A COMPARISON OF TWO PALLIATIVE METHODS OF INTERVENTION FOR THE TREATMENT OF MATHEMATICS ANXIETY AMONG FEMALE COLLEGE STUDENTS

by

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(ABSTRACT)

Bandura's (1978) self-efficacy theory provided the conceptual basis for two math-anxiety interventions: cognitive restructuring (CR) and modified progressive relaxation (MPR). These two palliative techniques were chosen since considerable evidence exists which indicates that both intrapsychic and symptom-directed methods are effective as therapeutic interventions for a wide range of stress-related problems. In addition to the treatment variable, there were two other independent variables: level of achievement in mathematics (SAT), and level of participation in mathematics (remedial, intermediate, or advanced). The sample consisted of sixty-two female subjects enrolled in a small private liberal arts college for women. Four research questions were investigated: (1) When administered over a six-week treatment period, are CR and MPR equally effective in reducing mathematics anxiety among female college students? (2) Are any combinations of treatment and level of achievement in mathematics characterized by lower levels of anxiety than other combinations? (3) Are

any combinations of treatment and level of participation in mathematics characterized by lower levels of anxiety than other combinations? (4) To what extent do physiological indicators of mathematics anxiety and paper-and-pencil assessments measure the same construct?

Data were collected in two stages. The first stage occurred at the end of a six-week treatment period, at which time Sandman's (1973) Mathematics Attitude Inventory (MAI) and an electromyograph (EMG) were used to obtain self-report and physiological measures of mathematics anxiety, respectively. The second stage occurred eight weeks later, at which time the MAI was readministered. Inferential methods revealed that: (1) when mathematics anxiety was measured with Sandman's MAI, for both the immediate and delayed posttests, the difference between the mean levels of self-reported anxiety for CR and MPR subjects was not statistically discernible; (2) when anxiety was operationally defined as skeletal muscle tension and measured with an electromyograph, CR led to significantly greater reductions in anxiety than MPR ($F=2.81$, $p=.036$); (3) there was no interaction between type of intervention and level of achievement in mathematics; (4) when anxiety was operationally defined as skeletal muscle tension and measured with an electromyograph, a statistically discernible (F=3.925, p=.027) synergistic effect was detected between type of intervention and level of particpation in mathematics, indicating that CR is superior to MPR for subjects at advanced levels of participation in mathematics; (5) there was insufficient evidence to indicate that a linear relationship exists between paper-and-pencil (MAI) and physiological (EMG) measures of mathematics anxiety, implying that the two instruments may be tapping different dimensions of the mathematics anxiety construct.

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Chapter I

The Nature of the Investigation

Awareness of and commitment to educational equity is an important goal of democratic societies. A serious inequity that exists in American society is that many more females than males fail to achieve their full potential in mathematics (Fennema, 1984). Betz and Hackett (1981) found that female students judge themselves as less efficacious in mastering the educational prerequisites of vocations dominated by men and shy away from such careers despite equality with males in actual verbal and quantitative ability.

Without extensive preparation in mathematics, females are blocked from entering an increasing number of professions (Sells, 1980; Taylor and Betz, 1983). Betz (1978) investigated the factors related to the prevalence and intensity of mathematics anxiety among college students and reported that mathematics anxiety is more common and more severe among women than among men.

Since mathematics anxiety is one of the factors contributing to the problem of underrepresentation of females in scientific and technical fields (Tobias, 1976), there is a need to pursue at least three levels of investigation: (1) to understand the etiology of mathematics anxiety, (2) to develop intervention strategies which help individuals who exhibit this affective problem, and (3) to compare the relative effectiveness of these interventions. This investigation focuses on the latter need.

In 1980 Tobias and Weissbrod published an article in the Harvard Educational Review entitled "Anxiety and Mathematics: An Update." After carefully reviewing the numerous math anxiety interventions available at that time they concluded: (1) There is no typical technique; (2) Practice is moving ahead of theory (i.e., most of the intervention strategies originated from an urgent desire to produce change rather than a desire to test one theory against another, so that practitioners frequently utilize a shotgun approach hoping that at least one component of the program will be effective); (3) There is a need for formal evaluation of these interventions; (4) New techniques need to be devised that are more closely linked to theories of learning since theory-based interventions will not only help eliminate the symptoms of mathematics anxiety but will eventually lead to a clearer understanding of its causes; and (5) We need to know much more than we do now about how and why they work, and under what conditions one strategy is more effective than another before broad use of these interventions can be recommended.

A review of post-1980 literature reveals little change in the situation. Practitioners utilize a variety of intervention techniques, and although positive results have been achieved, most interventions are not designed on theory-based considerations. As a result, current practice is not guided by a conceptual framework.

Theoretical Framework

The term 'math anxiety' first appeared in the scholarly literature about thirty years ago (Gough, 1954). There are a variety of definitions of the math-anxiety syndrome, but certain commonalities emerge (Heller and Kogelman, 1982): (1) Mathematics anxiety sufferers exhibit mild to severe physical discomfort; (2) mathematics anxiety is frequently associated with early traumatic experiences with particular mathematics concepts; and (3) mathematics anxiety is frequently associated with irrational beliefs about mathematics and how it is performed. Therefore, the math-anxious individual must struggle with a combination of three negative elements: (1) undesirable physiological responses, (2) certain pernicious features of the math-environment, and (3) maladaptive thoughts.

