, Mckeachie, Lin & Holinger, 1981; Culler & Holahan, 1980; Desiderato & Koskinen, 1969b; Wittmaier, 1972). Hunsley (1987) found that high test-anxious students feel less well prepared and tend to expect lower grades than their counterparts. In separate studies undertaken by Benjamin, Mckeachie, Lin, and Hollinger (1981) and Culler and Holahan (1980), high anxious college students reported spending significantly more time studying for an examination than low-anxious students. However, the high-anxious students had more problems reviewing and learning study material. In addition, Dusek (1980) found that students with high levels of anxiety are easily distracted when they are learning new and difficult material. Culler and Holahan (1980) and Mckeachie, Pintrich, and Lin (1985) concluded that anxiety may affect test performance by interfering with preparation for examinations, inasmuch as highly test anxious students fail to use appropriate study skills to focus their attention on relevant information, encode complex information, and adequately assessing their learning state via methods of self-examination.

With regard to examination-taking coping strategies, Boniface (1985) found that psychology students who devoted more examination time to the use of classroom notes and textbooks tended to obtain lower scores than their counterparts.

On the other hand, some studies have found no relationship between study habits, test taking skills and test anxiety (Brown & Nelson, 1983; Bruch, Juster, & Kaflowitz, 1983; Paulman & Kennelly, 1984). For example, Bruch, Juster, and Kaflowitz (1983) found no difference between low and high test-anxious students' reports of the number of hours per week they allocated to study for a specific course, the number of study hours in the week prior to the final examination, or the number of hours spent studying on the day prior to the final examination. In addition, Klinger (1984) found no significant difference between high and low test-anxious students in the number of pages read for the course examination, a perceived measure of the level of examination preparedness, amongst other aspects of examination behaviours.

As can be seen, there is inconsistent evidence regarding the relationship between test anxiety and study and test coping skills. However, the body of research seems to point towards the existence of at least a moderate relationship between test anxiety and coping skills. The present study is thus, in part, an attempt to identify students with varying degrees of study and test coping skills as well as to test formally the relationship between coping skills and statistics anxiety. In addition, it is hoped that some of the characteristics of students with inadequate skills will be identified.

The Research on Timed Examinations.

Most of the research on the effect of time on performance levels has been correlational in nature, and as such, has given rise to contradictory findings. A few researchers found a relationship between examination completion time and performance. For example, Johnston (1977) reported that students who finished early in an examination tended to get relatively high or relatively low scores. Clyde and Rosenkoetter (1980) also found a positive relationship between examination completion time and performance. Michael and Michael (1969) found that students who took a moderate amount of time obtained high scores. Terranova (1972) discovered a curvilinear relationship between examination completion time and performance.

However, most studies have found no relationship between examination-taking time and achievement (Lester, 1991; Paul & Rosenkoetter, 1980). Wright (1984), grouping students according to ethnic group, gender and native language, found that increasing time limits did not result in statistically significant increases in examination scores. In a similar study, Wild, Durso, and Rubin (1982) found no effect when examination time was extended, regardless of ethnic group, sex and time elapsed since leaving school. These findings corroborated the original findings of Evans and Reilly (1972) and Reilly and Evans (1974) who found that increasing the time allocated to examinations did not differentially increase scores with respect to ethnic group and gender. More recently, Grover, Kixmiller, Davis, Thomas and Tramill (1988) found no relationship between examination-taking time and personality dimension (as defined by Type A and Type B behaviour patterns.)

Bridges (1982) found no linear or curvilinear relationship between examination completion time and performance. The mean scores of those students finishing in the first quartile were not significantly different from those finishing in the last three quartiles. In addition, Bridges (1985) reported that examination completion time on an untimed examination was unrelated to examination performance. Caudery (1990) found no significant differences between timed- and untimed-essay examination scores of adolescent students of English as a Second Language. In a study of the effects of response styles on examination performance, Bridgeman (1980) found that children with "fast" and "slow" response styles performed similarly on both timed and untimed examinations.

Ratcliffe (1983) explored certain factors which may differentiate the scores of adults in a timed examination condition from those examined under a non-timed framework. He found that, although there were no differences in mean scores due to race, sex and years in formal education, age was a significant factor in the performance of adults in timed examinations, but not in untimed examinations. In the timed examination condition, older students attained lower scores than their younger counterparts.

Experimental studies on the effect of timed examinations on student performance have been few and far between (Llabre & Froman, 1987; Bridges, 1985). Indeed, the only experimental studies in the literature which relate to the effects of optimum examination conditions with respect to time limits and time pressure on performance appear to be those conducted by Hill and his associates (Hill, 1977; Hill, 1979; Hill, 1980; Hill, 1984; Hill & Eaton, 1977; Hill, Wigfield, & Plass, 1980). Subjects in these experiments ranged from second to eighth graders.

In an initial experiment, Hill and Eaton (1977) investigated the effects of time pressure on the performance of fifth- and sixth-grade students in an arithmetic computation examination. They found that high-anxious students who took the examination under a timed condition took twice as long to complete the problems and made three times as many errors as low-anxious children. In the condition in which there was no time pressure, high anxious children completed the problems almost as quickly as their counterparts, and made only a few more errors. However, this study took place in a laboratory and, as such, might not be generalisable to school settings.

In a follow-up experiment, a more examination-like situation was set up, in which third- and fourth-grade students were randomised to either a timed or untimed mathematics examination group (Plass & Hill, 1979). As predicted, high-anxious children did not perform as well as low-anxious children in the timed group. On the other hand, in the untimed group, high-anxious boys performed as well as low-anxious boys. Surprisingly, the performance of high-anxious girls remained below that of low-anxious girls in the untimed group. It was also found that most of the low-anxious boys in the timed group worked at an intermediate rate, maintaining accuracy. The high-anxious children comprised those who worked at an intermediate rate, but with less accuracy (intermediate-accurate); those who showed extreme caution by working slowly and with moderate accuracy (slow-moderately accurate); and those, mostly boys, who worked very quickly, but inaccurately (fast-inaccurate). However, when no time limits were imposed, very few of the high-anxious boys could be classified as fast-inaccurate, culminating in higher overall performance.

Hill (1980, 1984) and Hill, Wigfield, and Plass (1980) found that the performance of high-anxious children improved significantly when optimum examination conditions were implemented, with respect to examination time limits, difficulty of the examination form, and clarity of examination instructions.

This set of optimising studies strongly indicates that the performance of many children is hampered by their level of anxiety under time pressure. However, when examination time limits are relaxed, high-anxious children tend to perform much better than under timed (standard) conditions.

Some researchers have suggested that if certain demographic subgroups of examinees are systematically given inadequate time to complete an examination, it may be that their scores are lowered on account of timing limitations and not because of lower ability (Bridgeman, 1980; Wild, Durso, & Rubin, 1982).

No optimising study was found which had used graduate students as subjects. In addition, no studies relating to statistics performance appear to have been conducted. These factors form the major focus of the present study. If Hill's model applies to the college graduate population, then it is expected that, with respect to achievement in graduate level statistics courses, untimed examinations will optimise performance for high-anxious students.

Important Considerations Stemming from Literature Review

An understanding of statistics anxiety in the context of general, test, and mathematics anxiety helps to give insight into some student reactions to statistics. There is widespread agreement that statistics anxiety, like mathematics anxiety and test anxiety, can be viewed as a situation-specific form of trait anxiety. Students who display high levels of statistics anxiety respond with greater elevations of state anxiety than those with low levels of statistics anxiety, when placed in an ego-threatening setting. Indeed, the justification for using a scale which measures statistics anxiety directly stems from evidence that measures of anxiety which limit their items to the assessment of specific reactions to specific situations have higher predictive validity than those which assess more wide-ranging content areas (Endler & Hunt, 1966; Sepie & Keeling, 1978).

Although there is little doubt that statistics anxiety needs to be considered and measured separately because its level is affected by factors other than perceptions of competence and performance expectations, the true nature of statistics anxiety, like mathematics anxiety, test anxiety, and general anxiety, is very difficult to ascertain, on account of conflicting results in the literature. The issue of causality is a difficult one in research pertaining to anxiety. Although several studies have been undertaken which attempt to establish the relationship between situation-specific anxiety and statistics performance, it is very difficult to draw any meaningful generalisations from many of the findings. Some studies are invalidated by small sample sizes relative to the number of variables studied, and others are hampered by the use of homogeneous samples which are not reflective of the more heterogeneous groups found in introductory and intermediate-level statistics classes (Feinberg & Halperin, 1978). Furthermore, it is impossible to infer causality in the vast majority of the studies discussed above, on account of their non-experimental nature.

This study was an attempt further to investigate some of the conflicting results which surround the construct of statistics anxiety. Despite the multitude of studies undertaken on the four anxiety constructs, it is still not clear whether high levels of anxiety decrease performance (Wine, 1980), or whether low performance levels increase anxiety (Tobias, 1986).

Some of the disagreements among researchers, pertaining to the correlates of general anxiety, test anxiety, and mathematics anxiety, stem from the fact that findings often rely on different instruments, some of which are inappropriate, since they measure features which are not directly relevant to the construct being studied. A measure of test anxiety must be appropriate for the educational group and the subject matter under investigation. Although many measures of test anxiety have been designed for use with college students, very few are suitable for graduate students. Furthermore, very few scales specifically relate to the field of statistics. It is imperative that any instrument being used to measure statistics test anxiety only include items which are specific to situations where statistics is involved.

The finding of Gourgey (1985), that mathematics anxiety is associated with a tendency to give up easily on a task, or to guess when a solution is not immediately obvious, will be applied to this study. Indeed, the tendency of students with high levels of statistics test anxiety to give up easily on a task was found by Onwuegbuzie (1992). In addition, the cognitive-interference model of Hembree (1990), the attentional hypothesis of Wine (1971), and the deficits model of Tobias (1985) will be investigated.

It is expected that the tendency of students with high levels of statistics test anxiety to give up more easily on a problem, will be exacerbated in a timed-examination condition, further debilitating performance. It is also expected that some of the background variables, such as level of study coping and examination-taking coping strategies, students' attitude towards statistics, the number of years which have elapsed since a student's previous mathematics course, students' mathematics background, and the final grade in a previous statistics course, will correlate with statistics anxiety. Finally, it is anticipated that the performance of highly test-anxious students will deteriorate as the level of difficulty of the examination items increases.

A literature review has led the author to conclude that a change in the examination condition (i.e. an untimed examination) might result in lower statistics test anxiety and, consequently, higher achievement in statistics courses, especially for highly anxious students. Indeed, Morris (1981) recommended, amongst other things, that in order to reduce mathematics anxiety, timed examinations should be eliminated.

The literature on general, test, mathematics, and statistics anxiety discussed in previous sections has been considered in order to generate the research questions and hypotheses listed in Chapter 1. A review of this literature suggests that there is a dire need for true experimental studies in order to further our understanding of the effect of statistics test anxiety on statistics performance.

An initial step in designing effective intervention strategies for the reduction of statistics test anxiety is to elucidate the very nature and etiology of that anxiety, as well as the moderating variables through which statistics test anxiety affects performance (Meichenbaum & Butler, 1980). It is hoped that, using a true experimental design, a clearer understanding of the relationship between statistics test anxiety and performance will ensue.

Chapter III

Methodology

Subjects

The subjects who participated in this study were students enrolled in an intermediate level educational statistics course at a large university in the southeast United States during the Fall 1992 semester. The Graduate Bulletin of this university, describes the course as "a second-level statistics course emphasising procedures such as correlation, multiple regression, factorial analysis of variance, and covariance. Includes non-parametric procedures and sampling statistics."

The class selected for this study comprised graduate students from a number of non-statistical disciplines. Each student in the class had completed an introductory graduate-level course in statistics, obtaining a minimum grade of "B" as a prerequisite for enrollment in the course. Thirty students were enrolled in this course. All participants in this study were volunteers, whose only inducement to participate was the opportunity to retake their final examination. In order to participate, students gave their consent by signing an Informed Consent Form.

Nearly all students in the class participated. Indeed, only two students did not participate in the study. These two students expressed a desire to participate, but were unable to do so due to scheduling conflicts. As a result, selection bias was not deemed a threat to the validity of the study.

Selection of Subjects

On December 1, 1992, two weeks before the final examination, the investigator informed the class that a study was planned, which would explore approaches to learning statistics. A packet, which contained an Informed Consent Form (Appendix A), the Statistical Anxiety Rating Scale (Appendix B), the Attitudes Toward Statistics scale (Appendix C), the Coping Strategies Inventory for statistics (Appendix D), the Preferred Assessment Style Scale (Appendix E), and the Background Information Form (Appendix F), was given to all students present. The Informed Consent Form provided the following information: the identity of the researcher, the underlying purpose of the study, an explanation of the background and objectives of the research and the potential implications for the teaching of statistics, the potential risks and benefits to participants. Students were also given a guarantee of confidentiality. The questionnaires in the packet took approximately ninety minutes to complete. The fact that information from the questionnaires would not influence students' grades in any way, and that it is hoped that the results of the study would be used to improve instruction in the course in the future, was emphasised by the investigator. The students were informed that they could withdraw from the study at any time, without consequences, by contacting the researcher.

Students who were interested in participating in the study were requested to return the completed consent form and questionnaires, sealed in the envelope provided, at the next class period, or to return the packet by mail in a stamped addressed envelope provided by the investigator. Participants were also informed that they would be randomly assigned to timed and untimed testing conditions at the beginning of the examination period. It was emphasised that participants would not be told which examination condition they were assigned to until the day of the examination, and, as such, they needed to prepare themselves for either kind of examination condition.

Research Instruments

Seven instruments were used in this study: the Statistical Anxiety Rating Scale (STARS), the Attitudes Toward Statistics (ATS), the Coping Strategies Inventory for Statistics (CSIS), the Preferred Assessment Style Scale (PASS), the Background Information Form (BIF), the Mid-term Examination (MTE), and the Practice Final Examination (PFE).

The STARS was developed by Cruise and Wilkins (1980). STARS is a 51-item, 5-point Likert-format instrument which assesses statistics anxiety in a wide variety of academic situations (Appendix B). The instrument comprises two parts. The first part evaluates level of anxiety in 23 different situations. A response of "1" indicates that no anxiety would be experienced by the student in the situation, whilst a response of "5" indicates that the student would experience high levels of statistics anxiety. The second part comprises 28 statements which pertain to statistics. A response of "1" denotes strong disagreement with the statement (low level of anxiety), whilst a response of "5" denotes strong agreement (high level of anxiety). Normative data have been gathered for this instrument. Construct validity was established through factor analysis, using 1265 subjects, in which six specific factors were identified (Cruise, Cash, & Bolton, 1985). These six factors were discussed in the previous chapter. The items which correspond to these six factors are reported in Appendix B. The operationalisation of these factors are presented in Appendix G. Loadings for these factors range from 0.483 to 0.864. Reliability of these factors, as measured by coefficient alpha, ranged from 0.678 to 0.940. The point multi-serial correlations, determined for each item within each factor, ranged from 0.589 to 0.906. In addition, Cruise, Cash and Bolton (1985), using a sample of 161 students, reported five-week test-retest reliability coefficients for each factor which ranged from 0.671 to 0.833, and for each item which ranged from 0.299 to 0.759. Concurrent validity was demonstrated via a correlation of 0.76 between the TEST AND CLASS ANXIETY factor of STARS and Fennema-Sherman's (1976) MATHEMATICS TEST ANXIETY factor (n=537). The Test and Class Anxiety component was used to test the major hypotheses of the current study.

The ATS was developed by Wise (1985). It is a 29-item, 5-point Likert-format instrument which measures student attitudes towards the field of statistics, and student attitudes towards the statistics course in which they are enrolled (Appendix C). Consequently, the ATS comprises two subscales. The first subscale, entitled Attitude Toward Field of Statistics (FIELD subscale), consists of 20 items, whilst the second subscale, entitled Attitude Toward Course (COURSE subscale), consists of 9 items. On both subscales, a response of "1" denotes strong agreement with the statement (positive attitude), whilst a response of "5" denotes strong disagreement (negative attitude). For the first subscale, the possible scores range from "20" to "100," whilst for the second scale, the possible scores range from "9" to "45." On both subscales, low scores indicate a positive attitude, whilst high scores indicate a negative attitude (Appendix G). Some of the items are reversed. These items are reported in Appendix C. The ATS was shown by the author to possess high reliability. The reliability of the FIELD and COURSE subscales, as measured by coefficient alpha, was found to be 0.92 and 0.90, respectively (n=92). Two-week test-retest reliabilities for the FIELD and COURSE subscales were found to be 0.82 and 0.91, respectively. Construct validity was demonstrated by a factor analysis, in which the presence of two factors explained 49% of the total variation (Wise, 1985).

The CSIS was developed by Jarrell and Burry (1989). It is a 40-item, 10-point Likert-format instrument which assesses the non-facilitative examination-taking and study-coping skills of students enrolled in statistics courses (Appendix D). The instrument comprises two scales. The first scale evaluates study-coping strategies, whilst the second scale assesses examination-taking coping strategies. In both scales, students are requested to read each scenario, decide how they would react to the situation, and then rate each of the coping strategies from "0" to "9," with "0" indicating that the coping strategy is "not at all characteristic," and "9" indicating that a coping strategy is "characteristic." The student scores range from 0 to 180 for each of the two scales (Appendix G). According to the authors, a student with a score of 130 or higher is able to cope well in that area. A score of between 110 and 129 indicates that remediation is needed in certain areas. A score of below 110 strongly suggests a need for training in the use of coping strategies (Appendix D). Criterion-related validity was established by correlating both scales of the scale with the final grade point average in a statistics course, using 117 subjects. The final grade point average correlated with scale 1, with a coefficient of 0.4558, and scale 2, with a coefficient of 0.5911 (Jarrell & Burry, 1989). Reliability, as measured by coefficient alpha, was 0.7920 for scale 1 and 0.8061 for scale 2. The reliability of the total instrument was 0.8821.

The PASS was developed by the author specifically for this study (Appendix E). The instrument comprises two parts. The first part is a Likert-format in which respondents are requested to rate, on a 5-point scale, fourteen different examination styles in statistics courses, such as "a timed in-class examination with unlimited supporting material," "a timed in-class examination with no supporting material," "an untimed in-class examination with supporting material limited to a specific number of pages," and "a final project." A response of "1" indicates strong dislike for the type of assessment, whilst a response of "5" denotes strong liking for the type of assessment. The second part of the PASS is also a Likert-format. Here respondents are requested to rate fourteen examination styles on a 3-point scale, and to indicate whether they would reduce, leave unchanged, or increase the following: level of anxiety, performance, higher-order thinking, and objectivity of assessment.

The BIF, also developed specifically for this study, records relevant demographic information (Appendix F). Items are constructed in such a way as to yield information about student background variables, namely, age, sex, and graduate degree program, as well as personal information regarding the number of credit hours previously taken in mathematics and statistics at college level, number of years elapsed since the last mathematics course, number of years elapsed since the students' last statistics class, and the final grade in their introductory graduate-level statistics course.

The MTE was constructed by the course instructor. The examination form comprised items which called upon computational and conceptual application. The examination form covered approximately the first half of the course material (Appendix H) and was scored by the instructor. For this study, the MTE scores were converted to a 100-point scale.

The PFE was also constructed by the course instructor (Appendix I). This examination form covered all of the components listed in the course syllabus (Appendix H). The examination was scored by the instructor. For the study, the PFE scores were converted to a 100-point scale.