Bandura's (1977) social learning theory seeks to incorporate these three components into an integrated framework. A basic premise of social learning theory is that psychological functioning involves a reciprocal interaction among three interlocking sets of factors: behavioral, environmental, and cognitive. The concept of reciprocal determinism is represented diagrammatically in Figure 1.

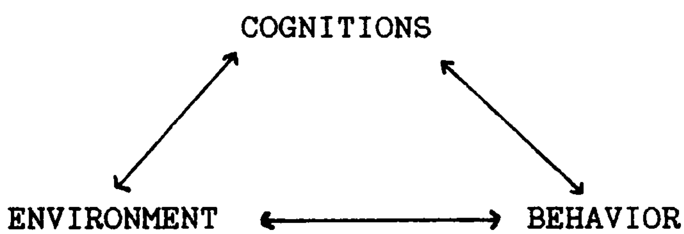

Figure 1. Reciprocal Determinism.

Cognitive, environmental, and behavioral factors do not function autonomously; they determine each other. Each arrow in Figure 1 represents a two-way regulatory system within a larger multi-faceted regulatory system.

The environment is not viewed as a fixed state that inevitably impinges upon individuals so that they are simply passive reactors to external stimuli; the environment can also be influenced. An individual's behavior partially determines which aspects of the potential environment are actualized. From a social learning theory perspective, people are both agents and objects of behavioral control. They are neither pawns controlled by environmental forces nor free agents who can become whatever they choose.

In addition, thoughts can regulate actions. People behave on the basis of outcomes they expect to prevail in the future. As a result, people's expectations influence how they behave, and the outcomes of their behaviors change their expectations.

Cognitive processes also play an important mediational role in the acquisition and retention of behavior. Identical environmental antecedents can have different behavioral effects depending on one's beliefs and expectations. Although thoughts are partly governed by external stimuli, people often distort what they see and hear through their personal biases. Acting on erroneous perceptions and expectations can alter how others behave, thus shaping the environment in the direction of one's expectations. In particular, expectations of personal efficacy play an important role in Bandura's theory. Efficacy expectations are perceptions of personal mastery, i.e., subjective estimates regarding one's ability to cope sucessfully. They are specific rather than global in nature; vary in magnitude (i.e., perceived task difficulty), strength (i.e., ability to persevere) and generality (i.e., a sense of efficacy that extends beyond a specific task); influence people's behaviors, thought processes, and emotional reactions; and determine how much effort people expend and how long they persist in the face of obstacles. In addition, efficacy expectations are derived from four different sources of information: (1) performance accomplishments (e.g., successes raise mastery expectations, whereas repeated failures lower them); (2) vicarious experience (e.g., observing others perform threatening activities without adverse consequences); (3) verbal persuasion (e.g., people are led, by suggestion, to believe they can cope successfully with what has overwhelmed them in the past); and (4) emotional arousal (e.g., people rely on their states of physiological arousal in judging their susceptibilities to stress).

The relationship between self-efficacy and attitudes toward mathematics was studied by Collins (1982) who reported that they are positively correlated (i.e., those who regard themselves as highly efficacious approach potentially threatening tasks nonanxiously). Further, Hackett (1981) reported a significant relationship between perceived self-inefficacy in dealing with numbers and mathematics anxiety (i.e., those who regard themselves as inefficacious experience varying degrees of anxiety and stress). Since Bandura (1978) argues that anxiety is the product of perceived inefficacy (i.e., a weak sense of personal mastery) social learning theory provides a useful framework for the study of mathematics anxiety.

Operating from different theoretical viewpoints, behavioral therapists have developed a variety of interventions for the treatment of anxiety disorders. Corresponding to the environmental component of Bandura's model are direct action methods of intervention designed to alter anxiety-eliciting environments. Corresponding to the cognitive and behavioral components of Bandura's model are intrapsychic and symptom-directed modes of intervention, respectively, which are aimed at reducing the level of anxiety once it has been aroused. Modified progressive relaxation (MPR) is a symptom-directed mode of reducing anxiety, whereas cognitive restructuring (CR) is an intrapsychic mode of alleviating anxiety. Palliative methods such as these are used to soften or moderate anxiety, thus helping individuals to function adequately within anxiety-eliciting environments. The relationships among the components of Bandura's model and the three classes of intervention techniques are illustrated in Figure 2.

From a social learning theory perspective, anxiety disorders are the result of faulty or inappropriately functioning reciprocal systems. Faulty reciprocal systems can be viewed as negative feedback loops among the mind, body, and environment (McKay, Davis, and Fanning, 1981). Each influences the other in an escalating pattern of debilitative cognitive and physiological reactions. For example, Kogelman and Warren (1978) describe the internal dialogue in which individuals engage when faced with mathematics problems. These "little conversations going on in our heads" are many times "negative and defeatist," creating environments in which anxiety can fluorish. To break a negative feedback loop it is necessary to modify at least one of the following: (1) physiological responses (e.g., use modified progressive relaxation), (2) negative thoughts (e.g., use cognitive restructuring), or (3) the environment (e.g., use a self-paced mode of instruction). Social learning theory postulates that treatments will be successful to the extent that they restore and