Research Design

On Saturday, December 12, at 12 pm, twenty-six participants were met in a designated classroom (examination room 1) in the College of Education by the researcher and two graduate students who had been carefully chosen to be proctors for this study. The researcher thanked subjects for their participation in the study and reminded them of the guarantee of confidentiality. At this point, students were randomly assigned to experimental conditions, such that there was an equal number of students (13) in each condition. Participants who were randomly selected for the timed examination condition were escorted to another room (examination room 2) in the same building by one of the proctors. Once seated, the students in this room were informed of the examination procedures (Appendix J), before receiving the Practice Final Examination. Although the PFE was constructed in such a way that students be capable of completing it within a one hour time limit, they were given ninety minutes in which to attempt all the questions. If any students completed the examination before the allotted time of ninety minutes had elapsed, the proctor was asked to record unobtrusively the length of time it took them to finish. Any students who completed their examination early were told to take their examination paper to the proctor in the other examination room (examination room 1). As soon as they left the examination room, students in the timed group were approached by the researcher who asked them whether they would like more time complete the examination. If a student stated that they needed more time, they would be given the opportunity to complete the examination on another copy of the examination form in the untimed examination room. However, in the event, no student from the timed examination group requested extra time.

Regardless of whether or not students had completed the examination, at the end of ninety minutes, the remaining students in the timed examination condition had their examination papers collected by the proctor. The researcher then asked them collectively if they needed more time to complete the examination. None of them requested an extension.

Soon after 12 pm, that is, when those students who had been selected for the timed examination condition had been escorted to examination room 2, the remaining students were informed by the second proctor that they were in the untimed examination condition. They were then informed of the examination procedures (Appendix K). The proctor recorded unobtrusively the length of time it took for each student in this group to complete the examination. When the last student had returned their examination paper, the proctor sealed the envelopes and gave them to the researcher.

Participants in both examination groups had identical examination forms. They were also examined at the same time. Students in both groups were permitted the use of calculators. Statistical tables were provided. In addition, students were allowed to bring up to three pages of supporting material with them to the examination.

After all students had submitted their papers, the researcher gave them to the course instructor for scoring. On Monday, 14 December, 1992, at 9 am, the course instructor gave the students' grades to the researcher. The researcher made himself available in the statistics laboratory between the hours of 10 am and 6 pm. Students were able to obtain their grade by telephoning him at the laboratory, or by meeting him in person. If they were satisfied with their grade, they could decide not to take the final examination which was held the next day (Tuesday, 15 December, 1992). The researcher also made himself available at the same time to tutor any student who decided to take the final examination, and who required assistance.

Statistical Analyses

An analysis of covariance (ANCOVA) was used to assess the extent to which: (1) level of statistics test anxiety interacts with length of time allocated to complete an examination in determining statistics achievement; (2) level of statistics anxiety determines statistics achievement; (3) length of time allocated to completing an examination determines statistics achievement; and (4) level of statistics test anxiety interacts with examination completion time (i.e., the first four research questions listed in chapter 1).

It was contended that by using the full range of the concomitant variable, that is, by ensuring maximum overlap, employment of the ANCOVA would eliminate some of the problems inherent in designs in which overlap is minimised (Rubin, 1977). ANCOVA models were used to address the primary research questions because it is widely believed that, when comparing treatment groups in many educational contexts, it is important to control for prior student achievement (Campbell & Erlebacher, 1975; Cook & Campbell, 1979; Cronbach, Rogosa, Floden and Price, 1975).

Simple correlation techniques were used to address the secondary hypotheses, that is, to determine the relationship between level of statistics anxiety (comprising the six dimensions of STARS) and the endogenous and exogenous variables.

In addition, in an exploratory section, multiple regression techniques were used to examine the data for interesting patterns which were not addressed by prior hypotheses.

Data analysis included calculation of descriptive statistics for all variables and internal consistency reliabilities for each instrument. Descriptive statistics were also employed to highlight the most preferred methods of assessing students' statistics achievement.

The significance level for this study was set at 0.05 for each effect. In addition, for the analysis of covariance, the standardised effect size was interpreted using the guidelines set by Cohen (1988). That is, an effect was considered small if it was less than 0.25, moderate if it lay between 0.25 and 0.4, and large if it was larger than 0.4. For the correlational analysis, omega squared was used as a measure of association strength (Maxwell, Delaney & Arvey, 1981; O'Grady, 1982). The Statistical Analysis System (SAS, 1989) was used to analyse the data.

Selection of a Setting

The setting for this study was an intermediate level educational statistics course at a large Southeastern university taught during the Fall, 1992 semester. This course was chosen for four main reasons. Firstly, it attracted students from a wide range of academic backgrounds. Secondly, the researcher was familiar with the course since he had been previously enrolled in it. Thirdly, since the researcher has previously conducted an ethnographic study on statistics anxiety with a different group of students enrolled in the same course, it is likely that awareness of most threats to internal and external validity had been identified. Fourthly, since the course was taught by the researcher's advisor, collection of data was facilitated. In addition, increased internal validity due to use of a similar setting, afforded the opportunity to test some of the hypotheses generated in the pilot study. The permission of the course instructor to study his students was sought and obtained.

Potential Difficulties

One procedural difficulty involved arranging the most suitable time to administer the Practice Final Examination. This arose from the fact that many of the students enrolled in the statistics course were part-time students with professional commitments. Therefore, in order to maximise the sample size, the PFE could only be administered after 4:30 pm during weekdays, or on weekends. In addition, some of the students lived a long way from the location of the course. Subject attrition was eliminated, probably owing to the fact that participation in the study gave students the opportunity to improve their final grade in the course. In addition, owing to the possibility that students might have given biased responses if they knew the exact nature of the study, the amount of information supplied to them was minimal.

A potential risk to the participants was the psychological discomfort associated with taking an examination. This risk was minimised by allowing each participant a second opportunity to take the final examination.

In order to ensure that those students who were examined under a timed condition would not be unfairly penalised as a result, they were given the opportunity to complete their examination paper, once they had submitted their original examination form within the ninety-minute period.

Presentation of Ethical Considerations

The research proposal was approved by the College of Education Ethics Committee. Participants were informed of the purpose of the study, the time commitment involved, and the procedure for maintaining confidentiality of the questionnaire responses and the examination scores. Confidentiality was maintained in the following ways: (1) No names appeared on any of the forms; (2) A number, based on the last four digits of a participant's social security number, was assigned to each participant for purposes of record keeping; (3) Access to the forms was limited to the researcher and his advisor; (4) All materials connected with the study were kept in a secure place.

A consent form was developed which reflected the purpose and significance of the study, as well as emphasising the importance of the students' participation. A guarantee of confidentiality was also included. In addition, participants were informed of the potential benefits of participation in the study. Each participant was given a copy of the consent form to read and sign prior to entering the study (Appendix A) and an extra copy to keep. Participants were encouraged to ask questions to clarify the process and were provided with an opportunity to do so. Finally, a summary of the research findings was made available to the participants upon request.

Chapter IV

Results

This chapter will comprise three parts. Firstly, the demographics of the participants will be delineated. An analysis of the three published instruments which were used will follow, as well as a description of the characteristics of the subjects, as assessed by these instruments. The second section will test the primary and secondary hypotheses listed in Chapter 1. Finally, the third section will be exploratory in nature, examining students' performance rates with respect to anxiety level in each examination condition, assessing predictors of the components of statistics anxiety and investigating students' examination preferences.

Characteristics of the Sample

The sample consisted of 26 graduate students, enrolled in either a Ph.D. program (88.5%), an Ed.D. program (7.7%), or a Masters program (3.8%). No subject attrition took place. That is, all participants completed every aspect of the study. Nineteen students (73.1%) belonged to the College of Education, whilst six students (23.1%) were enrolled in the College of Nursing, and one student (3.8%) was from the School of Public health. Of the nineteen subjects belonging to the College of Education, 32% were enrolled in Educational Research, 16% in Counselor Education, 11% each in Educational Administration, Higher Education and Curriculum Instruction Education, and 5% each in Early Childhood Education, Mathematics Education, Reading, and Education.

The students' ages ranged from 23 to 59 years, with a mean age of 40.7 years (Table 1). Sixty-two percent of the participants were over age 40. The sample comprised 21 women (81%) and 5 men (19%). This 4:1 gender ratio is representative of statistics classes taught by instructors from the College of Education.

Table 1

Means, Standard Deviations, Minimum, and Maximum Scores of the Demographic Variables

Variable	N	Mean	SD	Min	Max
Age	26	40.73	8.43	23	59
Number of College Mathematics Courses	26	4.50	7.54	0	30
Number of College Statistics Courses	26	2.69	2.89	0	13
Number of Years Since Last Mathematics Course	26	16.27	9.12	0	35
Number of Months Since Last Statistics Course	25	48.44	84.96	6	312
Midterm Examination Score	26	68.42	21.79	29	94

Although the mean number of college-level mathematics courses undertaken by the subjects was 4.5, nearly one-fourth of the total sample (23.1%) had never enrolled in a mathematics class. Only 34.6% had taken more than 2 mathematics courses. With regard to background in statistics, only 30.1% had enrolled in more than two college-level statistics courses, resulting in a mean of 2.69 classes. Subjects who had taken the most statistics classes also tended to have taken the most mathematics classes ($r = 0.61$; $p < 0.01$) and tended to be younger ($r = -0.48$; $p = 0.01$).

This finding related to age is supported by the previously cited literature in Chapter 2, which underlines the increasing emphasis on statistics in graduate programs. Seventy-seven percent of the sample had not taken a mathematics course in ten years or longer. Those subjects for whom the most time had elapsed since enrolling in their last mathematics course, not surprisingly, tended to be the oldest students ($r = 0.54$; $p < 0.01$). Sixty-two percent of the sample had taken a graduate-level statistics class in the last 12 months. However, 19% took their last statistics class more than 5 years prior to the study.

Although males and females were similar with respect to age, number of college statistics courses taken, and the number of years which had elapsed since their last mathematics and statistics courses, a pronounced difference emerged between males and females in the number of college-level mathematics courses taken (Wilcoxon statistic = 106.5; p =

0.02; effect size = 5), in favour of males (median for males = 6, median for females = 1). This finding is supported by the previously cited literature.

Finally, the majority of students (65.3%) had attained an A grade in the previous statistics course, whilst 30.8% had received a final grade of B.

Table 2 presents means, standard deviations, minimum and maximum scores of the subscales of the STARS (Statistical Anxiety Rating Scale), the ATS (Attitudes Toward Statistics), and the CSIS (Coping Strategies Inventory for Statistics). Comparing the univariate statistics for each factor of STARS in Table 2 with the percentile rank norms for graduate students as documented by the authors, it was found that the participants in the current study tended to have moderate levels of interpretation anxiety, test and class anxiety, and computation self-concept. On the other hand, the students tended to have relatively high levels of worth of statistics, fear of asking for help, and fear of statistics teachers. Indeed, using the Binomial test, it was found that a significant proportion of the participants were above the published median, with respect to worth of statistics ($p = 0.04$), fear of asking for help ($p < 0.01$), and fear of statistics teachers ($p = 0.04$), although this was not the case for interpretation anxiety ($p = 0.43$), test and class anxiety ($p = 0.16$), and computation self-concept ($p = 0.58$). A similar pattern emerged when STARS subscale scores for males and females were compared with the percentile rank norms for these populations.

Table 2

Means (Percentile Ranks), Standard Deviations, Minimum, and Maximum Scores of the Subscales of STARS, ATS, and CSIS

Instrument	N	Mean	SD	Min	Max
STARS:					
Worth of Statistics	26	30.42 (76)	10.85	16	50
Interpretation Anxiety	26	25.65 (58)	7.09	12	39
Test and Class Anxiety	26	26.04 (62)	7.74	12	37
Computation Self-Concept	26	15.54 (60)	7.91	7	34
Fear of Asking for Help	26	11.35 (83)	4.05	4	18
Fear of Statistics Teachers	26	13.15 (75)	5.26	5	25
ATS:					
Attitude Toward Field of Statistics	26	38.00	9.23	23	58
Attitude Toward Course	26	24.88	10.23	9	43
CSIS:					
Test-taking Coping Strategies	26	127.35	21.45	86	173
Study Coping Strategies	26	117.12	24.52	66	154

The total scores of the study coping strategies subscale revealed that 10 students (38.5%) had very high levels of coping strategies (i.e. obtained a total score greater than 129), 6 students (23.1%) needed remediation in certain areas (i.e. obtained a total score between 110 and 129, inclusive), and 10 students (38.5%) needed training in the use of study coping strategies (i.e. obtained a score below 110). With respect to examination-taking coping strategies, 12 students (46.2%) had very high levels, 9 students (34.6%) needed remediation in certain areas, and 5 students (19.2%) needed training in the use of examination-taking coping strategies. Using the Spearman rank-order correlation coefficient, which utilises the fact that the participants can be ranked on both the study coping and examination-taking coping strategies, no association between the category of examination-taking coping strategies and study coping strategies can be inferred to the population (Spearman $r_s = 0.29$; $p = 0.15$).

Descriptive statistics for the sample broken down by gender for the subscales used in the study are shown in Table 3. It can be seen that female subjects consistently reported higher levels of anxiety in all dimensions. Similarly, females expressed more negative attitudes towards the field of statistics and the course than did males (high scores on the ATS represent negative attitudes). With respect to coping strategies, whilst females exhibited better study coping strategies than did males, the reverse was true for examination-taking coping strategies. However, the only pronounced difference which existed between males and females was with respect to interpretation anxiety, with females reporting higher levels ($p < 0.05$).

The reliability coefficients of the subscales of STARS, ATS, and CSIS pertaining to the study are reported in Table 4.

Table 3

Means, Standard Deviations by Sex, and Wilcoxon t-Values of the Subscales of STARS, ATS, and CSIS

Instrument	Females (n=21) Median	Males (n=5) Median	Wilcoxon t-Values	P-Values
STARS:				
Worth of Statistics	28	27	49.5	0.26
Interpretation Anxiety	27	21	33.0	0.04
Test and Class Anxiety	27	21	42.0	0.10
Computation Self-Concept	16	10	45.5	0.17
Fear of Asking for Help	11	8	45.0	0.16
Fear of Statistics Teachers	15	8	48.0	0.23
ATS:				
Attitude Toward Field of Statistics	38	32	49.5	0.25
Attitude Toward Course	27	18	38.0	0.07
CSIS:				
Examination-taking Coping Strategies	124	131	66.0	0.95
Study Coping Strategies	122	113	69.0	0.95

Table 4

Reliability Coefficients (Coefficient Alpha) of the Subscales of STARS, ATS, and CSIS: Current Study and Original Author's

Instrument	Current Study		Author's	
	N	Reliability Coefficient (Alpha)	N	Reliability Coefficient (Alpha)
STARS:				
Worth of Statistics	26	0.915	1150	0.940
Interpretation Anxiety	26	0.819	1150	0.887
Test and Class Anxiety	26	0.898	1150	0.678
Computation Self-Concept	26	0.929	1150	0.876
Fear of Asking for Help	26	0.831	1150	0.848
Fear of Statistics Teachers	26	0.848	1150	0.799
Total STARS	26	0.959		
ATS:				
Attitude Toward Field of Statistics	26	0.892	92	0.920
Attitude Toward Course	26	0.939	92	0.900
Total ATS	26	0.943		
CSIS:				
Test-taking Coping Skills	26	0.766	117	0.806
Study Coping Skills	26	0.775	117	0.792
Total CSIS	26	0.850	117	0.882

As can be seen, these reliabilities correspond closely to those reported by their authors, and as such, are satisfactory.

In order to test the significance of the intercorrelations of subscales, Bonferroni critical t-values were used to hold the Type I error rate constant for multiple t-tests. Using this adjustment, seven out of the fifteen intercorrelations were significant (Table 5).

Table 5

Intercorrelations Between Subscales of STARS (n=26)

Subscale	2	3	4	5	6
1. Worth of Statistics	.71*	.37	.76*	.70*	.66*
2. Interpretation Anxiety	-	.52	.57*	.51	.39
3. Test and Class Anxiety		-	.42	.38	.30
4. Computation Self-concept			-	.62*	.54
5. Fear of Asking for Help				-	.56*
6. Fear of Stats Teachers					-

* significance reached after maintaining a family-wise error of 5% using the Bonferroni Adjustment

The two subscales of the CSIS, namely, examination-taking coping strategies and study coping strategies were significantly correlated ($r = 0.44$, $p = 0.03$). The correlation between attitude towards the field of statistics and attitude towards the course was also significant ($r = 0.79$, $p < 0.01$).

Equivalence of Examination Groups

A series of t-tests was performed, in order to ascertain the effectiveness of random assignment of the participants in equating the examination groups with respect to the demographic variables. Results of this analysis are presented in Table 6. There was no evidence to suggest that the groups were heterogeneous with respect to age ($p = 0.87$), number of college-level mathematics courses taken ($p = 0.08$), number of college-level statistics courses taken ($p = 0.11$), number of years elapsed since a student's previous mathematics course ($p = 0.57$), final grade in a previous statistics class ($p = 0.64$), worth of statistics ($p = 0.56$), interpretation anxiety ($p = 0.73$), class and test anxiety ($p = 0.1523$), computation self-concept ($p = 0.77$), fear of asking for help ($p = 0.81$), fear of statistics teachers ($p = 0.10$), attitude towards the field of statistics ($p = 0.71$), attitude towards the course ($p = 0.53$), study-coping strategies ($p = 0.45$), examination-taking coping strategies ($p = 0.81$), sex composition ($p = 0.99$), preference for timed examinations ($p = 0.28$), preference for untimed examinations ($p = 0.53$), preference for examinations with supporting material limited to a specific number of pages ($p = 0.37$), and the midterm examination ($p = 0.59$).

It should be pointed out that, although the difference between the timed and untimed examination groups, with respect to the mean number of college-level mathematics and statistics courses, was not significant, a discrepancy existed between the respective means, in favour of the timed examination group. This discrepancy is mainly due to the fact that, in the timed examination group, one student had taken 30 college-

Table 6

<u>Means, Standard Deviations by Experimental Group, and t-Values of Pre-measures</u>

	Timed Group (n=13)	Untimed Group (n=13)		
Pre-Measures	Mean (SD)	Mean (SD)	t	P-Values
Age	40.46 (7.55)	41.00 (9.53)	-0.16	0.87
Number of College-Level Mathematics Courses	7.23 (10.05)	1.77 (1.17)	1.95	0.08
Number of College-Level Statistics Courses	3.62 (3.73)	1.77 (1.30)	1.69	0.11
Number of Years Since Last Mathematics Course	17.31 (10.14)	15.23 (8.27)	0.57	0.57
Final Grade in Previous Statistics Class	3.77 (0.33)	3.67 (0.69)	0.47	0.64
Worth of Statistics	29.15 (0.56)	31.69 (9.04)	-0.59	0.56
Interpretation Anxiety	25.15 (8.88)	26.15 (5.03)	-0.35	0.73
Class and Test Anxiety	28.23 (7.63)	23.85 (7.49)	1.48	0.15
Computation Self-Concept	15.08 (9.85)	16.00 (5.72)	-0.29	0.77
Fear of Asking for Help	11.15 (4.02)	11.54 (4.23)	-0.24	0.81
Fear of Statistics Teachers	11.46 (5.09)	14.85 (5.05)	-1.70	0.10

Table 6 Contd ....

Means, Standard Deviations by Experimental Group, and t-Values of Pre-measures

Pre-Measures	Timed Group (n=13) Mean (SD)	Untimed Group (n=13) Mean (SD)	t	P-Values
Attitude Toward Field of Statistics	38.69 (11.68)	37.31 (6.30)	0.38	0.71
Attitude Toward Course	23.69 (11.73)	26.08 (8.79)	-0.59	0.56
Study-Coping Skills	113.4 (26.74)	120.9 (22.51)	-0.77	0.45
Test-Taking Coping Skills	126.3 (25.33)	128.4 (17.74)	-0.24	0.81
Preference for Timed Examinations	6.92 (1.98)	6.00 (2.45)	1.06	0.30
Preference for Untimed Examinations	9.38 (1.66)	10.00 (1.63)	-0.95	0.35
Preference for Examinations With Supporting Material Limited to a Few Pages	5.69 (2.06)	6.38 (1.39)	-1.01	0.33
Midterm Examination	66.08 (22.75)	70.77 (21.44)	-0.54	0.59

level mathematics and 13 college-level statistics courses--much more than any other participant in the study. However, this finding is not considered a cause for concern, since the number of mathematics and statistics courses were not considered to be important variables, with respect to testing the major hypotheses. Indeed, the more important variables of prior achievement and the components of statistics anxiety were very similar across groups.

The above findings strongly indicate that no systematic differences existed between the two groups, as a result of the randomisation process, thereby increasing the validity of the results.

Tests of Hypotheses

Analysis of covariance (ANCOVA) was performed, including both statistics test anxiety and treatment condition in the model simultaneously. To lend power to the analysis, statistics test anxiety was not categorised. The midterm score was used as a covariate. As was noted earlier, no difference in mean midterm scores between the two examination conditions can be inferred to the population ($t = -0.54$; $p = 0.59$). This result is encouraging since, if groups had differed significantly on the covariate, the ability of ANCOVA to adjust effectively for this would have been limited (Campbell & Erlebacher, 1975). In order to check the assumption that the midterm scores were linearly related to the final examination scores, partial correlations (adjusted for examination condition) based on the pooled variance estimate were computed. The residuals of the midterm scores, after partialling out examination condition, were linearly related to the final examination scores ($r = 0.88$, $p < 0.01$), providing justification for using the midterm scores as a covariate.

An important assumption in justifying use of ANCOVA was that the results were not confounded by any three-way or two-way interactions which were not of interest. In order to assess the feasibility of this assumption, all interactions were placed in the model and then removed in a stepwise manner. Neither the three-way interaction (examination condition x statistics test anxiety x midterm), nor the two-way interactions (statistics test anxiety x midterm, examination condition x midterm) were significant. Therefore, these interactions were dropped from the final ANCOVA model. The result that the two-way interactions which involved the covariate (i.e., statistics test anxiety x midterm and examination condition x midterm) were not significant, lends support to the assumption of homogeneity of regression.

Null Hypothesis One

H_1: There is no interaction between the level of statistics test anxiety and the examination condition, after adjusting for statistics prior achievement.

From Table 7, it can be seen that there is a significant anxiety by group interaction effect, $F(1, 21) = 8.12$, $p < 0.01$. In other words, examination condition appears to have differential effects for different anxiety levels. The squared partial correlation (P^2) and squared semi-partial correlation (SP^2) of 0.28 and 0.05, respectively, represent a moderate association.

Table 7

Summary ANCOVA for Dependent Variable (Final Score), Independent Variables (Examination Condition, Test Anxiety) and Covariate (Midterm)

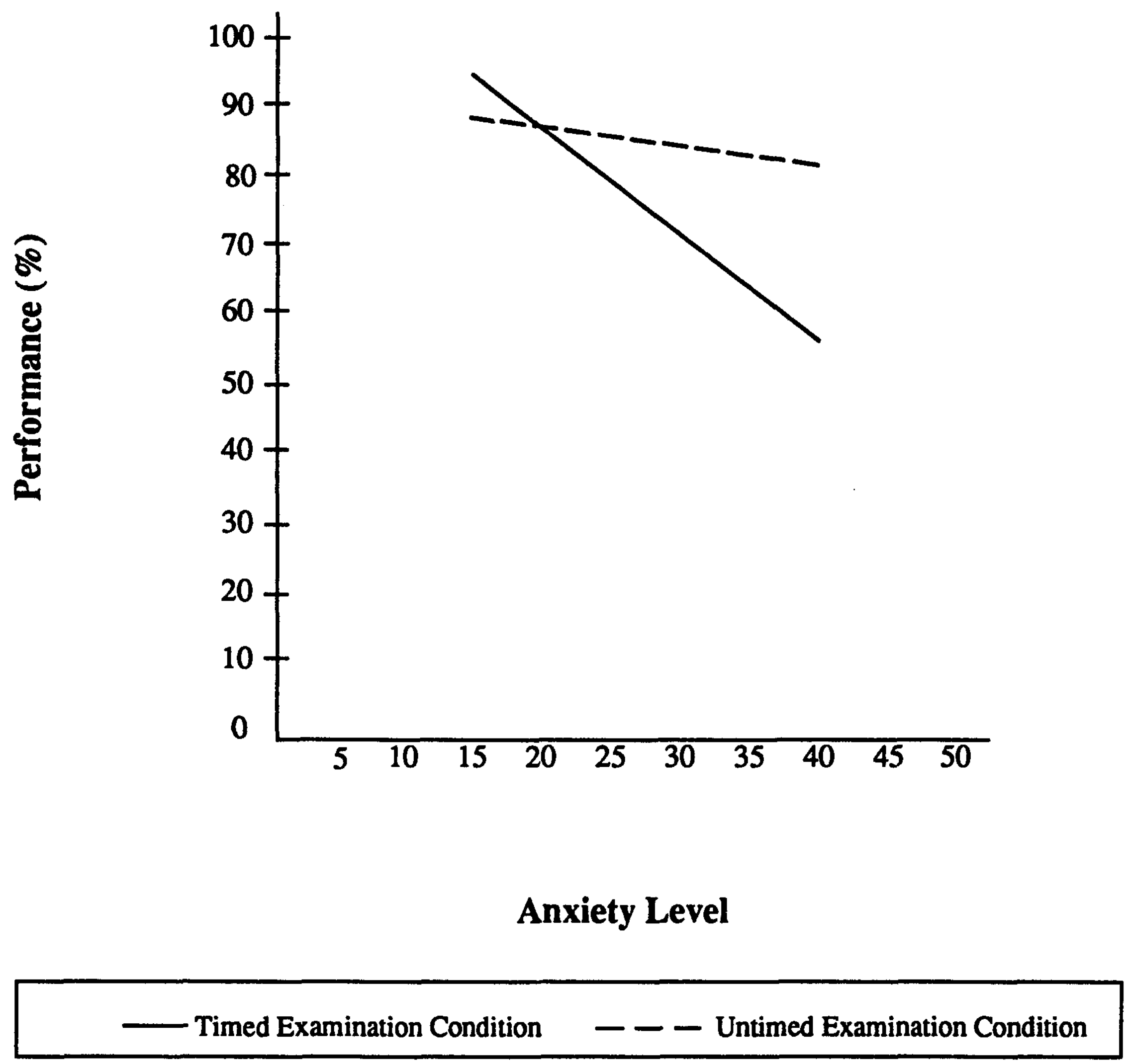
Source	SS	DF	MS	F	P-Value	SP^2	P^2
Group	310.19	1	310.19	4.65	0.04*	0.03	0.18
Anxiety	367.96	1	367.96	5.51	0.03*	0.01	0.08
Group x Anxiety	541.52	1	541.52	8.12	<.01**	0.05	0.28
Midterm	4913.92	1	4913.92	73.64	<.01**		
Error	1401.25	21	66.73				

* $p < 0.05$
** $p < 0.01$

In order to explore this interaction, the Pearson correlation coefficients between statistics test anxiety and statistics achievement were calculated separately by treatment group. The results suggest that the relationship between test anxiety and achievement was stronger for the timed examination group, $r(13) = -0.83$, than for the untimed examination group $r(13) = -0.22$. The power table of Cohen (1988, p. 119) was used to determine the power of the test that these correlations are equal. Setting a one-tailed significance criterion of 0.05, with a sample size of 13 per group, it was found that this hypothesis test represents a power of 0.72, which suggests relatively high power.

As can be seen in Figure 1, students with high levels of

Figure 1. Statistics Performance as a Function of Statistics Test Anxiety and Examination Condition, Adjusted for Statistics Prior Achievement.



statistics test anxiety tended to perform much better under untimed conditions than did their counterparts with high anxiety, who completed the examination under timed conditions. On the other hand, such strong optimising effects were not apparent with low anxious students.

Null Hypothesis Two

H_2: There is no relationship between the level of statistics test anxiety and statistics achievement across treatment groups after adjusting for statistics prior achievement.

An inspection of the ANCOVA in Table 7 shows a significant relationship between statistics test anxiety and statistics achievement, after adjusting for the covariate, $F(1, 21) = 5.51$, $p = 0.03$. However, the squared partial correlation and squared semi-partial correlation of 0.08 and 0.01, respectively, suggest a small association, after removing other effects in the model. Calculation of the Pearson product moment correlation revealed an inverse relationship between anxiety and achievement, $r(26) = -0.57$. Thus, it can be inferred that, in general, as the level of statistics test anxiety increases, the level of statistics performance decreases. The power of the test of the significance of this correlation, with 26 subjects, is approximately 0.92 (Cohen, 1988, p.86).

Null Hypothesis Three

H_3: There is no difference in statistics achievement between students examined under time constraints and students examined under no time limits, after adjusting for statistics prior achievement.

A summary of the adjusted means of the final examination is presented in Table 8. It can be noted that the adjusted mean of the untimed examination group (76.23) was significantly higher than that of the timed examination group (69.40). The effect size was defined as the number of pooled standard deviations between the scores of the two examination groups being compared (Cohen, 1988, p.20). An effect size of 0.84 was computed using the mean square error (66.73) in Table 7.

Table 8

Adjusted Final Examination Means

Group	Adjusted Mean	Std Error
Timed	69.40	2.40
Untimed	76.23	2.38

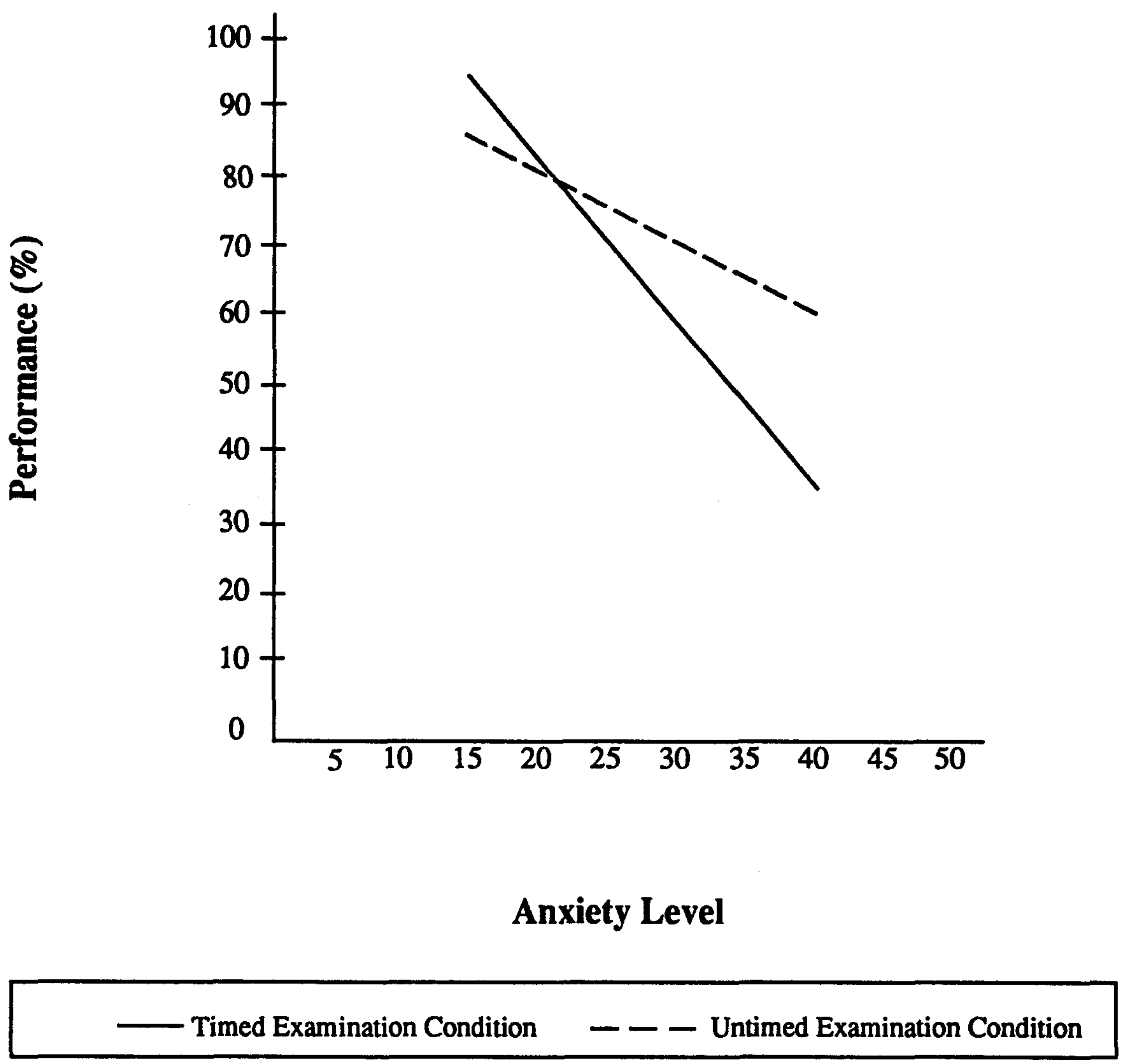
Using a mean square error (442.93) from a reduced model which only includes the group factor, gave an effect size of 0.32. This latter value, which is perhaps more appropriate and which suggests a moderate effect, depicts a difference of about 7% between the timed and untimed examination groups. The squared partial correlation and squared semi-partial correlation for this main effect are 0.18 and 0.03, respectively, which also suggest a moderate association. With respect to the statistics course under study, this adjusted mean difference could represent a change of up to a whole letter grade. Therefore, there is evidence to suggest that relaxing the time limits in a statistics examination enhances students' achievement. With a sample size of 26, the power for detecting the above difference of seven percentage points is 0.82. This represents reasonably high power.

A series of ANCOVAs was performed which tested the relationship between statistics achievement and the other five components of statistics anxiety measured in this study (after adjusting for statistics prior achievement). That is, five additional ANCOVA models were tested, using statistics achievement as the dependent variable, and prior achievement as the covariate, whilst replacing statistics test anxiety by worth of statistics, interpretation anxiety, computation self-concept, fear of asking for help, and fear of statistics teachers, in turn. These models indicated no relationship between statistics achievement and each of the five components of statistics anxiety, suggesting similar levels of worth of statistics ($p = 0.75$), interpretation anxiety ($p = 0.92$), computation self-concept ($p = 0.54$), fear of asking for help ($p = 0.58$), and fear of statistics teachers ($p = 0.51$) across treatment groups. In addition, of these components, only interpretation anxiety significantly interacted with examination condition in determining statistics achievement ($p < 0.05$, $P^2 = 0.14$, $SP^2 = 0.09$). It should be pointed out that statistics anxiety, comprising the above six dimensions, did not interact with treatment group.

Female Subjects

It was also of interest to investigate the finding of Plass and Hill (1979) that there were no optimising effects for high test-anxious females. An additional analysis, of female subjects only, led to findings which were consistent with those reported for the full sample, in relation to the optimising effects of the untimed examination condition (Figure 2). There was a significant interaction between statistics test anxiety and examination condition, $F(1, 16) = 452.92$, $p = 0.03$. The semi-partial and partial correlations ($SP^2 = 0.04$, $P^2 = 0.27$), indicated a moderate association. A follow-up analysis revealed that the relationship between statistics test anxiety and achievement was stronger for females in the timed examination group, $r(10) = -0.82$, than for females in the untimed group, $r(11) = -0.32$. Thus, as with the total sample, strong optimising effects were obtained for females in the untimed examination condition, in which high test anxious females performed as well as or better than low test-anxious females, as can be seen in Figure 2. ANCOVA could not be performed on male subjects due to the small number of males in the study.

__Figure 2__. **Statistics Performance of Female Subjects as a Function of Statistics Test Anxiety and Examination Condition, Adjusted for Statistics Prior Achievement.**



Null Hypothesis Four

H_4: There is no interaction between examination completion time and the level of statistics test anxiety, within each examination condition, after adjusting for statistics prior achievement.

Although there was no interaction between examination completion time and statistics test anxiety for the untimed examination group, $F(1, 8) = 0.70$, $p = 0.43$, such an effect was apparent for the timed examination group, $F(1, 8) = 6.74$, $p < 0.05$ (Table 9). This interaction is illustrated in Figure 3. The squared partial correlation and squared semi-partial correlation of 0.46 and 0.05, respectively, suggest a moderate effect. It should be pointed out that, for this analysis, the anxiety levels were dichotomised as high or low, by partitioning the anxiety distribution into halves (i.e. above and below the median.) It should be pointed out that, as required, none of the two-way or three-way interactions which involved the covariate were significant, suggesting homogeneity of regression. A follow-up analysis revealed that, for the timed examination group, the correlation between examination completion time and performance was stronger for high-anxious students, $r(7) = 0.38$, than for low-anxious students, $r(6) = 0.09$.

Of particular interest was the finding that in the timed examination group, although high-anxious students had a mean completion time (mean time = 81.43 minutes) which was similar

Table 9

Summary ANCOVA for Dependent Variable (Final Score), Independent Variables (Examination Completion Time, Test Anxiety) and Covariate (Midterm) in each Examination Condition

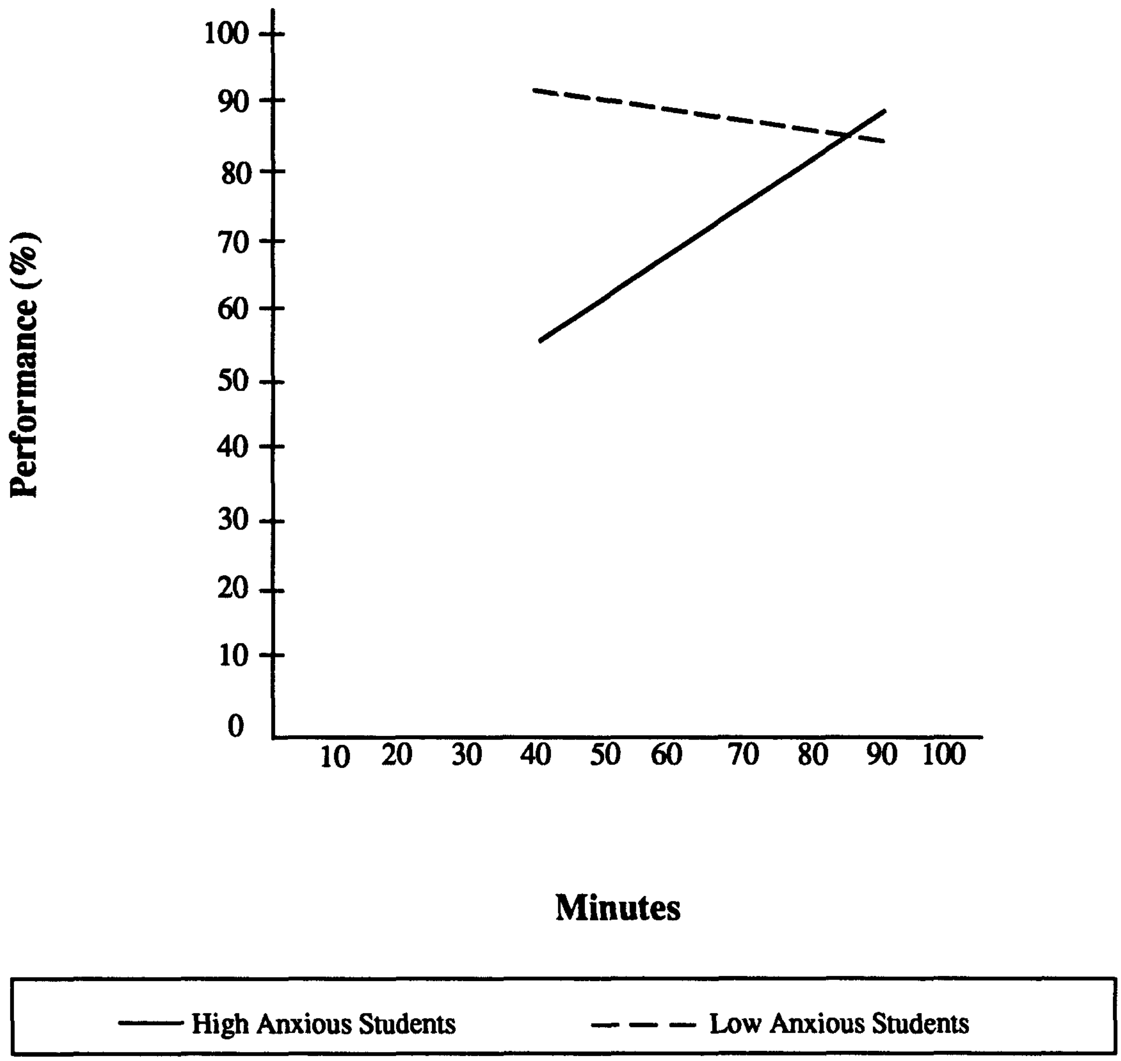
Timed Condition							
Source	SS	DF	MS	F	P-Value	SP^2	P^2
Time	30.94	1	30.94	0.67	0.44		
Time x Anxiety[a]	309.37	1	309.37	6.74	0.03*	0.05	0.46
Midterm	2238.77	1	2238.77	48.76	< .01**		
Error	367.33	8	45.92				
Untimed Condition							
Source	SS	DF	MS	F	P-Value		
Time	45.13	1	45.13	0.42	0.54		
Time x Anxiety[a]	75.54	1	75.54	0.70	0.43		
Midterm	3495.72	1	3495.72	32.53	< .01**		
Error	859.59	8	107.45				

[a] anxiety levels are -: 0 = low anxiety
1 = high anxiety

* $p < 0.05$
** $p < 0.01$

to that of low-anxious students (mean time = 78.83 minutes), there was a discrepancy between performance levels, with low-anxious subjects (mean score = 83.50) outperforming high-anxious subjects (mean score = 53.57). On the other hand, in the untimed examination condition, high anxious students (mean time = 103.86 minutes) completed the examination about as

Figure 3. Statistics Performance of Timed Examination Group as a Function of Statistics Test Anxiety and Examination Completion Time, Adjusted for Statistics Prior Achievement.



quickly as low anxious students (mean time = 106.17 minutes). However, at the same time, high-anxious students (mean score = 75.29) had similar performance levels to low-anxious students (mean score = 75.67).