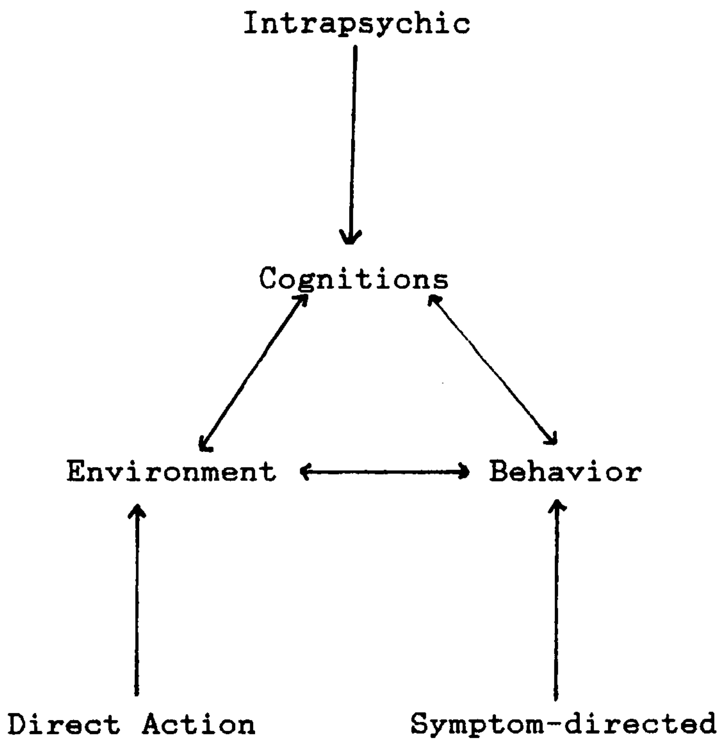

Figure 2. Intervention Strategies.

strengthen subjects' expectations of personal efficacy (i.e., the subjective estimate that they have the ability to cope successfully). The greater the increase in self-efficacy, the greater the likelihood of prolonged reduction in anxiety. The implication of self-efficacy theory is that unless treatments provide individuals with coping skills, the probability of treatment-produced improvements is very low.

Literature Review

Important gains have been made in mathematics anxiety research; however, several problems have surfaced: (1) a clear majority of the interventions are not designed on theory-based considerations, (2) only self-report inventories of mathematics anxiety are used in most studies, (3) few follow-up studies are conducted to test for durability of treatment-produced improvements, (4) the relationship between treatment time and treatment success is unclear, and (5) few studies deal exclusively with female subjects. These five criteria will provide a framework for the literature review.

Direct Action Interventions

Operant methods have traditionally been used to treat a variety of behavioral problems under the assumption that behavior is a function of the environment. Therapists have used the principles of positive reinforcement to successfully treat hypertension, migraine headaches, hyperactivity, and anxiety disorders (Birbaumer, 1977; Blanchard and Young, 1974; Blanchard, Theobald, Williamson, Silver, and Brown, 1978; Miller, 1978; Tarler-Benlolo, 1978). Despite the clear successes obtained with the operant approach, whenever long-term environmental control was not achieved, treatment failures occurred (Blanchard, 1979; Surwit, Shapiro, and Good, 1978).

Mathematics. Six studies were reviewed which are typical of direct action methods of mathematics anxiety intervention (Auslander, 1979; Esposito, 1984; Frye, 1983; Martin, 1980; Smith, 1983; Urbatsch, 1980). Three achieved positive outcomes (Auslander, 1979; Esposito, 1984; Frye, 1983); three did not (Martin, 1980; Smith, 1983; Urbatsch, 1980). In particular, interventions utilizing either strategy game play or diagnosis and prescription were superior to those making use of either calculators or a self-paced approach. For those studies that reported positive outcomes, at least a ten week treatment period was necesary to produce significant reductions in anxiety, although in general there appeared to be no definite relationship between treatment length and treatment effectiveness. Only self-report inventories were used in all six studies, no follow-up studies were conducted, and none of the studies dealt exclusively with female subjects.

Discussion. Although the theoretical underpinnings were not always explicit, the mixed results achieved by environmentally-focused interventions can be explained from a social learning theory perspective (Bandura, 1977). One scenario is that some math-anxious individuals are confident of their capabilities in mathematics but experience anxiety because they do not expect their behaviors to have any substantial effects on unresponsive environments. For individuals who experience outcome-based anxiety, direct action interventions that alter prevailing environmental contingencies are predictably successful in alleviating certain conditions which militate against a woman's success in mathematics (Hilton, 1978). However, other math-anxious individuals are not at all confident of their capabilities in mathematics, and, as a result, experience anxiety because they lack a sense of efficacy in achieving mastery. Because subjects are not equipped with active coping skills, simply changing the prevailing environmental contingencies does not substantially reduce efficacy-based anxiety. Consequently, treatment successes occur with some math-anxious individuals, while treatment failures occur with others. That is, it is possible that environmentally-focused methods of intervention achieve only limited short-term results because outcome-based anxiety rather than efficacy-based anxiety is the primary focus of treatment. Moreover, since few follow-up studies were conducted, no convincing evidence exists that direct action interventions produce durable rather than transitory improvements.

To reiterate, interventions aimed at modifying the mathematics learning environment are plentiful and achieve positive results. However, the impact of direct action interventions is limited, since at the conclusion of the interventions individuals who were math-anxious return to the usual "musty fare of chalkboard and lecture that has shored the traditional curriculum for so many years" (Mitzman, 1976). Treatment-produced improvement is not sustained, since the math-anxious individual is not provided with a set of coping skills.

Social learning theory provides a means of conceptualizing this relapse process. Environmental interventions do not adequately increase the strength and generality of subjects' expectations of personal efficacy. As a result, treatment effects are easily extinguished.