An analysis of performance rates revealed no relationship between examination completion time and statistics performance, for either the timed examination group, $F(1, 8) = 0.67$, $p = 0.44$, or the untimed examination group, $F(1, 8) = 0.42$, $p = 0.54$ (Table 9). This finding is in agreement with previously cited literature.

Null Hypothesis Five

H_5: There is no relationship between the level of study coping strategies and the level of statistics anxiety.

Calculation of the Pearson product moment correlation revealed a negative relationship between statistics anxiety and study-coping strategies, $r(26) = -0.39$, $p < 0.05$. Thus H_5 is rejected. The criteria set by Cohen (1988, p.83), suggests that the effect size (r^2) of 0.15 is moderate.

Null Hypothesis Six

H_6: There is no relationship between the level of examination-taking coping strategies and the level of statistics anxiety.

An inverse relationship was found between examination-taking coping strategies and statistics anxiety, $r(26) = -0.65$, $p < 0.01$. Thus H_6 is rejected. The effect size of 0.42 is large.

Null Hypothesis Seven

H_7: There is no relationship between a students' attitude towards the field of statistics and the level of statistics anxiety.

A negative relationship was revealed between attitude towards the field of statistics and statistics anxiety, $r(26) = -0.82$, $p < 0.01$. Thus H_7 is rejected. The effect size of 0.67 is very large.

Null Hypothesis Eight

H_8: There is no relationship between a student's attitude towards the course and the level of statistics anxiety.

A negative relationship was found between attitude towards the course and statistics anxiety, $r(26) = -0.86$, $p < 0.01$. Thus H_8 is rejected. The effect size of 0.74 is very large.

Null Hypothesis Nine

H_9: There is no relationship between the number of years which have elapsed since a student's previous mathematics course and the level of statistics anxiety.

A positive relationship was found between the number of years which have elapsed since a student's previous mathematics course and the level of statistics anxiety, $r(26) = 0.42$, $p = 0.03$. Thus H_9 is rejected. The effect size of 0.19 is moderate.

Null Hypothesis Ten

H_{10}: There is no relationship between the number of mathematics courses completed by a student and the level of statistics anxiety.

A negative relationship between the number of mathematics courses completed by a student and the level of statistics anxiety was found, $r(26) = -0.61$, $p < 0.01$. Thus H_{10} is rejected. The effect size of 0.37 is large.

Null Hypothesis Eleven

H_{11}: There is no relationship between the number of statistics courses completed by a student and the level of statistics anxiety.

A negative relationship between the number of statistics courses completed by a student and the level of statistics anxiety was found, $r(26) = -0.45$, $p = 0.02$. Thus H_{11} is rejected. The effect size of 0.20 is moderate.

Null Hypothesis Twelve

H_{12}: There is no relationship between level of achievement in a previous statistics course and the level of statistics anxiety.

Results indicated that no relationship between a student's level of achievement in a previous statistics course and statistics anxiety can be inferred to the population, $r(25) = -0.12$, $p = 0.57$.

Exploratory Analyses

Examination Completion Time

In order to investigate the rate by performance patterns of the anxiety groups within both examination conditions, the number of students of each anxiety level in each condition who completed the examination at a fast or slow rate and a high or low level of performance, were analysed.

It can be seen from the top half of Table 10 that, under the timed examination condition, nearly all the low-anxious students (85.7%) had a high level of performance, although they were almost equally distributed with respect to examination completion rate. The high-anxious students showed a slight tendency to work at a slow rate (66.7%) and to perform at a low level (83.3%). Thus the timed condition was characterised by low-anxious students who performed either at a fast and accurate level, or at a slow and accurate level, and high-anxious students who performed at a slow inaccurate level.

As can also be seen from the bottom half of Table 10, in the untimed examination condition, there was a slight tendency for low-anxious students to perform at a slow rate (66.7%), either at an accurate (50%) or an inaccurate level (50%). With respect to high anxious students in this untimed condition, there was a slight tendency for them to perform at a fast rate (66.7%) with a better rate of accuracy (42.9%) than their high-anxious counterparts in the timed examination condition. Thus, the untimed examination group was characterised by low-anxious students who were, in general, either slow and accurate or slow and inaccurate, and by high-

Table 10

Rate x Performance Distributions for each Test Anxiety Group in each Examination Condition

Timed Condition				
	Low Anxious (N=7) Rate		High Anxious (N=6) Rate	
Performance	Fast	Slow	Fast	Slow
High	3	3	0	1
Low	1	0	2	3
Untimed Condition				
	Low Anxious (N=6) Rate		High Anxious (N=7) Rate	
Performance	Fast	Slow	Fast	Slow
High	2	1	1	2
Low	0	3	3	1

anxious students who were either fast and accurate or fast and inaccurate.

Antecedent Correlates of the Components of Statistics Anxiety

Multiple regression analysis was used to determine the relationship between the anxiety components and the demographic variables. The technique of least squares was used to estimate the regression coefficients in all the models which were fitted. More specifically, a setwise regression was utilised as an exploratory tool, in order to select an optimal subset of variables in terms of maximum R^2. All possible models with five variables or less were examined, in order to ensure that the bare minimum requirement of five subjects for every independent variable was maintained (Tabachnick & Fidell, 1989, p. 129).

Worth of Statistics

The first setwise regression analysis performed, used students' perception of the relevance of statistics as the dependent variable. Table 11 displays the unstandardised regression coefficients (B) and intercept, the standard error of the unstandardised coefficients, the standardised regression coefficients (β), the semi-partial correlations (SP^2), the variance inflation factor (VIF), the root mean square error, the multiple correlation (R), the squared multiple correlation (R^2), and the adjusted squared multiple correlation (adjusted R^2), of the chosen model.

Of the demographic variables analysed, only three contributed significantly to the prediction of a student's perception of the relevance of statistics. These were attitude towards the field of statistics ($t = 7.65$, $p < 0.01$), number of college-level mathematics courses taken ($t = -2.66$, $p < 0.05$) and study coping strategies ($t = -2.19$, $p < 0.05$).

Table 11

Standard Multiple Regression of Demographic Variables on Worth of Statistics

Variable	Regression Coefficient (B)	Standard Error	t-value	Standardised Regression Coefficients (β)	Semi-Partial Squared (SP^2)	Variance Inflation Factor (VIF)
INTERCEPT	9.17	7.37	1.24	0.00		
FIELD	0.86	0.11	7.65**	0.73	0.42	1.29
NUMMATH	-0.35	0.13	-2.66*	-0.24	0.05	1.17
STUDY	-0.09	0.04	-2.19*	-0.19	0.03	1.11

* $p < 0.05$
** $p < 0.01$

$R^2 = 0.85$
adjusted $R^2 = 0.83$
$R = 0.92$
$S = 20.34$

FIELD = Attitude Toward Field of Statistics

NUMMATH = Number of College Mathematics Courses

STUDY = Study Coping Strategies

These variables combined, produced an R^2 of 0.85 (adjusted R^2 = 0.83), $F(3, 22) = 40.93$, $p < 0.001$. When the semi-partial correlation coefficient was used to assess impact, the variable with by far the greatest effect was attitude towards the field of statistics ($SP^2 = 0.42$), followed by number of college-level mathematics courses taken ($SP^2 = 0.05$) and study coping strategies ($SP^2 = 0.03$). The variance inflation factors (Table 11) do not suggest that multicollinearity is severe enough to have damaged the precision of the estimation of the coefficients in the model.

Addition of gender, the next most important variable, to the three-variable model, had a nonsignificant impact ($p = 0.34$) and increased R^2 by only 0.66%, whilst, at the same time, increasing the error variance by 0.19%. Thus, students who reported more negative attitudes towards the field of statistics, had taken less college-level mathematics courses, and were assessed as having less adequate study coping strategies, were more likely to deem statistics less relevant.

<u>Interpretation Anxiety</u>

Only two variables made statistically significant contributions to the prediction of interpretation anxiety (Table 12). These two variables, in order of importance were, examination-taking coping strategies ($t = -3.76$, $p < 0.01$, $SP^2 = 0.30$) and gender ($t = 3.16$, $p < 0.01$, $SP^2 = 0.21$). When these variables were combined, they produced an R^2 of 0.51 (adjusted $R^2 = 0.47$), which was significant, $F(2, 23) = 11.87$, $p < 0.001$.

The addition of the number of college-level mathematics courses to the model ($p = 0.07$) only increased the explanatory

Table 12

Standard Multiple Regression of Demographic Variables on Interpretation Anxiety

Variable	Regression Coefficient (B)	Standard Error	t-value	Standardised Regression Coefficients (β)	Semi-Partial Squared (SP^2)	Variance Inflation Factor (VIF)
INTERCEPT	42.25	6.55	6.45**	0.00		
EXAMCOP	-0.18	0.05	-3.76**	-0.55	0.30	1.00
GENDER	8.16	2.58	3.16**	0.46	0.21	1.00

* $p < 0.05$
** $p < 0.01$

$R^2 = 0.51$
adjusted $R^2 = 0.47$
$R = 0.71$
$S = 26.91$

EXAMCOP = Examination-taking Coping Strategies

GENDER = Sex of Participant

power by 6.61%. Multicollinearity did not seem to be a threat to the model. Consequently, female students who were assessed as having less adequate examination-taking coping strategies tended to have higher levels of interpretation anxiety.

Test and Class Anxiety

The two variables which predicted level of interpretation anxiety also predicted test and class anxiety, $F(2, 23) = 6.26$, $p < 0.01$. As before, examination-taking coping strategies was the best predictor ($t = -2.90$, $p < 0.01$, $SP^2 = 0.24$), followed by gender ($t = 2.06$, $p < 0.05$, $SP^2 = 0.12$), as can be seen in Table 13. The coefficients of multiple variation indicated that these variables combined accounted for 35% of the variability in test and class anxiety (adjusted $R^2 = 0.29$). The addition of age ($p = 0.16$) added only 5.8% to the explanatory power of the model. Thus, female students who were assessed as having less adequate examination-taking coping strategies tended to have higher levels of test and class anxiety.

Table 13

Standard Multiple Regression of Demographic Variables on Test and Class Anxiety

Variable	Regression Coefficient (B)	Standard Error	t-value	Standardised Regression Coefficients (β)	Semi-Partial Squared (SP^2)	Variance Inflation Factor (VIF)
INTERCEPT	43.05	8.21	5.25**	0.00		
EXAMCOP	-0.18	0.06	-2.90**	-0.49	0.24	1.00
GENDER	6.65	3.23	2.06*	0.35	0.12	1.00

* $p < 0.05$
** $p < 0.01$

$R^2 = 0.35$
adjusted $R^2 = 0.29$
$R = 0.59$
$S = 42.25$

EXAMCOP = Examination-taking Coping Strategies

GENDER = Sex of Participant

Computation Self-Concept

Attitude towards the course was the only variable which contributed significantly to the explanation of computation self-concept, $F(1, 24) = 43.65$, $p < 0.001$, $R^2 = 0.65$, adjusted $R^2 = 0.63$ (Table 14). Attitude towards the field of statistics did not enter significantly into the model ($p = 0.13$), and indeed, increased R^2 by only 5.52%. Thus, it appears that students with the most negative attitudes towards the course tended to experience the highest levels of anxiety during problem-solving.

Table 14

Standard Multiple Regression of Demographic Variables on Computation Self-Concept

Variable	Regression Coefficient (B)	Standard Error	t-value	Standardised Regression Coefficients (β)	Semi-Partial Squared (SP^2)	Variance Inflation Factor (VIF)
INTERCEPT	0.09	2.52	0.03	0.00		
COURSE	0.62	0.09	6.61**	0.80	0.65	1.00

* $p < 0.05$
** $p < 0.01$

$R^2 = 0.65$
adjusted $R^2 = 0.63$
$R = 0.80$
$S = 23.09$

COURSE = Attitude Toward Course

Fear of Asking for Help

The model which best explained the anxiety experienced by students when asking for help contained two variables: attitude towards the course ($t = 4.98$, $p < 0.01$, $SP^2 = 0.46$)

and study coping strategies ($t = -1.73$, $p = 0.10$, $SP^2 = 0.06$). This model accounted for 57% of the variation (adjusted $R^2 = 0.53$), $F(2, 23) = 15.29$, $p < 0.001$ (Table 15). When age was added to the model, an increase in R^2 of only 0.59% ensued. Consequently, it appears that students with the most negative attitudes towards the course and who had the least adequate study coping strategies tended to be most afraid of asking for help from a fellow student or from the instructor.

Table 15

Standard Multiple Regression of Demographic Variables on Fear of Asking for Help

Variable	Regression Coefficient (B)	Standard Error	t-value	Standardised Regression Coefficients (β)	Semi-Partial Squared (SP^2)	Variance Inflation Factor (VIF)
INTERCEPT	9.18	3.19	2.88**	0.00		
COURSE	0.27	0.05	4.98**	0.69	0.46	1.02
STUDY	-0.04	0.02	-1.73	-0.24	0.06	1.02

* $p < 0.05$
** $p < 0.01$

$R^2 = 0.57$
adjusted $R^2 = 0.53$
$R = 0.76$
$S = 7.65$

COURSE = Attitude Toward Course
STUDY = Study Coping Strategies

Fear of Statistics Teachers

An examination of Table 16 shows that attitude towards the course ($t = 3.74$, $p < 0.01$, $SP^2 = 0.34$) and study coping strategies ($t = -1.57$, $p = 0.13$, $SP^2 = 0.06$) accounted for 44% of the variation in the explanation of student's perception of the statistics teacher (adjusted $R^2 = 0.40$; $F(2, 23) = 9.15$, $p = 0.001$). Thus, students with the most negative attitudes towards the course and who had the least adequate study coping strategies tended to be most afraid of statistics teachers.

Table 16

Standard Multiple Regression of Demographic Variables on Fear of Statistics Teachers

Variable	Regression Coefficient (B)	Standard Error	t-value	Standardised Regression Coefficients (β)	Semi-Partial Squared (SP^2)	Variance Inflation Factor (VIF)
INTERCEPT	11.83	4.72	2.51*	0.00		
COURSE	0.30	0.08	3.74**	0.59	0.34	1.02
STUDY	-0.05	0.03	-1.57	-0.25	0.06	1.02

* $p < 0.05$
** $p < 0.01$

$R^2 = 0.44$
adjusted $R^2 = 0.40$
$R = 0.67$
$S = 16.74$

COURSE = Attitude Toward Course

STUDY = Study Coping Strategies

Statistics Anxiety

The results of the regression analysis in Table 17 indicate that 87% of the variance in statistics anxiety (obtained by combining the above six dimensions) is accounted for by four correlates (adjusted $R^2 = 0.84$; $F(4, 21) = 34.59$,

$p < 0.0001$). These variables, in order of importance, were: attitude towards the course ($t = 3.04$, $p < 0.01$, $SP^2 = 0.06$), study coping strategies ($t = -2.8$, $p < 0.05$, $SP^2 = 0.05$), number of college-level mathematics courses taken ($t = -2.33$, $p < 0.05$, $SP^2 = 0.03$), and attitude towards the field of statistics ($t = 2.16$, $p < 0.05$, $SP^2 = 0.03$). Thus, those

Table 17

Standard Multiple Regression of Demographic Variables on Statistics Anxiety

Variable	Regression Coefficient (B)	Standard Error	t-value	Standardised Regression Coefficients (β)	Semi-Partial Squared (SP^2)	Variance Inflation Factor (VIF)
INTERCEPT	85.59	22.29	3.84**	0.00		
COURSE	1.53	0.50	3.04**	0.46	0.06	3.62
STUDY	-0.33	0.12	-2.80*	-0.24	0.05	1.14
NUMMATH	-1.04	0.45	-2.33*	-0.23	0.03	1.56
FIELD	1.09	0.51	2.16*	0.30	0.03	3.03

* $p < 0.05$
** $p < 0.01$

$R^2 = 0.87$
adjusted $R^2 = 0.84$
$R = 0.93$
$S = 13.50$

COURSE = Attitude Toward Course

STUDY = Study Coping Strategies

NUMMATH = Number of College Mathematics Courses

FIELD = Attitude Toward Field of Statistics

students who expressed the most negative attitudes towards the course, who had the least adequate study coping strategies, who had taken the least number of college-level mathematics courses, and who had the most negative attitudes towards the field of statistics, tended to experience the highest levels of statistics anxiety.

Preferred Assessment Style Scale (PASS)

PASS - Preference

PASS was used to survey the types of examinations utilised in college-level statistics courses. The results, with respect to the fourteen different types of examinations (A-N), based on a Likert-type scale of preference for each item (1 = strong dislike, 5 = strong preference), are summarised in Table 18.