On balance, environmental interventions have made an important contribution toward understanding and treating mathematics anxiety. Better teaching, more readable textbooks, improved evaluation instruments, and the modification of other pertinent environmental contingencies help create relatively anxiety-free environments conducive to learning mathematics. A better understanding of the etiology of mathematics anxiety may reveal that environmental interventions designed to alter certain features of the standard curriculum and pedagogy of mathematics impact some of the possible causes of mathematics anxiety (Hilton, 1978).

Intrapsychic Interventions

Cognitively oriented theories postulate that emotional or physiological arousal flows from cognitive or thought processes. First individuals evaluate the personal significance of what is happening, then this evaluation becomes the cognitive basis for their emotional reactions (Lazarus and Folkman, 1984). Although emotion and cognition are theoretically separable, from a social learning perspective they are interdependent. Cognitions are shaped by emotions and emotions are shaped by thought processes. According to the principle of reciprocal determinism, causality is bidirectional (Bandura, 1977). That is, anxiety not only refers to a particular set of physiological reactions; it also refers to maladaptive thoughts about certain environmental contingencies. When the number and/or intensity of maladaptive cognitions decreases anxiety begins to subside and may eventually disappear. The physiological reaction by itself cannot be said to be anxiety (Lazarus and Folkman, 1984). Lazarus (1982) argues that cognitive appraisal mediates emotional reactions to a greater or lesser degree, although emotions once generated can then affect the appraisal process. From a social learning perspective, these cognitive mediators are efficacy expectations (Bandura, 1978).

Some theorists (Meichenbaum, 1977) argue that maladaptive cognitions (catastrophic or irrational thoughts) are critical to both the genesis and maintenance of anxiety reactions. The ways individuals label or evaluate external stimuli often have more impact on their emotional states than the objective characteristics of the situations. When people inappropriately label situations or events as "threatening," this mislabeling process is likely to mediate emotional arousal and, as a result, they report being upset, tense, nervous, or scared. To the extent that individuals hold irrational or unrealistic beliefs about certain classes of events or situations they increase the likelihood of mislabeling those events, and, consequently, increase their susceptibilities to emotional upset. In a recent study conducted at the State University of New York at Albany, Last, Barlow, and O'Brien (1985) reported that negative thoughts are correlated with anxiety, and larger percentages of these thoughts correspond to higher anxiety ratings. Himle, Thyer, and Papsdorf (1982) found consistent negative correlations between specific irrational beliefs and measures of anxiety, and Galassi, Frierson, and Sharer (1981) found that individuals characterized by high levels of test anxiety exhibit thoughts and self-statements which are distinctly different from those of less anxious persons. Sewitch and Kirsch (1984) tested Beck's (1976) hypothesis that the experience of anxiety is preceded by threat-related thoughts. Results offered qualified support for Beck's threat-anxiety connection. Making use of a cognitive method for reducing stress associated with public speaking, McKibben (1983) found that "irrational beliefs can describe some of the symptoms of stress." She concluded that the "experience of stress is due to the perception and attitude of the individual and not to any event or situation." This lends support to the idea that individuals react to the environment as they perceive it, rather than the actual environment.

Since the theory asserts that maladaptive thoughts exert causal effects on behavior, cognitive behavioral therapists have designed a variety of cognitive restructuring interventions. Treatments consist of helping subjects identify irrational self-statements and teaching them to substitute more positive, realistic statements. Cognitive therapy has been successfully used to reduce test anxiety, speech anxiety, social-evaluative anxiety, and to treat depression (DiLoreto, 1971; Ellis and Greiger, 1977; Holroyd, 1976; Kanter and Goldfried, 1979; Meichenbaum, Gilmore, and Fedoravicius, 1971). For example, Wise and Haynes (1983) compared rational restructuring and attentional training for the cognitive treatment of test anxiety. Both cognitive treatments were superior to a control group in reducing test anxiety, and treatment effects were maintained at the time of an eight-month follow-up. D'Alelio and Murray (1981) also reported that both eight-week and four-week cognitive therapy sessions were superior to a control group in reducing self-reported anxiety.

Mathematics. The literature indicates that intrapsychic techniques (e.g., cognitive restructuring, hypnotherapeutic restructuring, self-instructional training, rational-emotive therapy) are effective in reducing mathematics anxiety when presented to subjects as active coping skills (DeBronac-Meade and Brown, 1982; Deitch, 1981; Genshaft and Hirt, 1980; Probert, 1981; Themes, 1982; Trent, 1985). Positive results were reported in five of the six studies reviewed. With the exception of one study (Deitch, 1981), only paper-and-pencil assessments were utilized. The majority of studies were typically six to eight weeks in duration, with a modal treatment time of six weeks. Two of the six studies (Deitch, 1981; Themes, 1982) included follow-up assessments to test for durability of improvements; the results of both studies indicated that cognitive restructuring produces durable rather than transitory improvements. Half of the studies (Deitch, 1981; Genshaft and Hirt, 1980; Themes, 1982) dealt exclusively with female subjects. At least one study (Themes, 1982) was theory-based, building on the work of Meichenbaum (1977) and Ellis (1977). In addition, cognitive restructuring was at least as effective as systematic desensitization in those investigations in which the two were competing treatments (Deitch, 1981; Trent, 1985).

Discussion. Evidence exists that intrapsychic methods of intervention successfully reduce anxiety, and that long-term improvement results. One explanation for this phenomenon is that intrapsychic techniques, unlike direct action techniques, focus primarily on efficacy-based anxiety. During treatment math-anxious persons learn to replace maladaptive thoughts with more positive rational thoughts. As they gain a sense of personal mastery their efficacy expectations are strengthened leading to a reduction in anxiety. To the extent that math-anxious individuals continue to use these coping skills, long-term or durable improvements are achieved. Since the success of intrapsychic techniques in treating a variety of anxiety disorders has been confirmed, the present investigation will study cognitive restructuring as an intrapsychic mathematics anxiety intervention strategy.

Symptom-directed Interventions

Self-control is a behavior modification procedure initiated primarily by individuals for the purpose of influencing their own behavior. Some therapists rely heavily on the use of progressive relaxation for the treatment of anxiety disorders; they assume that people are agents of change and possess the capacity for self-direction. In progressive relaxation intervention, therapists teach individuals to systematically tense and relax different muscle groups. Individuals learn to substitute feelings of relaxation for unwanted physiological responses (Wilson and O'Leary, 1980) since deep muscle relaxation reduces physiological tension and is incompatible with anxiety (Jacobson, 1938).

Muscular relaxation was first introduced as an effective treatment for various forms of tension and anxiety approximately fifty years ago (Jacobson, 1938). However, the technique did not receive recognition by the scholarly community until Wolpe (1958) introduced a modified form of relaxation and provided the theoretical underpinnings for the method. He postulated that individuals experience anxiety in the presence of specific stimuli through a process of classical conditioning. If a response incompatible with anxiety (e.g., relaxation) is produced in the presence of an anxiety-provoking stimulus, then the bond between the stimulus and the anxiety response is weakened. Several researchers concluded that muscular relaxation reduces autonomic activity (Benjamin, Marks, and Huson, 1972;

Mathews and Gelder, 1969; Paul, 1969). Wolpe described the inhibition of anxiety by some competing response as 'reciprocal inhibition.' From a social learning theory perspective, it is primarily perceived inefficacy that leads to anxiety; that is, anxiety is reactive rather than conditioned (Bandura, 1978).

Behavior therapists successfully use progressive relaxation for the treatment of anxiety, tension, insomnia, hypertension, fear, and other stress-related disorders (Jacob, Kraemer, and Agras, 1977; Benson, 1975; Bootzin and Nicassio, 1978; Borkovec, Grayson, and Cooper, 1978; Lehrer, 1978). Hillenberg and Collins (1982) conducted an extensive review of the relaxation training literature published between 1970 and 1979. After reviewing eighty studies, the authors concluded that "relaxation training is apparently effective as a therapeutic intervention for a wide variety of problems." For example, Lehrer, Woolfolk, Rooney, McCann, and Carrington (1983) compared progressive relaxation, meditation, and a waiting-list control for the treatment of general anxiety. Results indicated that progressive relaxation produced larger decreases in forearm EMG responsiveness to stressful stimulation than meditation. Pitkin (1983) found a combination of cognitive restructuring and relaxation-imagery to be effective in reducing college students' levels of generalized anxiety when treatment sessions were conducted by a state-licensed psychologist over a period of six weeks. In a study at West Virginia University (Hillenberg and Collins, 1983) subjects experiencing general anxiety and tension problems were assigned to one of three treatments: (1) home practice relaxation, (2) no home practice relaxation, or (3) control group. Treatment was conducted for ten sessions over a five-week period. Both progressive relaxation conditions were superior to the control condition.

Several studies have shown applied relaxation training to be effective in reducing test anxiety (Chang-Liang and Denney, 1976; Russell, Wise, and Stratoudakis, 1976) and speech anxiety (Goldfried and Trier, 1974; Russell and Wise, 1976). An investigation by Robinson (1983) at the University of Arkansas revealed that a relaxation-desensitization exercise program was effective in reducing test anxiety. In addition, findings strongly suggested that a reduction in test anxiety helped students recall materials which resulted in higher academic achievement. The results of a four-week study at Temple University (Cavallaro, 1983) involving sixty-seven female subjects with high scores on Spielberger's Test Anxiety Inventory indicated that relaxation combined with cognitive restructuring was more effective than relaxation combined with study skills in reducing test anxiety.

A five-week study (Ahmad, 1983) involving sixty teacher trainees found that teaching anxiety, as measured by the Teaching Anxiety Scale, can be effectively reduced using relaxation exercise, situational message, or group counseling. Post hoc comparisons showed no particular treatment to be superior. There are also a number of studies in which relaxation has played a facilitative role in the treatment of phobias (Bedell, 1976; Borkovec and Sides, 1979; O'Brien and Borkovec, 1977; Waters, McDonald and Koresko, 1972).

Mathematics. The literature indicates that symptom-directed techniques (e.g., progressive relaxation, systematic desensitization, anxiety management training, and cue-controlled relaxation) are effective in reducing mathematics anxiety when presented to subjects as active coping skills (Bander, Russell, Zamostny, 1982; Bromach, 1980; Fitzgerald, 1984; Goodall, 1981; Olson and Gillingham, 1980; Piggott, 1983; Richardson and Suinn, 1973; Toliver, 1982). Positive results were reported in six of the eight studies reviewed. The two studies that reported treatment failures (Bromach, 1980; Fitzgerald, 1984) were at least nine weeks in duration, and, as a result, longer in duration than the other studies. Only self-report measures of anxiety were utilized, and only one study (Bromach, 1980) dealt exclusively with female subjects. At least one study (Bromach, 1980) was theory-based, predicated on the work of Wolpe (1969). No follow-up assessments of treatment stability were reported.