It is clear that "a take home examination" (type H, "take-home") and "an untimed in-class examination with unlimited supporting material" (type D, "untimed-unlimited") were by far the most preferred methods of assessment. Students consistently expressed either a preference or a strong preference for these methods of assessment (92.3% and 88.5% of the total sample rated type H and type D in this manner, respectively). In addition, an untimed in-class examination with supporting material limited to a specific number of pages (type E, "untimed-specific") and a final project (type G, "project") were also looked upon relatively favourably. More than one-half of the participants (69.2% for type E and 53.8% for type G) expressed either a preference or

Table 18

Preferences of Graduate Students (N=26) Concerning Styles of Assessments in Statistics Courses (Range 1-5)

Exam Type	Description	Mean	SD
H	A "take home" examination with unlimited supporting material.	4.58	1.03
D	An untimed in-class examination with unlimited supporting material.	4.54	0.90
E	An untimed in-class examination with supporting material limited to a specific number of pages.	3.62	1.13
G	A final project.	3.46	0.95
A	A timed in-class examination with unlimited supporting material.	2.81	1.44
B	A timed in-class examination with supporting material limited to a specific number of pages.	2.42	1.10
K	An oral examination in small groups with supporting material.	2.23	1.34
M	An oral examination involving the whole class with supporting material.	1.88	1.31
I	An individual oral examination with supporting material.	1.81	1.10
F	An untimed in-class examination with no supporting material.	1.54	0.95
J	An individual oral examination with no supporting material.	1.50	0.95
L	An oral examination in small groups with no supporting material.	1.50	0.95
N	An oral examination involving the whole class with no supporting material.	1.35	0.85
C	A timed in-class examination with no supporting material.	1.23	0.65

a strong preference for these types of examinations. The next most popular methods of assessment, in order of preference, were: a timed in-class examination with unlimited supporting material (type A, "timed-unlimited"), a timed in-class examination with supporting material limited to a specific number of pages (type B, "timed-specific"), and an oral examination in small groups with supporting material (type K, "oral-group-unlimited"). However, it should be pointed out that approximately one-half of the sample expressed either a dislike or a strong dislike for these methods of testing (42.3%, 57.7% and 57.7% for type A, type B, and type K, respectively).

The remaining seven methods of assessment received a mean rating of less than 2, suggesting strong dislike. In fact, between 73.1% (type I, "oral-individual-unlimited") and 96.1% (type N, "oral-whole-no-support") of the sample reported either a dislike or a strong dislike for these items, suggesting a general disinclination towards oral examinations. An important finding is that the five least favoured methods of assessment are ones which do not permit the use of supporting material.

Overall, with respect to the preferences of graduate students concerning methods of assessment in statistics courses, two patterns emerged. Firstly, students were much more in favour of examinations in which <u>the time duration is unlimited</u>, or at least relaxed. Secondly, students preferred assessments in which <u>the use of supporting material is</u>

allowed. These components will henceforth be labelled "duration" and "supporting material."

With respect to the two examination methods used in this study, the "untimed in-class examination with supporting material limited to a specific number of pages" was rated third out of fourteen on the scale, whilst the "timed in-class examination with supporting material limited to a specific number of pages" was rated sixth out of fourteen.

PASS - Anxiety

The perceived effect of various methods of assessment on anxiety level was also measured (Table 19). Here, a low mean represents a reduction in anxiety, whilst a high mean represents an increase in the level of anxiety.

It can be seen that, in order of preference, take-home, untimed-unlimited, and untimed-specific examinations led to a reduction in reported anxiety level for the majority of students. The percentage of students for whom anxiety was perceived as being reduced was 84.6%, 84.6%, and 50.0%, respectively. The next most effective method of assessment, with respect to perceived anxiety-reduction, was the timed-unlimited examination, which 46.2% of the sample rated as anxiety-reducing. It should be pointed out however, that 34.6% of the sample felt that a timed-unlimited examination would increase anxiety levels. The finding that only 23.1% of the respondents rated projects as anxiety-relieving was somewhat surprising. This finding may be due to the fact that

Table 19

Impact of Assessment Style on Anxiety (Range 1-3)

Exam Type	Description	Mean	SD
H	A "take home" examination with unlimited supporting material.	1.19	0.49
D	An untimed in-class examination with unlimited supporting material.	1.23	0.59
E	An untimed in-class examination with supporting material limited to a specific number of pages.	1.58	0.64
A	A timed in-class examination with unlimited supporting material.	1.88	0.91
G	A final project.	2.15	0.78
B	A timed in-class examination with supporting material limited to a specific number of pages.	2.27	0.72
K	An oral examination in small groups with supporting material.	2.42	0.81
M	An oral examination involving the whole class with supporting material.	2.65	0.63
I	An individual oral examination with supporting material.	2.81	0.57
L	An oral examination in small groups with no supporting material.	2.81	0.49
N	An oral examination involving the whole class with no supporting material.	2.85	0.46
F	An untimed in-class examination with no supporting material.	2.88	0.43
C	A timed in-class examination with no supporting material.	2.92	0.39
J	An individual oral examination with no supporting material.	2.96	0.20

statistics projects are often open-ended in nature, giving students a sense of insecurity.

The remaining methods of assessment were rated as more anxiety-provoking than anxiety-reducing. These included all the oral examinations, as well as all the examinations in which supporting material was not permitted. Timed-no-support and oral-group-no-support examinations received the lowest ratings, with 96.2% of the sample deeming them anxiety-provoking.

PASS - Performance

The majority of students (73.1%) felt that take-home and untimed-unlimited examinations would increase their performance levels (Table 20). Other methods of assessment which had reasonable ratings, on average, were timed-unlimited (46.2%), untimed-specific (42.3%) and project (34.6%). With regard to the remaining types of assessments, most students felt that these examinations reduced performance levels. An interesting finding was that timed-no-support examinations were the least favoured method of assessment with respect to anxiety-reduction.

PASS - Higher Order Thinking

More than fifty percent of the sample rated three types of examinations as increasing the opportunity to assess higher-order thinking (Table 21). These were: project (61.5%), take-home examinations (61.5%), and untimed-unlimited

Table 20

Impact of Assessment Style on Performance (Range 1-3)

Exam Type	Description	Mean	SD
D	An untimed in-class examination with unlimited supporting material.	2.66	0.63
H	A "take home" examination with unlimited supporting material.	2.62	0.70
E	An untimed in-class examination with supporting material limited to a specific number of pages.	2.38	0.57
G	A final project.	2.27	0.60
A	A timed in-class examination with unlimited supporting material.	2.23	0.82
B	A timed in-class examination with supporting material limited to a specific number of pages.	1.81	0.63
K	An oral examination in small groups with supporting material.	1.58	0.70
M	An oral examination involving the whole class with supporting material.	1.50	0.65
I	An individual oral examination with supporting material.	1.46	0.76
F	An untimed in-class examination with no supporting material.	1.35	0.69
L	An oral examination in small groups with no supporting material.	1.35	0.63
N	An oral examination involving the whole class with no supporting material.	1.27	0.60
J	An individual oral examination with no supporting material.	1.23	0.59
C	A timed in-class examination with no supporting material.	1.19	0.57

(57.7%). Other methods of assessment which received reasonable ratings were timed-unlimited (46.2%), untimed-specific (34.6%), and timed-specific (23.1%). Once again, timed-no support received the lowest ratings, with 69.2% of the sample reporting that this method of assessment would reduce the opportunity to assess higher-order thinking.

PASS - Objectivity

Student ratings of the fourteen different types of assessment with respect to objectivity are summarised in Table 22. Clearly, untimed-unlimited examinations were rated as being the most objective, with 46.2% of subjects indicating that this type of assessment increases objectivity, and only 3.8% perceiving a reduction in objectivity. Other styles of assessment which were favourably rated, on average, were, in order of preference: untimed-specific, timed-unlimited, project, take-home, and timed-specific. All other methods of assessment, (i.e. examinations with no supporting material and/or oral examinations) were not highly rated.

Cluster Analysis

The VARCLUS procedure of the SAS statistical package (SAS Institute Inc., 1989) was used to perform a cluster analysis, in an attempt to identify unique, individualistic patterns of examination style preference. This procedure divided the participants into disjoint unidimensional clusters. The criterion of percentage variation explained by each cluster

Table 21

Impact of Assessment Style on Higher Order Thinking

(Range 1-3)

Exam Type	Description	Mean	SD
D	An untimed in-class examination with unlimited supporting material.	2.54	0.58
G	A final project.	2.54	0.65
H	A "take home" examination with unlimited supporting material.	2.50	0.71
A	A timed in-class examination with unlimited supporting material.	2.31	0.74
E	An untimed in-class examination with supporting material limited to a specific number of pages.	2.31	0.55
B	A timed in-class examination with supporting material limited to a specific number of pages.	2.08	0.63
K	An oral examination in small groups with supporting material.	1.77	0.71
I	An individual oral examination with supporting material.	1.73	0.83
K	An untimed in-class examination with no supporting material.	1.65	0.75
J	An individual oral examination with no supporting material.	1.62	0.85
L	An oral examination in small groups with no supporting material.	1.62	0.75
M	An oral examination involving the whole class with supporting material.	1.61	0.70
N	An oral examination involving the whole class with no supporting material.	1.58	0.70
C	A timed in-class examination with no supporting material.	1.38	0.64

Table 22

Impact of Assessment Style on Objectivity (Range 1-3)

Exam Type	Description	Mean	SD
D	An untimed in-class examination with unlimited supporting material.	2.42	0.58
E	An untimed in-class examination with supporting material limited to a specific number of pages.	2.27	0.45
A	A timed in-class examination with unlimited supporting material.	2.23	0.65
G	A final project.	2.15	0.54
H	A "take home" examination with unlimited supporting material.	2.08	0.69
B	A timed in-class examination with supporting material limited to a specific number of pages.	2.04	0.53
I	An individual oral examination with supporting material.	1.69	0.79
F	An untimed in-class examination with no supporting material.	1.65	0.63
C	A timed in-class examination with no supporting material.	1.62	0.64
K	An oral examination in small groups with supporting material.	1.54	0.58
J	An individual oral examination with no supporting material.	1.50	0.71
M	An oral examination involving the whole class with supporting material.	1.50	0.65
N	An oral examination involving the whole class with no supporting material.	1.50	0.65
L	An oral examination in small groups with no supporting material.	1.42	0.58

was considered most important in deciding the most meaningful cluster solution. For four of the five dimensions of PASS, namely: overall preference, anxiety, higher-order thinking, and objectivity, a two-cluster solution was deemed the most efficient. On the other hand, a three-cluster solution was selected for the performance dimension. The number of students assigned to each cluster, together with the proportion of variance explained for each dimension of PASS, is displayed in Table 23.

The next step was to describe the characteristics of these clusters in order to assist in the explanation of a student's rating of the different modes of assessment. As far as overall preference is concerned, students in the two clusters differed significantly with respect to mean number of college-level statistics courses taken, $t = -2.09$, $p < 0.05$ (Cluster 1 mean = 1.81; Cluster 2 mean = 4.10), and mean ratings of: timed examinations, $t = -4.42$, $p < 0.05$ (Cluster 1 mean = 1.79; Cluster 2 mean = 2.73); untimed examinations, $t = 2.76$, $p < 0.05$ (Cluster 1 mean = 3.44; Cluster 2 mean = 2.90); and examinations with unlimited material allowed, $t = -3.22$, $p < 0.05$ (Cluster 1 mean = 3.22; Cluster 2 mean = 4.40).

Subjects from the two clusters which emerged from responses to the impact of each examination style on anxiety levels, each differed with respect to prior achievement, $t = 2.52$, $p < 0.05$ (Cluster 1 mean = 75.53; Cluster 2 mean = 55.00). Not surprisingly, students in these clusters also differed in their levels of test anxiety, $t = -3.65$, $p < 0.05$

Table 23

Distribution of Students and Variation Explained by Clusters Based on Responses to the Preferred Assessment Style Scale (N=26)

PASS Dimension	Number of Students in Cluster 1	Number of Students in Cluster 2	Number of Students in Cluster 3	Percentage of Variation Explained by Clusters
Overall Preference	16	10	-	79.16
Anxiety	17	9	-	68.37
Performance	14	7	5	73.46
Higher- Order Thinking	19	7	-	63.76
Objectivity	14	12	-	63.03

(Cluster 1 mean = 23.00; Cluster 2 mean = 31.78). In addition, differences between members of the two clusters were apparent with respect to mean rating of projects as a method of assessment, $t = 6.08$, $p < 0.05$ (Cluster 1 mean = 2.59; Cluster 2 mean = 1.33).

As far as the effects on performance are concerned, students in the three clusters differed in many areas. These were: statistics prior achievement, $F(2, 23) = 4.46$, $p < 0.05$ (Cluster 1 mean = 74.71; Cluster 2 mean = 49.86; Cluster 3 mean = 76.80); statistics achievement, $F(2, 23) = 3.33$, $p < 0.05$ (Cluster 1 mean = 75.43; Cluster 2 mean = 56.00; Cluster

3 mean = 81.80); age, $F(2, 23) = 4.65$, $p < 0.05$ (Cluster 1 mean = 38.79; Cluster 2 mean = 47.86; Cluster 3 mean = 36.20); statistics test anxiety, $F(2, 23) = 4.46$, $p < 0.05$ (Cluster 1 mean = 23.21; Cluster 2 mean = 32.57; Cluster 3 mean = 24.80); examination-taking coping strategies, $F(2, 23) = 4.71$, $p < 0.05$ (Cluster 1 mean = 128.07; Cluster 2 mean = 112.43; Cluster 3 mean = 146.20); mean rating of examinations with unlimited material permitted, $F(2, 23) = 15.89$, $p < 0.05$ (Cluster 1 mean = 2.82; Cluster 2 mean = 2.07; Cluster 3 mean = 1.90); and mean rating of examinations with limited material permitted, $F(2, 23) = 4.01$, $p < 0.05$ (Cluster 1 mean = 2.22; Cluster 2 mean = 1.72; Cluster 3 mean = 2.30).

Assessment style preference with respect to higher-order thinking separated students in several areas. Students in the two clusters differed in: the number of years since their last mathematics course, $t = 2.86$, $p < 0.05$ (Cluster 1 mean = 18.63; Cluster 2 mean = 9.86); the number of college-level mathematics courses, $t = -2.32$, $p < 0.05$ (Cluster 1 mean = 4.50; Cluster 2 mean = 11.53); the number of college-level statistics courses, $t = -2.15$, $p < 0.05$ (Cluster 1 mean = 2.00; Cluster 2 mean = 4.57); their attitude towards the statistics course, $t = 2.73$, $p < 0.05$ (Cluster 1 mean = 27.53; Cluster 2 mean = 17.71); computation self-concept, $t = 2.97$, $p < 0.05$ (Cluster 1 mean = 17.47; Cluster 2 mean = 10.29); fear of statistics teachers, $t = 3.18$, $p < 0.05$ (Cluster 1 mean = 14.79; Cluster 2 mean = 8.71); statistics anxiety, $t = 2.60$, $p < 0.05$ (Cluster 1 mean = 130.58; Cluster 2 mean =

99.29); and mean rating of oral examinations, $t = -3.55$, $p < 0.05$ (Cluster 1 mean = 1.46; Cluster 2 mean = 2.19).

Responses to the question of objectivity in assessment divided participants into two distinct clusters. Students in these groups differed with respect to mean rating of oral examinations, $t = -4.15$, $p < 0.05$ (Cluster 1 mean = 1.20; Cluster 2 mean = 1.81).

Summary of PASS findings

The above findings with respect to PASS, suggest that those students with high statistics prior achievement and low levels of statistics test anxiety, tended to feel that the use of projects for assessment purposes brought about an increase in anxiety level, whilst students with low statistics prior achievement and high statistics test anxiety, tended to rate projects as anxiety-reducing. Furthermore, young students with low levels of test anxiety, high statistics prior achievement and achievement and who lacked examination-taking coping strategies in certain areas, tended to feel that examinations with limited supporting material would be conducive to an increase in performance levels. The majority of students with these characteristics felt that examinations with unlimited supporting material would have no impact on their performance levels (whether beneficial or adverse). On the other hand, older students with low statistics prior achievement and achievement, high test anxiety, and who needed training in the use of examination-taking coping strategies, tended to feel that examinations with unlimited supporting material would have no impact on their level of performance. However, this same group of students tended to rate examinations with limited supporting material as having a detrimental effect on performance levels. Finally, young graduate students with high statistics prior achievement and achievement, low test anxiety and adequate examination-taking coping strategies, tended to feel that examinations with limited supporting material would have a positive impact on their level of performance, whilst rating examinations with unlimited supporting material as having an extremely positive effect on their performance levels.

Interestingly, students with the following characteristics tended to feel that oral examinations would constitute a less effective means of testing higher-order thinking strategies: those who taken very few mathematics and statistics courses, who had taken their last college-level mathematics course a long time ago, who had a negative attitude towards the course, who experienced high levels of anxiety during problem-solving, who were afraid of statistics teachers, and who generally had high levels of statistics anxiety. On the other hand, students with the following characteristics tended to feel that oral examinations would constitute a more effective means of testing higher-order thinking strategies: those who had taken more than average mathematics and statistics courses, who had recently taken their last college-level mathematics course, who had a positive attitude towards the course, who did not experience high levels of anxiety during problem-solving, who were not afraid of statistics teachers, and who generally had low levels of statistics anxiety.

All in all, graduate students who had taken very few statistics classes, not surprisingly, tended to favour untimed examinations more highly than students with a strong statistics background. On the other hand, students who lacked experience of statistics courses, tended to rate timed examinations, as well as examinations with unlimited supporting material, less favourably than their more experienced counterparts.

Chapter V

Summary, Implications, Recommendations and Conclusions

Experimental studies are essential for increasing the understanding of any construct. This is no less so with respect to the construct of statistics test anxiety. When the conditions under which students perform are systematically manipulated, it becomes possible to begin to elucidate those aspects of the environment which are pertinent to a particular component of behaviour. This is the rationale behind the present study. As such, this study represents a unique attempt to determine the effects of statistics test anxiety on performance, utilising a true experimental design.

This final chapter will comprise four parts. Firstly, the results will be summarised and compared with findings from previous research. The second section will provide a discussion of implications for future research. The third section will provide recommendations for statistics instructors and educators. Finally, the fourth section will present conclusions derived from the findings.

Summary of Findings/ Comparison with other Research

The Optimising Effect of Statistics Test Anxiety

The primary finding of interest in this study is that an interaction between statistics test anxiety and examination condition is apparent. This finding, which pertains to the optimising effect of untimed examinations, strongly suggests that statistics test anxiety is the causal factor in the anxiety/performance relationship. It is consistent with the finding of Hill (1983), relating to mathematics anxiety. This clearly demonstrates that it is possible to improve the performance of test-anxious students via the introduction of examination conditions which minimise the debilitating effects of test anxiety (Hill, 1977).

The findings of the study indicate that students with high levels of statistics test anxiety have greater statistics ability than their performance under timed examination conditions suggests. Indeed, as Hill & Wigfield (1984) have suggested, examination scores of students with high levels of statistics test anxiety, obtained under timed examination conditions, may represent an invalid lower-bound estimate of their actual statistics ability or aptitude.

The finding that it is the interaction between statistics test anxiety and examination condition which explains test performance better than either factor separately, is consistent with other research on interactions between a treatment and an affective variable (Bowers, 1973; Ekehammar, 1974; Endler & Magnusson, 1976; Hill & Eaton, 1977). Contrary to the findings of Plass and Hill (1979), optimising effects were observed for high test-anxious female students in the untimed examination condition. This discrepancy may be due to differences in age groups, since the subjects in the Plass and Hill study were elementary school girls.

The effect size of the interaction between examination condition and statistics test anxiety is by no means trivial. Indeed, had course grades been assigned on the basis of this study, that is, on the basis of the practice final examination, in the timed examination group, subjects who were placed in the upper 40%, with respect to statistics test anxiety, would have each been awarded the lowest grades, whilst students in the timed examination group, who were placed in the lower 40%, with respect to statistics test anxiety, would have been awarded the highest grades. On the other hand, in the untimed examination condition, subjects who were placed in the upper 40%, with respect to statistics test anxiety, would have been awarded similar grades to those placed in the lower 40%. Taking into consideration the importance of grades for certain students, these findings provide a powerful illustration of the significance of statistics test anxiety in predicting success or failure in an essential area of a graduate student's academic program.

The reported interaction between statistics test anxiety and examination condition can be interpreted with respect to a negative motivation model (Hill, 1977), or with respect to a cognitive-attentional-interference model (Wine 1980).

Negative Motivation Model (Hill, 1984)

Hill's (1984) negative motivation model predicts that the low performance of high test-anxious students under timed examination conditions is due more to motivational problems than to a lack of knowledge of the material being examined.

In the present study, had high-anxious students not known the material being examined, they would have attained similar scores in both examination conditions. However, the fact that high-anxious students performed better under untimed examination conditions, strongly suggests that high anxious students do possess knowledge of the material being tested, but are unable to demonstrate this knowledge under timed examination conditions, due to inadequate examination-taking coping strategies and unsuitable motivational dispositions (Hill, 1984, Hill & Eaton, 1977), rather than on account of poor study skills, or study coping strategies (Bruch, Juster, & Kaflowitz, 1983; Klinger, 1984).

When time pressure is removed from the examination situation, negative motivational components are minimised, and the performance of high anxious students improves. Low anxious students, for whom negative motivation is not an important factor, perform well under both examination conditions.

<u>Cognitive-Attentional-Interference Model (Wine, 1980)</u>

According to Wine (1980), differences in performance of high and low anxious students are due to the differing attentional focuses of low- and high-anxious students in evaluative situations. The extent of task-irrelevant focus depends on the degree to which high anxious students interpret their physiological arousal as being unpleasant. It is highly likely that statistics test anxiety interferes with performance by impeding a student's ability to apply new knowledge to a specific problem, by making it difficult to recall what has been learned, and by hindering effective use of problem-solving strategies (Tobias, 1977, 1980).

In a previous ethnographic study, in-depth interviews of students revealed that, during examinations, high levels of statistics test anxiety interfere with cognitive functioning (Onwuegbuzie, 1992). High anxious students often become so preoccupied with failure, that their ability to suppress interfering thoughts and to attend continuously to task-relevant responses is severely impeded (Hembree, 1990; Wine, 1980). As a result, they are unable to optimise cognitive operations, such as short- and long-term memory retrieval, resulting in under-achievement (Sarason, 1972).

Mueller (1978) has shown that high anxious students recall less learned material than low anxious students. It is likely that this recall differential is exacerbated by timed examination conditions. It is also likely that high levels of statistics test anxiety could impede higher-order conceptual processes (Meyers and Martin, 1974), affecting organisational processes during free recall (Mueller, 1978). These effects are more likely to be apparent under timed examination conditions than untimed examination conditions. The reduced propensity for immediate recall of high anxious students under timed examination conditions is particularly detrimental to their performance.

It seems that cognitive-attentional-interference has more of a negative impact on high anxious students in timed examinations, since this method of assessment is more ego-threatening for them (Sarason, 1984). Increases in the level of ego-threat, as a result of timed examinations, reduce the performance levels of high anxious students by interfering with cognitive functioning. In this study, the untimed examination condition may have assisted high-anxious students, by either "reducing the processing capacity absorbed by the affective preoccupations" or "reducing the information-processing demands of the task" (Tobias, 1986, p.48).

It is also possible that during timed examinations, high test-anxious students who concentrate on task-irrelevant responses (Hill, 1972; Phillips, Martin, & Meyers, 1972), find it difficult to shift from one type of focus to another, culminating in an involuntary narrowing of attention (Nideffer, 1976).

The finding that high anxious students performed better under untimed examination conditions than under timed conditions, lends support to the notion that statistics test anxiety is more debilitating in a timed examination because it interferes with memory processes such as the storage and retrieval of information (Sarason, 1978). The self-preoccupation of test-anxious students interferes with the directed attention required to perform successfully (Hunsley, 1985). In the present study, it is interesting to note that, whereas all students in the untimed examination group recorded their identification number, as instructed, only one student in the timed examination group did so. This provides further evidence that statistics test anxiety resulting from time pressure induces task-irrelevant responses.

Integration of Models

A combination of the above models suggests that students who differ in statistics test anxiety levels tend also to differ in motivational levels and attentional focus. Time limits can induce stress, which often leads to strong negative motivational forces, taking the form of self-centred, task-irrelevant thoughts. These can interfere with cognitive functioning, affecting memory retrieval processes, reducing information-processing capabilities, and hindering the effective use of problem-solving strategies, amongst other functions. Students who are most susceptible to these debilitating forces are those with high test anxiety coupled with a history of poor examination performance, and those with high test anxiety who place great importance on their achievement in a particular examination (Onwuegbuzie, 1992).

The Relationship between Statistics Test Anxiety and Performance

A major goal of this study was to examine whether, after controlling for prior performance, the debilitating effects of reported statistics test anxiety would still be negatively correlated with examination performance. Findings indicate that, regardless of statistics prior achievement, students with high levels of statistics test anxiety tend to have lower levels of performance than low test-anxious students (significant negative partial correlation between statistics test anxiety and performance).

This finding differs from that of Zeidner (1991), who found that, after controlling for statistics aptitude, statistics test anxiety does not affect performance. However, Zeidner's study was non-experimental in nature.

On the other hand, Hill (1984), whose studies were experimental in nature, found that the negative correlation between test anxiety and test performance increases steadily from approximately -0.20 in the early grades, to approximately -0.40 in the middle elementary grades, to about -0.45 in the later elementary school grades, and to approximately -0.60 in the eleventh grade. The correlation between statistics test anxiety and performance of -0.57 found in the present study, suggests that the relationship between anxiety and performance may reach a plateau somewhere in adulthood.

<u>Timed vs Untimed Examinations</u>

The finding in this study that students performed better in the untimed testing condition than in the timed testing condition, is in accordance with previous experimental research (Hill, 1977, 1979, 1980, 1984; Hill & Eaton, 1977;

Hill, Wigfield, & Plass, 1980). This finding suggests that timed examinations serve to induce anxiety levels which interfere with the cognitive processes essential for effective performance. As such, they do not simply measure what a student knows, but also the extent to which s/he is able to demonstrate this knowledge under time pressure. As such, examinations administered under time pressure can be detrimental to the performance of both low- and high-anxious students.

Examination-taking Strategies

The finding that there was no relationship between performance and time taken to complete these examinations is concordant with the bulk of the literature (Blumenfeld & Berry, 1965; Burack, 1967; Lester, 1991; Longstaff & Porter, 1928; Paul & Rosenkoetter, 1980; Schnell & Dwarshuis, 1967).

With regard to the inter-relationships among statistics test anxiety, examination completion rate and performance, in the timed examination condition, low anxious students showed adaptive rate strategies, since the vast majority of them exhibited high levels of performance, regardless of completion time. On the other hand, high anxious students showed maladaptive rate strategies. These students demonstrated either a fast-inaccurate or slow-inaccurate performance strategy. In the untimed examination condition, a greater percentage of high anxious students demonstrated adaptive rate strategies, compared with high anxious students in the timed examination condition. The reverse was true for low anxious students, in that a greater percentage of these students demonstrated maladaptive rate strategies, compared with their low anxious counterparts in the untimed examination condition.

The finding, in the untimed examination group, that high anxious students performed as quickly as less anxious students, and, at the same time, were more successful than their high anxious counterparts in the timed examination group, suggests that test-anxious students have the same levels of ability as less anxious students, and that they are capable of working at the same rate. This leads to the conclusion that test-anxious students do not need more time than their counterparts if an examination is administered without time pressure. However, results suggest that high-anxious students are unable to demonstrate their ability effectively under timed examination conditions. This finding, which is consistent with the findings of Plass and Hill (1979), further supports the contention that motivational and examination-taking coping strategies, rather than lack of statistics ability, are responsible for the under-achievement in statistics examinations administered under time limits of graduate students who experience high levels of test anxiety.

Optimising Effect of Interpretation Anxiety

One finding of this study, although not hypothesised, was that in the timed examination condition, students with high levels of interpretation anxiety were outperformed by students with low levels of interpretation anxiety. However, when time limits were removed, students with high levels of interpretation anxiety performed as well as their counterparts with low levels of interpretation anxiety.

Out of all the statistics anxiety components, apart from test anxiety, only interpretation anxiety was found to interact with examination condition in the determination of performance levels. In other words, no optimising effect was found for students with high levels of the following: worth of statistics, computation self-concept, fear of asking for help, and fear of statistics teachers.

It is not surprising that the possible interfering effects of worth of statistics, fear of asking for help, and fear of statistics teachers were not reduced through the use of untimed examinations, since it is unlikely that these anxiety components are directly related to test anxiety. Indeed, in the study, the correlations between test anxiety and these components were not significant. On the other hand, it is somewhat surprising that the interfering effects of anxiety relating to computation self-concept were not reduced when time pressure was removed. This lack of optimising effect of the removal of time pressure, with respect to computation self-concept, may have occurred on account of the fact that very few of the examination items in this examination involved direct computation. Indeed, most of the test items called upon students to interpret data. Therefore, it is not surprising that optimising effects with respect to time were found for students with high levels of interpretation anxiety. Further research is needed, in order to ascertain the reliability of this finding, pertaining to interpretation anxiety.

Antecedent Correlates of the Components of Statistics Anxiety

Theoretical models for the prediction of the components of statistics anxiety were formulated using multiple regression analyses. The multiple regression analyses suggest that, of the variables considered in this study, attitude towards the field of statistics, attitude towards the course, level of examination-taking coping strategies and study coping strategies, number of college mathematics courses taken, and the sex of the subject, constitute those factors which appear to contribute to the prediction of one or more of the components of statistics anxiety. In particular, attitude towards the course and level of study coping strategies each predicted three of the six components of statistics anxiety measured in this study.

With respect to worth of statistics, it appears that those students who report more negative attitudes towards the field of statistics, who have taken less college-level mathematics courses, and who are assessed as having less adequate study coping strategies, are those who are more likely to deem statistics less relevant. In addition, those female students who were assessed as having less adequate test-taking coping strategies tended to have higher levels of interpretation anxiety. With respect to computation self-concept, students with the most negative attitudes towards the course tended to experience the highest levels of anxiety during problem-solving.

Students who possessed the most negative attitudes towards the course and who had the least adequate study coping strategies, tended to be most afraid of asking for help from a fellow student or from the instructor. In addition, these students tended to be more afraid of statistics teachers.

It is interesting that, while level of examination-taking coping strategies appears to be a significant predictor of statistics test anxiety, level of study coping strategies is not. This finding lends support to the notion that it is in fact inadequate examination-taking coping strategies which affect performance, rather than inadequate study coping strategies. Although it runs contrary to the findings of some researchers (Alpert & Haber, 1960; Benjamin, Mckeachie, Lin & Holinger, 1981; Culler & Holahan, 1980, Dusek, 1980; Desiderato & Koskinen, 1969b; Mckeachie, Pintrich, & Lin, 1985; Tobias, 1977, 1980; Wittmaier, 1972), it is consistent with some of the more recent studies (Brown & Nelson, 1983; Bruch, Juster, & Kaflowitz, 1983; Klinger, 1984; Paulman & Kennelly, 1984). The findings in the study, pertaining to student attitude, are consistent with previous research on mathematics anxiety, which demonstrated that mathematics anxiety is related to attitude (Betz, 1977; Harris & Harris, 1987) and mathematics background (Betz, 1977, 1978; Brush, 1978; Burton & Russell, 1979; Calvert, 1981).

Another important finding is that statistics anxiety, comprising the six anxiety components measured in the study, is related to the following: level of study coping strategies, level of examination-taking coping strategies, attitude towards the field of statistics, attitude towards the course, number of years which have elapsed since a student's previous mathematics course, mathematics background and statistics background. The data suggest that all these variables may play a role in the development of statistics anxiety. The findings are consistent with previous research on statistics anxiety, which has indicated that statistics anxiety is related to mathematics background (Robert & Saxe, 1982; Zeidner, 1991), statistics background and attitude towards the course (Robert & Saxe, 1982), and study coping and examination-taking coping strategies (Hunsley, 1987).

It should be pointed out, however, that the findings of this study indicate that attitude towards the field of statistics, attitude towards the course, level of study coping strategies and mathematics background, were the best predictors of statistics anxiety.

The only relationship pertaining to statistics anxiety which cannot be inferred to the population in this study is that of prior achievement. This finding is in direct contrast to that of Robert and Saxe (1982). One possible explanation for the lack of correlation between statistics anxiety and prior achievement in statistics, is that there was little variation in subjects' previous course grades, since the majority of students had attained a final grade of A. In addition, only those students who had received a passing grade in their previous statistics course, were allowed to enroll in the course under study. Such a restriction in the range of grades would almost certainly have attenuated any relationship between statistics anxiety and prior achievement.

The finding that there was no relationship between statistics test anxiety and the score on the final project, suggests that take-home assessments, which do not invoke the anxiety elicited by timed examinations, do not place high anxious students at an unfair disadvantage relative to low anxious students.

Sex Differences

The subjectively reported sex group differences in statistics test anxiety found in this study are consistent with previous data in the statistics literature (Zeidner, 1991), as well as with findings in the mathematics anxiety literature (Richardson & Suinn, 1972). This suggests that females report higher levels of statistics test anxiety than their male counterparts. However, the extent to which these sex differences are due to reporting biases is open to question.

Preferred Methods of Assessment

Results from PASS indicate that the majority of students believe that, compared with timed examinations, untimed examinations completed either in a classroom or home setting reduce anxiety levels, improve performance levels, increase levels of objectivity, and increase the opportunity to assess higher-order thinking, and as such, are definitely preferable. Similarly, examinations which permit the use of supporting-material are preferred to closed-book examinations, with respect to anxiety levels, performance levels, higher-order thinking and objectivity. Overall, untimed-unlimited and take-home examinations, in which the emphasis is on conceptual understanding rather than on memorisation, were considered to be the best methods of assessment, with respect to the four indices (anxiety, performance, higher-order thinking, objectivity).

A somewhat disturbing finding was the fact that oral examinations consistently received low ratings. The ability to communicate using statistical terminology is an important skill, one which is often under-emphasised by instructors. Consequently, students need to be given more opportunity to present their knowledge orally, so that they may be better prepared to consult, teach and present findings to future audiences.

The finding that students prefer examinations which permit the use of supporting material is an important one. In fact, the majority of students felt that "supporting material" examinations serve to reduce anxiety levels. This supports the findings of Feldhusen (1961), Jehu, Picton, and Cher (1970), Michaels and Kieren (1973), and Webber, Mcbee, and

Krebs (1983), that open-book examinations reduce anxiety levels and consequently, constitute a fairer and more accurate means of testing a student's ability. It is fair to assume that "supporting-material" examinations reduce the emphasis on rote memorisation of facts, giving students more time to devote to conceptual understanding. It is also possible that examination procedures which permit the use of supporting material increase performance levels of high-anxious students, as was found by Sieber and Kameya (1968) and Sinclair (1969).

It should be pointed out that open-book examinations more closely resemble the real-life application of statistical knowledge. Therefore, as well as constituting a better predictor of student statistics ability, they should also be more meaningful to students from a practical point of view. If a major goal of statistics examinations is to provide a meaningful and accurate method of assessing statistics ability, then the implementation of take-home examinations and projects should be seriously considered.

Although it is recognised that implementing a method of assessment which is favoured by the majority of students is not necessarily going to reduce anxiety or to increase performance levels, it is proposed that statistics instructors, and indeed, instructors in general, not only ask students about their preferences regarding assessment methods, but, when appropriate, attempt to utilise some of these preferences, with respect to their teaching strategies and in accordance with the particular characteristics and needs of their students. It is suggested that the application of such an approach would bring about an improvement in the general atmosphere of statistics teaching, and would enable students to demonstrate their true competence and potential in statistics.

Implications for Future Research

This study represents a unique attempt to determine the effects of statistics test anxiety on performance, utilising a true experimental design. More studies of this type are needed to understand clearly the construct of statistics test anxiety. A number of implications for future research are suggested by the results of the present study. Firstly, this experimental study should be replicated using a larger number of subjects.

Secondly, relatively few of the subjects in this study were male. There is a need for research to be undertaken in order to ascertain whether the conclusions reached in this study also hold true for males, as well as for undergraduate students.

Thirdly, since statistics test anxiety represents a demonstrably prevalent phenomena, and since unsuccessful performance in statistics examinations can be a stumbling block for many graduate students, then the search for a method of assessment which will measure accurately a student's true ability is of the utmost importance.

Fourthly, it would be helpful to investigate whether untimed-unlimited examinations lead to performance increments in statistics courses, compared with other on-site examination formats. The effects of take-home examinations on statistics performance could also be investigated, via experimental studies. The various types of examinations used to assess statistics achievement could then be ranked objectively, according to the extent to which they increase performance levels. These rankings could then be compared with those made by students using PASS, in this, and subsequent studies.

Fifthly, it might be useful to investigate additional affective, cognitive and behavioural variables, in order to reach a more complete understanding of the construct of statistics test anxiety.

Sixthly, future research is necessary, in order to ascertain the reliability of the finding that, under no time constraints, some high anxious students perform more effectively than their low anxious counterparts. In other words, future research on the relationship between statistics test anxiety and performance needs to address critically the debilitating and facilitating effects of statistics test anxiety.

Finally, it should be pointed out that, although replacing timed examinations with untimed examinations will, almost certainly, improve the overall performance levels of students, there is no absolute guarantee that anxiety levels, per se, will also decrease. Therefore, the implementation of optimising testing conditions, is in itself, not sufficient to improve student attitudes towards either the field of statistics or to the statistics course. Effective anxiety-reduction and anxiety-management training programs also need to be introduced. On account of evidence that cognitive-attentional-interference appears to affect the performance levels of test anxious students, task-attentional training schemes, such as cognitive-attentional intervention (Wine, 1974), should be studied extensively.

Recommendations

There is little doubt that high levels of statistics test anxiety can have a debilitative effect on statistics performance. Taking into account the findings of this study, it is imperative that every statistics instructor be made fully aware of the role which statistics anxiety can play in the formation of student attitudes and responses towards statistics. Such an awareness would, it is hoped, culminate in instructors modifying their teaching styles and classroom interactions, in order to reduce anxiety levels. Indeed, all faculty members should be made aware of the possible consequences of statistics anxiety, in order that they could give students who are embarking on these courses effective advice. It would be helpful if students were advised to enroll in statistics courses in successive semesters, if possible, since the length of time which has elapsed since a student's previous statistics course seems to be an antecedent of statistics anxiety.

Advisors should be aware of assisting students in the development and maintenance of a positive attitude towards the statistics course, as well as a positive attitude towards the field of statistics. Students for whom many years have elapsed since their previous mathematics or statistics course, and those with inadequate backgrounds in mathematics and statistics, should be forewarned that they may be at a disadvantage compared with other students. It might even be necessary to dissuade them from enrolling in intermediate statistics courses until they have completed a few lower level mathematics and statistics classes. Students should also be advised about the necessity of developing adequate examination-taking coping and study coping strategies.

Many factors can contribute to the goal of assisting students to reach their potential. However, there appear to be some recommendations which can be given to all statistics instructors. First and foremost, instructors should strive to establish an atmosphere which encourages learning and creativity in the statistics classroom. Statistics instructors can thereby attempt to reduce the fears of their students from the onset. In addition, a more positive attitude will ensue, if statistics instructors place less emphasis on obtaining the correct answer. Students should be given the opportunity to correct their own errors. One technique which has shown itself to be successful in this respect, is to allow students to re-submit their homework, if necessary, in order to obtain full credit (Onwuegbuzie, 1992). Process should be given at least as much emphasis as end-product.

In addition, less emphasis should be placed on examinations. If possible, the number of examinations should be kept to a minimum. Where examinations are given, students should be presented with a practice examination which is an accurate reflection of the actual examination, in order to give them the opportunity of familiarising themselves fully with the instructions, as well as with the examination format. This procedure would serve to minimise confusion about any of the examination parameters, thereby assisting in the reduction of statistics test anxiety. It would also be helpful if information could be given about how to direct attention away from self-centred worries and onto appropriate tasks during examinations, as well as supply information about effective problem-solving strategies.

It is imperative that long-term goals of assessment methods be considered, and that these should dictate the conditions under which classroom examinations are undertaken. Since statistical analysis of data is not usually performed under stringent time conditions, it seems logical for instructors to administer untimed examinations. These more closely approximate real-life application of statistical knowledge, as well as serving to improve the performance levels of both low and high test-anxious students.