Discussion. Many individuals with mathematics anxiety experience mild to severe physical discomfort and report being tense, upset, nervous, and/or scared in math-related situations (Heller and Kogelman, 1982; Sandman, 1973). They sometimes feel helpless when they attempt to control these unwanted physiological responses (Tobias, 1978). Interventions that utilize deep muscle relaxation equip subjects with coping skills. As they learn to function adequately within anxiety-eliciting environments, they gain a sense of personal mastery, i.e., efficacy expectations are strengthened, and, as a result, anxiety decreases. Since the success of symptom-directed interventions has been confirmed in treating anxiety, tension, insomnia, hypertension, fear, and other stress-related disorders, the present study will investigate the use of modified progressive relaxation as a symptom-directed mathematics anxiety intervention strategy.

Summary and Implications

There are a variety of techniques available for the treatment of mathematics anxiety. A review of the literature reveals that no particular intervention is effective with all math-anxious individuals, although palliative methods such as cognitive restructuring and modified progressive relaxation which equip individuals with coping skills have a higher success rate than direct action methods. This perspective is supported by a study at George Peabody College for Teachers (Henderson, 1982) in which elementary school teachers with low levels of anxiety utilized a wide variety of coping techniques to alleviate stress.

Tobias and Weissbrod (1980) report that research to date depends almost entirely on paper-and-pencil assessments of mathematics anxiety. A review of nineteen studies revealed that only two studies utilized a physiological measure of mathematics anxiety (Christopher, 1980; Deitch, 1981). Seven of the nineteen studies used the Fennema-Sherman Mathematics Anxiety Scales (FSMAS), and the remaining ten studies used Suinn's Mathematics Anxiety Rating Scale (MARS). The investigation being reported utilized a self-reporting instrument along with a physiological indicator of anxiety to contribute to a refinement of the mathematics anxiety construct. This dual approach may help clarify the controversy surrounding the structure and dimensionality of mathematics anxiety (Ferguson, 1983; Frary and Ling, 1983; Rounds and Hendel, 1980).

There is no uniform standard for treatment time. Some researchers have successfully abbreviated the treatment time to a single marathon session (Richardson and Suinn, 1973), while others have used one-hour sessions spread over a five-week period (Bander, Russell, and Zamostny, 1982), or have designed interventions that last for one semester (Smith, 1982). There is insufficient evidence to indicate that a direct link exists between treatment time and treatment success. Apparently the type and quality of treatment, and whether or not the treatment is expertly administered, are as important or more important than treatment time, per se. In the study being reported each treatment group met once each week for six consecutive weeks; this seemed reasonable since the typical or modal treatment time for successful interventions utilizing some form of cognitive restructuring or deep muscle relaxation was six weeks.

A review of twenty-one mathematics anxiety intervention studies revealed that only four included a follow-up study to test for durability of treatment-produced improvement (Bander, Russell, and Zamostny, 1982; Deitch, 1981; Drapac, 1981; Themes, 1982). In both a mathematics setting (Deitch, 1981; Themes, 1982) and a non-mathematics setting (Deffenbacher and Hahnloser, 1981; Holroyd and Andrasik, 1982), findings suggest that the effects of palliative methods such as cognitive restructuring and progressive relaxation used separately or in tandem are durable rather than transitory. Since social learning theory predicts that coping behaviors may be easily extinguished unless strong expectations of personal efficacy are induced by the treatments, a two-month follow-up study was conducted in the study being reported to test for stability of treatment effects.

A review of twenty-three mathematics anxiety intervention studies revealed that only seven dealt exclusively with female subjects (Bromach, 1980; Buere, 1981; Deitch, 1981; Genshaft and Hirt, 1980; Glass, 1982; Spungin, 1981; Themes, 1982). Consideration of this statistic, together with the issue of differential treatment of female and male students by mathematics teachers (Becker, 1980), and the belief that mathematics anxiety is more common and severe among females (Betz, 1978), contributed to the decision to limit this study to females, while acknowledging that mathematics anxiety is not confined to the female gender (Hilton, 1978).

The present study compared cognitive restructuring and modified progressive relaxation for the reduction of mathematics anxiety among female college students. Unlike direct action interventions, both intrapsychic (CR) and symptom-directed (MPR) modes of intervention equip math-anxious individuals with coping skills. Since efficacy-based anxiety is the focus of treatment, it was anticipated that both CR and MPR would produce significant and durable reductions in anxiety.

Need for the Study

This investigation focused on the problem of mathematics anxiety among female college students, and is important for several reasons. Of primary importance is the contribution it can make in helping clear away obstacles that prevent women from being equally represented in scientific and technical fields. It is anticipated that this study will contribute to the removal of these obstacles. Further, the problem of mathematics anxiety among female college students is of national concern, and appears to be endemic among students enrolled in southern liberal-arts colleges (Thompson and Levin, 1977). This study, conducted at

Mary Baldwin College, a private liberal arts school for women, can contribute to the resolution of this problem as well.

Investigations of intervention strategies should be grounded in and extend the existing knowledge base. This study is based on a social learning theory interpretation of the math-anxiety syndrome. It will contribute to a testable theory of anxiety reduction and extend our knowledge of intervention strategies.

While of secondary importance, research in the area of mathematics anxiety may also reveal answers to some related problems: What causes sex-related differences in mathematics achievement and participation? Why do females as a group have less confidence in learning mathematics? Why do males as a group perceive mathematics to be more useful to them?

Finally, the majority of previous math-anxiety research relied only on paper-and-pencil assessment data (Tobias and Weissbrod, 1980). This study utilized a two-dimensional response, i.e., a self-reporting instrument and a physiological measure of anxiety, and will contribute to a better understanding of the mathematics anxiety construct.