Statistics instructors should consider the use of unlimited supporting material, in all statistics examinations. Indeed, where possible, take-home examinations and projects, which students seem to prefer, should be seriously considered as an alternative, or, at least, a supplementary means of assessing statistics achievement. It seems reasonable to expect that high anxious students will benefit from the use of any intervention which helps them to remember and to recall previously learned materials. The opportunity to consult notes, textbooks and other supporting material may have the dual effect of reassuring high anxious students and increasing their performance levels, by reducing the emphasis on memory retrieval, and hence, task-irrelevant responses.

Statistics instructors should also consider computer-based learning environments. Some form of Computer-Assisted Instruction may be effective in the reduction of anxieties due to lack of confidence, negative attitudes, authoritarian teaching styles, lack of variety in modes of teaching, teacher centredness, lack of relevance to the real world, and emphasis on memorisation, accuracy, and speed.

The finding that, in the timed examination condition, there was a stronger relationship between examination completion time and performance for the high anxious students than there was for the low anxious students, is very informative. Indeed, it seems that, under time pressure, high anxious students who finish early, tend to have lower performance levels than high anxious students who take longer to complete the examination. It is likely that some students may have a tendency to spend insufficient time on tasks and may give up too easily (Plass & Hill, 1979). This finding has implications for the teaching of examination-taking strategies. In particular, programs should be developed and implemented, which educate students as to the existence and management of negative motivations and learned helplessness (Dweck, 1975). Students should be taught how to minimise the debilitating effects of high test anxiety by: reducing off-task behavior, increasing effort, developing positive attitudes and motivational attributes, and promoting effective examination-taking and study coping strategies.

Statistics instructors should be aware that worth of statistics, interpretation anxiety, test and class anxiety, computation self-concept, fear of asking for help, and fear of statistics teachers are significant correlates of statistics achievement. The reduction of one or more of these dimensions should serve to decrease the overall level of statistics anxiety.

The list of recommendations made above is by no means exhaustive. It is hoped that they might serve as guidelines to making enrollment and participation in a statistics course a more positive experience. The implications for statistics instructors are clear: they must strive to develop greater sensitivity and awareness of self and of their students, if their instructional methods are to become more effective.

Conclusions

The findings of the present study are based on a single academic course. As with most research, replications are necessary, in order to ensure generalisability to other academic courses, students and academic institutions. However, based on the present findings, several conclusions can be made about the relationship between statistics test anxiety and statistics achievement, in the presence and absence of time pressure.

First and foremost, the present study strongly suggests that, not only does statistics test anxiety exist, but that high levels can, under certain examination conditions, impair student performance.

The main finding of this study, is that there is an interaction between statistics test anxiety and examination condition. The implication for college education is that a change in examination conditions from a timed to an untimed format appears to affect high- and low-anxious students differently. Timed examinations place high anxious students at a big disadvantage relative to low anxious students. However, both low anxious and high anxious students exhibited higher performance levels in the untimed examination condition, relative to their counterparts in the timed examination condition.

The findings of the present study strongly suggest that timed examinations increase evaluative stress. The performance levels of high anxious students was higher in the untimed examination condition than in the timed examination condition. As a consequence, one way of reducing the debilitative effects of evaluative stress would be to evaluate students under untimed examination conditions.

The advantage of an untimed examination over a timed examination has been clearly demonstrated in this study. Not only does it improve performance levels, but it is also rated more highly by students themselves. It is important that instructors consider seriously the most effective means of assessment, both from the point of view of accuracy and students' preference. The possible consequences of this incongruity between student preferences and actual teaching reality, with respect to methods of assessment, needs to be addressed by all those concerned with the improvement of statistics instruction and learning. In particular, since untimed examinations are not only preferred by most students, but also appear to measure student ability more accurately, they should be given the utmost consideration. Statistics instructors need to re-evaluate their teaching strategies, as well as the means of assessing the knowledge and understanding of the information which they seek to convey.

It is not uncommon for students in academic settings to report that timed examinations induce such high levels of anxiety that their performance levels are seriously impaired (Onwuegbuzie, 1992). As a consequence, they are unable to perform at levels which match the potential they have demonstrated in less stressful situations. This form of complaint is sometimes discounted by statistics instructors, who attribute students' poor performance purely to lack of ability or inadequate examination preparation, and who view such complaints as meager excuses. Taking into account the findings of the present study, as well as those of Hill and his associates, it is clear that statistics instructors should take these complaints seriously, because there does exist a sizable number of students, whose true ability is not measured accurately and fairly by timed examinations. It is important that statistics instructors begin to call into question current examination strategies.

The findings of this study have specific implications for the development of a more objective means of assessing statistical knowledge. If examination procedures are not modified, with this aim in mind, statistics may continue to be perceived as a negative experience by many students. The benefits to students, which would result from the implementation of untimed examinations at graduate level educational statistics courses have been elucidated. The subsequent contribution and potential, resulting from this, to the improvement of college-level statistics teaching and learning is now apparent.

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APPENDICES

APPENDIX A

Informed Consent Form (ICF)

Dear Student:

This is to request your participation in a research study to explore approaches to learning statistics. Your participation in this study is voluntary, and you may withdraw at any time. Your decision to participate, not to participate, or to withdraw from the study, will not adversely affect your final grade in the course. However, participation may possibly improve your grade. If you are willing to participate, it is necessary for you to complete the five questionnaires enclosed and return them in the envelope provided. In addition, you will be required to participate in a practice final examination held on Saturday, 12 December, 1992. The questionnaires should take about two hours of your time. You are also requested to sign and return the informed consent form with the completed questionnaires. The information you provide will be kept confidential. Only the researcher will see the completed forms. Your name will not be used in any reports of this study. You will be given the opportunity to take the final examination in addition to the practice final examination, if desired, whereby the highest of the two scores will be used to determine your final grade.

One benefit from participating in the study is that you will contribute to the improvement of future statistics courses. There are no risks, but participating will require some of your time. Participants will be randomly selected for timed or untimed tests at the beginning of the examination period. You need to be prepared to take either kind of examination. The questionnaires will be coded with a number that will correspond to numbers on your examination form. Please sign and keep a copy of this form as an explanation of the study. If you have any questions please ask your statistics instructor or contact the researcher at the following address:

Tony Onwuegbuzie
Department of Educational Psychology
College of Education, Room 135
University of South Carolina
Columbia, South Carolina 29208
Phone: (803) 777-6627

We will be glad to share the results of the study if you write to us at the above address. Thank you again for your assistance in this project.

Sincerely,

Tony Onwuegbuzie	Michael Seaman, Ph.D.
Ph.D. candidate	Assistant Professor
______________________	______________________
Signature	Signature

I agree to participate in this study under the conditions mentioned above

______________________	______________________
Signature	Date

APPENDIX B

Statistical Anxiety Rating Scale (STARS)

LOMA LINDA UNIVERSITY

Loma Linda University

School of Public Health

Loma Linda, California 92350
(714) 824-4546
FAX: (714) 824-4087

November 24, 1992

Tony Onwuegruzie
2009 Greene Street Apt. #213
Columbia, SC 29205-1601

Dear Mr. Onwuegruzie:

This letter is an official notice that you have my permission to use the instrument, Statistical Anxiety Rating Scale (STARS) for your research.

If you have any further questions, feel free to contact me.

Sincerely,

Robert J. Cruise, Ph.D.
Professor of Biostatistics

RJC/sbr

STATISTICAL ANXIETY RATING SCALE

Part I

The items below refer to experiences that may cause anxiety. Circle the number indicating the amount of anxiety you would experience in each of the following situations.

No Anxiety				Very Much Anxiety
1	2	3	4	5

1.	Studying for an examination in a statistics course..........................	1	2	3	4	5
2.	Interpreting the meaning of a table in a journal article............................	1	2	3	4	5
3.	Going to ask my statistics teacher for individual help with material I am having difficulty understanding..................	1	2	3	4	5
4.	Doing the homework for a statistics course.	1	2	3	4	5
5.	Making an objective decision based on empirical data............................	1	2	3	4	5
6.	Reading a journal article that includes some statistical analyses..................	1	2	3	4	5
7.	Trying to decide which analysis is appropriate for your research project......	1	2	3	4	5
8.	Doing the final examination in a statistics course..........................	1	2	3	4	5
9.	Reading an advertisement for an automobile which includes figures on gas mileage, compliance with population regulations, etc...........	1	2	3	4	5
10.	Walking into the classroom to take a statistics test...........................	1	2	3	4	5

No Anxiety				**Very Much Anxiety**
1	**2**	**3**	**4**	**5**

11. Interpreting the meaning of a probability value once I have found it.................. 1 2 3 4 5

12. Arranging to have a body of data put into the computer................................. 1 2 3 4 5

13. Finding that another student in class got a different answer than you did to a statistical problem......................... 1 2 3 4 5

14. Figuring out whether to reject or retain the null hypothesis......................... 1 2 3 4 5

15. Waking up in the morning on the day of a statistics test.......................... 1 2 3 4 5

16. Asking one of your professors for help in understanding a printout................... 1 2 3 4 5

17. Trying to understand the odds in a lottery. 1 2 3 4 5

18. Seeing a student poring over the computer printouts related to his/her research...... 1 2 3 4 5

19. Asking someone in the computer center for help in understanding a printout........... 1 2 3 4 5

20. Trying to understand the statistical analyses described in the abstract of a journal article........................... 1 2 3 4 5

21. Enrolling in a statistics course........... 1 2 3 4 5

22. Going over a final examination in statistics after it has been graded................... 1 2 3 4 5

23. Asking a fellow student for help in understanding a printout................... 1 2 3 4 5

Part II

This is an inventory of your feelings toward statistics. There are no right or wrong responses - only different ones. You can indicate whether or not a statement describes your feelings by circling the appropriate response below. Please respond to all of the items.

Strongly Disagree 1	2	3	4	Strongly Agree 5

24. Since I am by nature a subjective person, the objectivity of statistics is inappropriate for me........................ 1 2 3 4 5

25. I haven't had math for a long time. I know I'll have problems getting through statistics... 1 2 3 4 5

26. I wonder why I have to do all these things in statistics when in actual life I'll never use them............................ 1 2 3 4 5

27. Statistics is worthless to me since it's empirical and my area of specialization is philosophical............................ 1 2 3 4 5

28. Statistics takes more time than it's worth. 1 2 3 4 5

29. I feel statistics is a waste............... 1 2 3 4 5

30. Statistics teachers are so abstract they seem inhuman................................ 1 2 3 4 5

31. I can't even understand seventh- and eighth-grade math; how can I possibly do statistics................................ 1 2 3 4 5

32. Most statistics teachers are not human..... 1 2 3 4 5

33. I lived this long without knowing statistics, why should I learn it now?................. 1 2 3 4 5

Strongly Disagree 1	**2**	**3**	**4**	**Strongly Agree 5**

34. Since I've never enjoyed math, I don't see how I can enjoy statistics................. 1 2 3 4 5

35. I don't want to learn to like statistics... 1 2 3 4 5

36. Statistics is for people, who have a natural leaning toward math......................... 1 2 3 4 5

37. Statistics is a grind, a pain I could do without.................................... 1 2 3 4 5

38. I don't have enough brains to get through statistics................................ 1 2 3 4 5

39. I could enjoy statistics if it weren't so mathematical............................... 1 2 3 4 5

40. I wish the statistics requirement would be removed from my academic program........... 1 2 3 4 5

41. I don't understand why someone in my field needs statistics.......................... 1 2 3 4 5

42. I don't see why I have to clutter up my head with statistics. It has no significance to my life work............................... 1 2 3 4 5

43. Statistics teachers talk a different language.................................. 1 2 3 4 5

44. Statisticians are more number oriented than they are people oriented.................. 1 2 3 4 5

45. I can't tell you why, but I just don't like statistics................................ 1 2 3 4 5

46. Statistics teachers talk so fast you cannot logically follow them..................... 1 2 3 4 5

Strongly Disagree				**Strongly Agree**
1	**2**	**3**	**4**	**5**

47. Statistical figures are not fit for human consumption.................................. 1 2 3 4 5

48. Statistics isn't really bad. It's just too mathematical................................. 1 2 3 4 5

49 Affective skills are so important in my profession that I don't want to clutter my thinking with something as cognitive as statistics................................. 1 2 3 4 5

50. I'm never going to use statistics so why should I have to take it?.................. 1 2 3 4 5

51. I'm too slow in my thinking to get through statistics................................. 1 2 3 4 5

Statistical Anxiety Rating Scale

General Rules for Scoring

Scoring may be done by hand or by computer. Scale 1 includes Items 24, 26, 27, 28, 29, 33, 35, 36, 37, 40, 41, 42, 45, 47, 49, and 50; Scale 2 includes Items 2, 5, 6, 7, 9, 11, 12, 14, 17, 18, and 20; Scale 3 includes Items 1, 4, 8, 10, 13, 15, 21, and 22; Scale 4 includes Items 25, 31, 34, 38, 39, 48, and 51; Scale 5 includes Items 3, 16, 19, and 23; Scale 6 includes Items 30, 32, 43, 44, and 46. The Scale 1 score refers to worth of statistics, Scale 2 refers to interpretation anxiety, Scale 3 refers to test and class anxiety, Scale 4 refers to computation self-concept, Scale 5 refers to fear of asking for help, and Scale 6 refers to fear of statistics teachers. The total for each Scale gives the raw score for that scale.

Interpretation of Scores

For the first scale the possible scores range from "15" to "75" with low scores indicating a high perception of the relevance of statistics and high scores indicating a low perception of the relevance of statistics. For the second scale the possible scores range from "11" to "55" with low scores indicating low levels of interpretation anxiety and high scores indicating high levels of interpretation anxiety. For the third scale the possible scores range from "8" to "40" with low scores indicating low levels of test and class anxiety and high scores indicating high levels of interpretation anxiety. For the fourth scale the possible scores range from "7" to "35" with low scores indicating low levels of problem solving/computation anxiety and high scores indicating high levels of problem solving/computation anxiety. For the fifth scale the possible scores range from "4" to "20" with low scores indicating little fear of asking for help and high scores indicating a lot of fear of asking for help. For the sixth scale the possible scores range from "5" to "25" with low scores indicating little fear of statistics teachers and high scores indicating a lot of fear of statistics teachers.

APPENDIX C

Attitudes Toward Statistics (ATS)

University of
Nebraska
Lincoln
Teachers College

Steven L. Wise, Ph.D.
Educational Psychology
122 Bancroft Hall
Lincoln, NE 68588-0345

MEMORANDUM

TO: Researchers Requesting the *Attitudes Toward Statistics* Scale

FROM: Steven Wise

RE: Using the *ATS*

You have requested a copy of the *Attitude Toward Statistics* scale to use in your research. I have enclosed a copy of the scale that should be suitable for reproduction. I have also enclosed a table that lists the corrected item-total correlations that were obtained during development of the *ATS*. What should be of particular use to you is the notation in the table of the items that are reverse keyed.

In exchange for permission to use my scale, I'd like you send me a copy of any manuscripts that result from the use of the *ATS*. I'm always interested in seeing the results of studies involving this scale. I thank you in advance for your cooperation.

Telephone: (402) 472-2736 Internet SWISE@UNL.EDU Fax: (402) 472-6207

ATTITUDES TOWARD STATISTICS

Directions: For each of the following statements mark the rating category that most indicates how you currently feel about the statement. Please respond to all of the items.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. I feel that statistics will be useful to me in my profession.	____	____	____	____	____
2. The thought of being enrolled in a statistics course makes me nervous.	____	____	____	____	____
3. A good researcher must have training in statistics.	____	____	____	____	____
4. Statistics seems very mysterious to me.	____	____	____	____	____
5. Most people would benefit from taking a statistics course.	____	____	____	____	____
6. I have difficulty seeing how statistics relates to my field of study.	____	____	____	____	____
7. I see being enrolled in a statistics course as a very unpleasant experience.	____	____	____	____	____
8. I would like to continue my statistical training in an advanced course.	____	____	____	____	____
9. Statistics will be useful to me in comparing the relative merits of different objects, methods, programs, etc.	____	____	____	____	____
10. Statistics is not really very useful because it tells us what we already know anyway.	____	____	____	____	____
11. Statistical training is relevant to my performance in my field of study.	____	____	____	____	____
12. I wish that I could have avoided taking my statistics course.	____	____	____	____	____
13. Statistics is a worthwhile part of my professional training.	____	____	____	____	____
14. Statistics is too math oriented to be of much use to me in the future.	____	____	____	____	____

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
15. I get upset at the thought of enrolling in another statistics course.	____	____	____	____	____
16. Statistical analysis is best left to the "experts" and should not be part of a lay professional's job.	____	____	____	____	____
17. Statistics is an inseparable aspect of scientific research.	____	____	____	____	____
18. I feel intimidated when I have to deal with mathematical formulas.	____	____	____	____	____
19. I am excited at the prospect of actually using statistics in my job.	____	____	____	____	____
20. Studying statistics is a waste of time.	____	____	____	____	____
21. My statistical training will help me better understand the research being done in my field of study.	____	____	____	____	____
22. One becomes a more effective "consumer" of research findings if one has some training in statistics.	____	____	____	____	____
23. Training in statistics makes for a more well-rounded professional experience.	____	____	____	____	____
24. Statistical thinking can play a useful role in everyday life.	____	____	____	____	____
25. Dealing with numbers makes me uneasy.	____	____	____	____	____
26. I feel that statistics should be required early in one's professional training.	____	____	____	____	____
27. Statistics is too complicated for me to use effectively.	____	____	____	____	____
28. Statistical training is not really useful for most professionals.	____	____	____	____	____
29. Statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write.	____	____	____	____	____

Attitudes Toward Statistics

General Rules for Scoring

Scoring may be done by hand or by computer. The studies have been scored by computer. Some of the items are reversed keyed, necessitating some manipulation of the data before analysis. The items which must be reversed are: 2, 4, 6, 7, 10, 12, 14, 15, 16, 18, 20, 25, 27, and 28. Once the recoding is done, the score for each scale is the sum of the points for the items in that scale. Scale 1 (FIELD) includes Items 1, 3, 5, 6, 9, 10, 11, 13, 14, 16, 17, 19, 20, 21, 22, 23, 24, 26, 28, and 29; Scale 2 (COURSE) includes Items 2, 4, 7, 8, 12, 15, 18, 25, 27. The Scale 1 score refers to attitudes toward the field of statistics, and the Scale 2 score refers to attitudes toward the course. The total for each Scale gives the raw score for that scale.

Interpretation of Scores

For the first scale the possible scores range from "20" to "100" with low scores indicating a positive attitude toward the field of statistics and high scores indicating a negative attitude toward the field of statistics. For the second scale the possible scores range from "9" to "45" with low scores indicating a positive attitude toward the course and high scores indicating a negative attitude toward the course.

APPENDIX D

Coping Strategies Inventory for Statistics (CSIS)

COLLEGE OF EDUCATION THE UNIVERSITY OF ALABAMA

Office of Research and Service
EVALUATION AND ASSESSMENT LABORATORY

October 19, 1992

Tony Onwuegbuzie
2009 Greene St.
Apt. 213
Columbia, S. C. 29205-1681

Mr. Onwuegbuzie:

Thank you for your interest in the Coping Strategies Inventory for Statistics. Some work has been done with the inventory since the pilot, basically collecting more data and re-affirming the factor analysis. I wrote the inventory as a graduate student and used it in the statistics classes I was teaching at the time. Shortly after the MSERA presentation, dissertation work came to the forefront of my priorities, and except for the additional data collected, I have not been able to put much time into the inventory.

I am enclosing a copy of the inventory, the information on how I score it, and some broad interpretation guidelines. If you find them to be of some use, I would appreciate it if you could share your data with me. Now that I have finished school, there is more time for research and I hope to continue with this project.

Good luck with your dissertation.