Definitions

Mathematics anxiety is a set of negative feelings and thoughts that causes students to experience mild to severe physical discomfort; interferes with their abilities to concentrate, pay attention, and assimilate information; and impedes their capacities to deal with mathematical concepts (Richardson and Suinn, 1972). For the purposes of this investigation two instruments were used to measure each subject's level of mathematics anxiety: (1) Sandman's Mathematics Attitude Inventory, a paper-and-pencil assessment of anxiety, and (2) an Electromyograph, a device used to monitor skeletal muscle tension. Electrodes are attached to a subject's body and readings are recorded in microvolts.

Intervention strategies are ameliorative procedures for reducing the severity of mathematics anxiety. Two palliative intervention strategies were used in this study: (1) Cognitive restructuring is an intervention strategy in which subjects learn to substitute positive coping self-statements for irrational or unrealistic beliefs; and (2) Modified progressive relaxation is an intervention strategy which utilizes deep muscle relaxation to help subjects control unwanted physiological responses.

Level of achievement in mathematics is operationally defined as as a student's score on the mathematics portion of the Scholastic Aptitude Test (SAT).

Level of participation in mathematics is defined as the scope of mathematics content delivered to students. In this study the three levels of participation were Mary Baldwin College courses: (1) Math 130, Basic Mathematics Concepts, is a remedial course, (2) Math 160, Finite Mathematics with Applications, is a prerequisite for Math 213, and (3) Math 213, Introduction to Statistics, is the most advanced of the three courses. A more detailed description of these three courses is given in Appendix B.

Statement of the Problem

A social learning theory context provided the conceptual basis for two math-anxiety interventions: (1) Cognitive Restructuring (CR), and (2) Modified Progressive Relaxation (MPR). In particular, the following major research question was investigated:

When administered over a six-week treatment period, are cognitive restructuring and modified progressive relaxation equally effective in reducing mathematics anxiety among female college students?

The following related questions were also explored:

(1) Are any combinations of treatment and level of achievement in mathematics characterized by lower levels of anxiety than other combinations?

(2) Are any combinations of treatment and level of participation in mathematics characterized by lower levels of anxiety than other combinations?

(3) To what extent do physiological indicators of mathematics anxiety and paper-and-pencil assessments measure the same construct?

Design and Analysis

The present investigation was conducted at Mary Baldwin College during the 1985-86 academic year. Students enrolled in Math 130, Math 160, and Math 213 during the 1985 fall semester were randomly assigned to one of two treatment groups: (1) E1, Experimental Group 1 - Cognitive Restructuring (CR); or (2) E2, Experimental Group 2 - Modified Progressive Relaxation (MPR).

At the end of a six-week treatment period, each subject's level of mathematics anxiety was measured using two instruments: (1) Sandman's Mathematics Attitude Inventory, a paper-and-pencil assessment, and (2) an electromyograph, a device for monitoring skeletal muscle tension. To test for durability of treatment-produced improvement, a two-month follow-up study was conducted. Multiple linear regression was used to analyze the data.

Outline of the Report

Chapter I presents the background, conceptual framework, review of pertinent literature, definitions, and need for the study. Chapter II presents a detailed report of the design of the study, a description of the subjects, instrumentation, and methods of data collection and analyses. And Chapter III presents the results of the study, conclusions, limitations, and implications of findings for professional practice and future research.

Chapter II

Design of the Study

Self-efficacy theory (Bandura, 1978) provided the theoretical underpinnings for two mathematics anxiety interventions, cognitive restructuring (CR) and modified progressive relaxation (MPR). The purpose of this investigation was to compare the effectiveness of these two interventions for reducing mathematics anxiety among female college students. In this chapter the procedures of the study, including the selection of subjects, instrumentation, treatments, and methods of data collection are described. For each research question, operational hypotheses are stated and the method of analysis is described.

Subjects

Subjects for this investigation were sixty-two Mary Baldwin College students enrolled in Math 130, Math 160, or Math 213 during Fall semester, 1985. Participation was a course requirement.

Independent Variables

There were three independent variables in this study: (1) type of intervention strategy, (2) level of participation in mathematics, and (3) level of achievement in mathematics. Type of intervention was included as one of the independent variables since the primary objective of the study being reported was to determine the relative effectiveness of cognitive restructuring and modified progressive relaxation. Level of participation in mathematics was included as a second independent variable since previous research (Armstrong, 1982) indicates that it is highly correlated with positive feelings toward mathematics (i.e., enjoyment of mathematics, confidence in mathematics, and low anxiety). The three levels of participation, indicating the most advanced course completed, were: (1) Basic Mathematics Concepts (Math 130), (2) Finite Mathematics with Applications (Math 160), and (3) Introduction to Statistics (Math 213). Level of achievement in mathematics is a continuous variable that reflects the degree to which subjects understand, in both an instrumental and relational sense, basic mathematical concepts. In a study at Ohio State University, Betz (1978) correlated American College Test (ACT) Mathematics subtest scores with scores on a modified version of the Fennema-Sherman Mathematics Anxiety Scale, and reported that "there is a general tendency for higher levels of mathematics anxiety to be associated with lower mathematics achievement test scores." For the purposes of the current investigation, a subject's level of achievement was operationally defined as her score on the mathematics portion of the Scholastic Aptitude Test (SAT).