Sincerely,

Michele G. Jarrell

Michele G. Jarrell, Ph.D.

enclosures

348-6203
BOX 870231 • TUSCALOOSA, ALABAMA 35487-0231 • PHONE (205) 348-9325 • FAX 348-6873

Coping Strategies Inventory for Statistics
Directions

Below you will find two scenarios. In each of these scenarios imagine that you are the student. Think about the following questions: what is your initial reaction to the description in the scenario; how would you personally cope in each situation; what action(s), if any, would you take?

Next, read the descriptions for each of the possible coping strategies. Respond by asking yourself if each of these coping strategies is CHARACTERISTIC of you or NOT AT ALL CHARACTERISTIC of you. You are to use a scale of 0 - 9 when responding to each of the possible strategies. A response at the lowest end ("0") of the scale indicates that the coping strategy is NOT AT ALL CHARACTERISTIC of you. A response at the highest end ("9") of the scale indicates that the coping strategy is DEFINITELY CHARACTERISTIC of you. A response "2", "3". ..."8" indicates the extent to which you believe that the coping strategy is characteristic of you at some point between NOT AT ALL CHARACTERISTIC and DEFINITELY CHARACTERISTIC. Each of the coping strategies is prefaced by a number, beginning with number 1. Read each statement and mark the appropriate response from "0" to "9" for the corresponding number on the answer sheet.

Rate each of the following coping strategies by filling in a circle with a number from "0" to "9" on the answer sheet to indicate the extent to which you believe it is characteristic of your behavior in that situation.

Scenario 1

You are a student in a statistics or research class, and there is an exam today. Since the semester began, you have studied hard learning statistical concepts and formulas and working many problems. As you approach the building for the exam, you are thinking about the many hours of work you have devoted to this course and how you have gone about learning the material.

Rate each of the following statements by filling in a circle with a number from "0" to "9" on the answer sheet to indicate the extent to which you believe it is characteristic of your behavior in that situation.

NOT AT ALL CHARACTERISTIC	**0 1 2 3 4 5 6 7 8 9**	**DEFINITELY CHARACTERISTIC**

While studying, you ...

1. kept reminding yourself of all the things you needed to do after studying.
2. told yourself you would understand the material if you worked calmly.
3. told yourself to concentrate on the concepts and work the study problems.
4. told yourself you could not understand the material.
5. thought the other people in the class were smarter than you.
6. thought the time and effort spent studying would pay off and that you would do well on the exam.
7. were always thinking about your plans for the weekend.
8. listed the major concepts for the exam and reviewed your notes and problems.
9. spent a lot of time getting ready to study.
10. devoted a regular time at least three or four days a week to this class.
11. were easily distracted.
12. watched television.

13. were in a calm atmosphere.

14. "studied" for more than one course at a time.

15. concentrated only on the concepts the professor indicted were important for the exam.

16. usually put off studying for an exam until the day before the exam.

17. skimmed through the text and could not make any sense out of it, so you did not study.

18. made note of questions to ask the professor in class.

19. made note of questions to ask the professor outside of class.

20. stayed with every concept until you thought you understood

Scenario 2

You are a student in a statistics or research class, and it is time for an exam. You have studied hard since the semester began and examined the statistical concepts covered in the course. You have your calculator and list of formulas ready to use during the exam. The professor hands you your paper; you read over the exam and start to work.

Rate each of the following statements by filling in a circle with a number from "0" to "9" on the answer sheet to indicate the extent to which you believe it is characteristic of your behavior in that situation.

NOT AT ALL CHARACTERISTIC	**0 1 2 3 4 5 6 7 8 9**	**DEFINITELY CHARACTERISTIC**

As you are working, you tell yourself ...

21. to stay calm and concentrate.

22. you can figure out anything that you are asked to do.

23. that you will not be able to do the problems.

24. to work as much as you can on each problem so that you can get partial credit.

25. that you are going to fail the exam.

26. to do your best and see what happens.

While you are working, you ...

27. focus on one problem at a time.

28. worry about the remainder of the test while working on problems.

29. think about what you did last night instead of studying.

30. work a problem and recall similar study problems.

31. notice other students seem to be working more rapidly.

32. find yourself in an uncontrollable state of panic.

33. skip difficult problems, do the easy problems, then go back and do the hard problems.

34. check your calculations to make sure they are right.

35. read each problem twice and check the answer.

After the exam you ...

36. know you did not prepare well enough.

37. blame the teacher for not explaining clearly.

38. did poorly because the exam was at an odd time.

39. did poorly because the professor made the exam too difficult.

40. did well because of your hard work.

There are two final questions.

41. How well do you cope with taking a statistics exam?

NOT WELL AT ALL 0 1 2 3 4 5 6 7 8 9 VERY WELL

42. How well do you cope with studying for a statistics exam?

NOT WELL AT ALL 0 1 2 3 4 5 6 7 8 9 VERY WELL

Coping Strategies Inventory for Statistics

General Rules for Scoring

Scoring may be done by hand or by computer. The studies have been scored by computer. Some of the items are reversed keyed, necessitating some manipulation of the data before analysis. The items which must be reversed are: 1, 4, 5, 7, 9, 11, 12, 14, 16, 17, 23, 25, 28, 29, 31, 32, 36, 37, 38, and 39. Once the recoding is done, the score for each scale is the sum of the points for the items in that scale. Scale 1 includes Items 1 to 20; Scale 2 includes Items 21 to 40. The Scale 1 score refers to study coping strategies, and the Scale 2 score refers to test-taking coping strategies. The total for each Scale gives the raw score for that scale.

Interpretation of Scores

For each of the two scales the possible scores range from "0" to "180" with a "0" indicating a complete lack of coping strategies and "180" indicating a very high level of coping strategies. A student with a score of "130" or higher on a scale is able to cope well in that area. A score between "110" and "129" might indicate remediation in certain areas. A score below "110" is indicative of a need for training in the use of coping strategies.

APPENDIX E

Preferred Assessment Style Scale (PASS)

APPENDIX F

Background Information Form (BIF)

BACKGROUND INFORMATION FORM

DIRECTIONS: Please complete the following statements by filling in the blanks with the required information or by circling the appropriate response.

1. The last four digits of your social security number:

    ____

2. Age: _______ Date of birth: _____________
   day/month/year

3. Sex:
Male
Female

4. Graduate degree program: _____________

5. Number of courses taken at college level in mathematics: ___________

6. Number of courses taken at college level in statistics: ___________

7. Number of years since previous college/high school mathematics course: __________

8. Number of months/years since last statistics class:

    ____

9. Final grade in previous statistics class:

A
B+
B
C+
C
D+
D
F
Other (please specify) __________

APPENDIX G

Operationalistion of Variables

STATISTICS ANXIETY RATING SCALE

WORTH OF STATISTICS (16 ITEMS):

16 USEFUL	80 WORTHLESS

INTERPRETATION ANXIETY (11 ITEMS):

11 LOW ANXIETY	55 HIGH ANXIETY

TEST AND CLASS ANXIETY (8 ITEMS):

8 LOW ANXIETY	40 HIGH ANXIETY

COMPUTATION SELF-CONCEPT (7 ITEMS):

7 LOW ANXIETY	35 HIGH ANXIETY

FEAR OF ASKING FOR HELP (4 ITEMS):

4 LOW ANXIETY	20 HIGH ANXIETY

FEAR OF STATISTICS TEACHERS (5 ITEMS):

5 LOW ANXIETY	25 HIGH ANXIETY

COPING STRATEGIES INVENTORY FOR STATISTICS

EXAMINATION-TAKING COPING STRATEGIES/STUDY COPING STRATEGIES (20 ITEMS EACH):

0	110	130	180
COMPLETE LACK OF COPING STRATEGIES	SOME REMEDIATION NEEDED	HIGH COPING STRATEGIES	

ATTITUDES TOWARD STATISTICS SCALE

ATTITUDES TOWARD THE FIELD OF STATISTICS (20 ITEMS):

20	100
POSITIVE ATTITUDE	NEGATIVE ATTITUDE

ATTITUDES TOWARD THE COURSE (9 ITEMS):

9	45
POSITIVE ATTITUDE	NEGATIVE ATTITUDE

PREFERRED ASSESSMENT STYLE SCALE

OVERALL PREFERENCE (14 ASSESSMENT STYLES)

1	5
STRONG DISLIKE	STRONG LIKING FOR

ANXIETY/PERFORMANCE/OBJECTIVITY/HIGHER-ORDER THINKING (14 ITEMS EACH):

1	2	3
REDUCE	NO CHANGE	INCREASE

APPENDIX H

Course Outline

Course Outline

Listed below are topical headings for each lecture. These lectures correspond to sections in the text. Page numbers for the sections to be covered in each lecture are given in parenthesis (MS represents the Marascuilo and Serlin text, while FRH represents the Freed, Ryan, and Hess text). The dates each lecture will be given are also listed, though this schedule may vary as the needs of the class dictate.

Date	**Topic**
1 Sep	Introduction to Course; Introduction to SAS: Review of Statistical Inference Concepts (FRH 185-194)
8	Association and Homogeneity of Qualitative Variables (MS 345-363; FRH 196)
15	Multiple Comparisons for Qualitative Variables; (Analysis of One Variance (MS 364-379, 394-403; FRH 201)
22	Two-Group Comparisons (MS 411-428; FRH 202-204)
29	Pairwise Comparisons; Complex Contrasts (MS 429-461; FRH 220-221)
6 Oct	Analysis of Two Variances; One-Factor ANOVA (MS 465-491, 500-503; FRH 207-209, 220-221)
20	Midterm Examination
27	Two-Factor Crossed Designs (MS 517-523, 533-548; FRH 209-211)
10 Nov	Two-Factor Nested Designs; Cell Means Model (MS 524-528; FRH 217-218)
17	Randomized Block Designs; Repeated Measures (MS 562-570; FRH 211-212)
24	Split-Plot Designs (MS 570-578; FRH 212-217); Project Assigned
1 Dec	Simple Regression; Multiple Regression (MS 79-117, 639-663; FRH 194-199)
8	ANCOVA (MS 693-708; FRH 218-219)
15	Final Examination

APPENDIX I

Practice Final Examination

PRACTICE FINAL EXAM

Name____

Directions: Carry out the following tasks and answer all questions. Show work where applicable. If necessary, you may use the back of the page.

An experiment was conducted to look at the effect of class gender mix on level of enjoyment of an auto mechanics class. Some subjects were placed in classes in which only one gender was present. Others were assigned to classes with about an equal mix of males and females. Subjects in the third condition were placed in classes that were primarily the other gender. At the end of the course, subjects were administered an instrument that measured their level of enjoyment of the course. Following are some analyses of the data:

ANALYSIS OF VARIANCE PROCEDURE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	5	762.96666667	152.59333333	4.74	0.0037	0.497057	35.5213
ERROR	24	772.00000000	32.16666667	ROOT MSE		SCORE MEAN	
TOTAL	29	1534.96666667		5.67156651		15.96666667	

SOURCE	DF	ANOVA SS	F VALUE	PR > F
GENDER	1	40.83333333	1.27	0.2710
TYPE	2	17.86666667	0.28	0.7599
GENDER*TYPE	2	704.26666667	10.95	0.0004

MEANS

GENDER	N	SCORE
1	15	14.8000000
2	15	17.1333333

TYPE	N	SCORE
1	10	16.7000000
2	10	16.3000000
3	10	14.9000000

GENDER	TYPE	N	SCORE
1	1	5	20.0000000
1	2	5	17.4000000
1	3	5	7.0000000
2	1	5	13.4000000
2	2	5	15.2000000
2	3	5	22.8000000

CODE FOR GENDER: 1 = FEMALE
2 = MALE

CODE FOR TYPE: 1 = SAME
2 = MIXED
3 = OTHER

1. Write the omnibus hypotheses for the effects and then circle those hypotheses that are rejected. Use $\alpha = .025$ for each effect.

2. Use a post hoc procedure to test the null hypothesis that students in same-gender auto mechanics classes report the same level of enjoyment as students in the mixed- and other-gender classes combined.

3. Calculate an interaction contrast to see if the difference between same-gender and other-gender means is different for males and females. You do **not** need to test this contrast.

4. Briefly state what the above interaction contrast shows for this set of data.

5. Suppose this same data had been analyzed using a nested model such that GENDER and TYPE(GENDER) were the main effects of interest. What would the Scheffé critical value be for testing contrasts subsumed by TYPE(GENDER)?

The usefulness of computer-managed spelling drills for the classroom was evaluated in the following manner. Six sixth graders were given a spelling test. Those students who scored above the median were categorized as "good" spellers, while those scoring below the median were categorized as "poor" spellers. The scores were recorded for later analysis. During the next two months, all students used the computer for self-paced spelling drills. Two additional spelling tests were given after one month and after two months. Here are some analyses from the experiment:

ANALYSIS OF VARIANCE PROCEDURE

TESTS OF HYPOTHESES FOR BETWEEN SUBJECTS EFFECTS

SOURCE	DF	ANOVA SS	MEAN SQUARE	F VALUE	PR > F
GROUP	1	29.38888889	29.38888889	0.65	0.4656
ERROR	4	181.11111111	45.27777778		

UNIVARIATE TESTS OF HYPOTHESES FOR WITHIN SUBJECT EFFECTS

SOURCE	DF	ANOVA SS	MEAN SQUARE	F VALUE	PR > F
TEST	2	597.00000000	298.50000000	86.66	0.0001
TEST*GROUP	2	131.44444444	65.72222222	19.08	0.0009
ERROR(TEST)	8	27.55555556	3.44444444		

CODE FOR GROUP: 1 = GOOD
2 = POOR

6. Calculate an estimate of the effect size for all effects that are statistically significant using α = .10 for each family.

Listed below are some correlational analyses for three test scores: first test, second test, and final test.

DEP VARIABLE: FINAL

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	1	6036.64033	6036.64033	11.164	0.0034
ERROR	19	10273.35967	540.70314		
C TOTAL	20	16310.00000			

ROOT MSE	23.25302	R-SQUARE	0.3701
DEP MEAN	100	ADJ R-SQ	0.3370
C.V.	23.25302		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > ¦T¦
INTERCEP	1	35.72343921	19.89484767	1.796	0.0885
FIRST	1	1.38869113	0.41561140	3.341	0.0034

DEP VARIABLE: FINAL

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	1	5685.31964	5685.31964	10.167	0.0048
ERROR	19	10624.68036	559.19370		
C TOTAL	20	16310.00000			

ROOT MSE	23.64728	R-SQUARE	0.3486
DEP MEAN	100	ADJ R-SQ	0.3143
C.V.	23.64728		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > ¦T¦
INTERCEP	1	41.40412924	19.08759596	2.169	0.0430
SECOND	1	0.96738466	0.30339114	3.189	0.0048

DEP VARIABLE: FINAL

ANALYSIS OF VARIANCE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	2	7521.12646	3760.56323	7.702	0.0038
ERROR	18	8788.87354	488.27075		
C TOTAL	20	16310.00000			

ROOT MSE	22.09685	R-SQUARE	0.4611
DEP MEAN	100	ADJ R-SQ	0.4013
C.V.	22.09685		

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR H0: PARAMETER=0	PROB > |T|
INTERCEP	1	21.11294276	20.67936104	1.021	0.3208
FIRST	1	0.92391067	0.47648238	1.939	0.0683
SECOND	1	0.59637346	0.34202716	1.744	0.0983

7. State the sample correlation between the first and final tests. Use α = .05 to test the null hypothesis that the population correlation is zero. Report the effect size, if appropriate.

8. Briefly describe how the error sum of squares of 10273.4 was calculated for the first model tested above.

9. Write the equation for predicting the final test score from the second test score.

10. Calculate the predicted final test score for a second test score of 30.

11. Calculate the squared semipartial correlation for the first test when adding this test score to the prediction equation of #3. Use α = .05 to test the null hypothesis that this correlation is zero.

A study was conducted to look for differences in school success for students with different authoritarian styles. The dependent variable (SUCCESS) is an aggregate measure of success for four years of college. The independent variable (AUTHOR) is a four-category grouping of authoritarian style. An ANCOVA was conducted since a third variable, student anxiety (ANXIETY), is known to be correlated with school success. Here are the results of the analysis:

GENERAL LINEAR MODELS PROCEDURE

DEPENDENT VARIABLE: SUCCESS

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PR > F	R-SQUARE	C.V.
MODEL	4	624.74434586	156.18608646	68.67	0.0001	0.935304	6.6904
ERROR	19	43.21398747	2.27442039	ROOT MSE		SUCCESS MEAN	
CORRECTED TOTAL	23	667.95833333		1.50811816		22.54166667	

SOURCE	DF	TYPE I SS	F VALUE	PR > F	DF	TYPE III SS	F VALUE	PR > F
AUTHOR	3	488.79166667	71.64	0.0001	3	559.62424782	82.02	0.0001
ANXIETY	1	135.95267919	59.77	0.0001	1	135.95267919	59.77	0.0001

12. State the appropriate null hypothesis to be tested.

13. Use the results given here to conduct the test of the above hypothesis with $\alpha = .01$. If appropriate, report an effect size.

14. Describe the conditions necessary for the appropriate inclusion of the variable ANXIETY as a covariate.

APPENDIX J

Instructions for Timed Examination Group

<u>**Instruction for Proctor of Timed Examination**</u>

Please:

(1) Make sure that all students are seated as far apart from one another as possible.

(2) If any student turns in their examination sheet within the 90-minute time period, instruct them to take their sheet to the proctor in Room 203, the room in which they originally assembled.

(3) I will come into the classroom when the 90 minutes have elapsed, in order to collect up all remaining examination papers.

When students are seated appropriately, please give out the examination forms which are contained in separate envelopes. When everyone has received a form please read out the following, verbatim:

"Thank you for participating in this study. Your examination will be a maximum of 90-minutes. There are 19 questions. You are encouraged to attempt all 19 questions, showing all your work. If necessary, you may use the back of the page for your solutions.

If you have any questions about any of the examination items, take your examination sheet to the front of the class and ask the proctor. If already there is another student asking the proctor a question, please wait until the student has returned to her/his seat before going up to ask your question. There is no guarantee that your question will be answered.

Please ensure that you write your name and last four digits of your social security number on the first page of your examination sheet.

You are allowed to use a maximum of three 8.5" x 11" pages (that is, 6 sides). You are also permitted to use pocket calculators. Statistical tables have been provided. Please do not write on these tables and return them together with your examination sheet in the envelope provided.

All students are expected to adhere to the academic code of conduct.

The amount of time remaining will be written on the blackboard periodically. If you complete the examination before the allotted time put your examination sheet and statistical tables in the envelope provided and take it to the proctor at the front of the class. Please do not seal the envelope.

Good luck. You may now begin."

APPENDIX K

Instructions for Untimed Examination Group

Instruction for Proctor of Untimed Examination

Please:

Make sure that all students are seated as far apart from one another as possible.

When students are seated appropriately, please give out the examination forms which are contained in separate envelopes. When everyone has received a form please read out the following, verbatim:

"Thank you for participating in this study. You can take as long as you like to complete the examination. There are 19 questions. You are encouraged to attempt all 19 questions, showing all your work. If necessary, you may use the back of the page for your solutions.

If you have any questions about any of the examination items, take your examination sheet to the front of the class and ask the proctor. If already there is another student asking the proctor a question, please wait until the student has returned to her/his seat before going up to ask your question. There is no guarantee that your question will be answered.

Please ensure that you write your name and last four digits of your social security number on the first page of your examination sheet.

You are allowed to use a maximum of three 8.5" x 11" pages (that is, 6 sides). You are also permitted to use pocket calculators. Statistical tables have been provided. Please do not write on these tables and return them together with your examination sheet in the envelope provided.

All students are expected to adhere to the academic code of conduct.

Whne you complete the examination, put your examination sheet and statistical tables in the envelope provided and take it to the proctor at the front of the class. Please do not seal the envelope.

Good luck. You may now begin."