Dependent Variables

Although anxiety was the primary focus of treatment, palliative methods like cognitive restructuring and modified progressive relaxation that soften or moderate anxiety may quite possibly enhance subjects' attitudes toward mathematics. Therefore, six constructs were chosen as dependent variables: (1) anxiety toward mathematics, (2) self-concept in mathematics, (3) enjoyment of mathematics, (4) motivation in mathematics, (5) value of mathematics in society, and (6) perception of the mathematics teacher.

Further, since previous research relied primarily on paper-and-pencil assessments of anxiety (Tobias and Weissbrod, 1980), both paper-and-pencil and physiological measures of anxiety were utilized to contribute to a better understanding of the mathematics anxiety construct.

Instrumentation

Paper-and-Pencil Assessment

The Mathematics Attitude Inventory (MAI) was developed by Richard S. Sandman (1973) and Wayne W. Welch at the University of Minnesota. It is a 48-item Likert-type instrument, and requires approximately twenty minutes to complete. A copy is included in Appendix A. Subscale II, Anxiety Toward Mathematics, is designed to measure the uneasiness felt by a student in math-related situations, and consists of the following items:

(1) I feel tense when someone talks to me about mathematics.

(2) Working with numbers upsets me.

(3) It makes me nervous to even think about doing mathematics.

(4) I would rather be given the right answer to a mathematics problem than to work it out myself.

(5) It scares me to have to take mathematics.

(6) If I don't see how to work a mathematics problem right away, I never get it.

For each item, subjects indicate whether they agree, tend to agree, tend to disagree, or disagree. A high subscale score indicates high anxiety toward mathematics; scores may range from 6 to 24. For subscale II, Anxiety Toward Mathematics, Sandman reported a Cronbach alpha coefficient of 0.76 .

In addition to anxiety, the MAI is designed to measure five other mathematics attitude constructs: (1) self-concept in mathematics, (2) enjoyment of mathematics, (3) motivation in mathematics, (4) value of mathematics in society, and (5) perception of the mathematics teacher. For these five scales Sandman reported Cronbach alpha coefficients ranging from 0.68 to 0.89. Intercorrelations among the MAI scales for Sandman's data are reported in Table I.

Table I

Intercorrelations among the Six Scales of the MAI

Scale	1	2	3	4	5	6
1. Teacher	1.00					
2. Anxiety	-.43	1.00				
3. Value	.34	-.38	1.00			
4. Self-concept	.32	-.60	.30	1.00		
5. Enjoyment	.42	-.62	.43	.66	1.00	
6. Motivation	.25	-.33	.28	.44	.59	1.00

<u>Linkage Analysis</u>. Since there is considerable disagreement among practitioners regarding the dimensionality and structure of mathematics anxiety (Ferguson, 1983; Frary and Ling, 1983; Rounds and Hendel, 1980), a linkage analysis (McQuitty, 1961) of the immediate posttest data was performed on the matrix of intercorrelations among the 48 items of Sandman's

Mathematics Attitude Inventory (MAI). Items that intercorrelated meaningfully were identified, and a corresponding 27-item attitude scale was constructed. This scale served as another dependent measure for comparing the relative effectiveness of the two treatments. This approach seemed desirable, since Sandman's MAI was developed using 5034 high school students from the states of California and Indiana, whereas Mary Baldwin students constitute a much smaller and more specialized population.

Physiological Assessment

To obtain a physiological measure of mathematics anxiety, an electromyograph was used to monitor skeletal muscle tension. Electrodes were attached to each subject's nondominant forearm, and readings were recorded in microvolts. After a five minute baseline reading, a series of mathematics problems was presented as learning material. Six mental arithmetic exercises (see Appendix D), previously identified as anxiety eliciting stimuli, were presented sequentially on a visual display unit for sixty seconds each. The order of presentation was random, and virtually no interstimulus interval existed between exercises. The level of mathematics anxiety for each subject was computed by subtracting the average EMG reading obtained during the baseline period from the average EMG reading obtained during the learning period.

Procedures

Prior to instruction, a table of random numbers was used to assign subjects, stratified by level of participation, to the two treatment groups. Forty-two subjects were assigned to Experimental Group I, Cognitive Restructuring (CR), and twenty subjects were assigned to Experimental Group II, Modified Progressive Relaxation (MPR). Unequal sample sizes were necessary because of treatment time restrictions; the MPR counselor worked with subjects individually, whereas the CR counselor met subjects on a small-group basis. Subjects in the two experimental groups met with their respective counselors once each week for a period of six weeks.

A randomized posttest only design was utilized.

R	X1	Y1	Z	O1	O2 . . . O2'
R	X1	Y2	Z	O1	O2 . . . O2'
R	X1	Y3	Z	O1	O2 . . . O2'
R	X2	Y1	Z	O1	O2 . . . O2'
R	X2	Y2	Z	O1	O2 . . . O2'
R	X2	Y3	Z	O1	O2 . . . O2'

In the above schematic, X1 and X2 represent the two treatments, CR and MPR, respectively. Y1, Y2, and Y3 represent the three levels of participation, Math 130, Math 160, and Math 213, respectively. Z is a continuous variable representing level of achievement in mathematics (SAT). O1 represents data collected using an electromyograph, providing a physiological assessment of the level of mathematics anxiety. O2 represents data collected using the Mathematics Attitude Inventory (Sandman, 1973). This phase of the data collection procedure occurred immediately after the treatment period.

Since social learning theory (Bandura, 1977) predicts that coping behaviors may be easily extinguished unless strong expectations of personal efficacy are induced by the treatments, a two-month follow-up study was conducted to provide a test for long-term maintenance of treatment-produced improvement. O2' represents data collected in a delayed posttest fashion using Sandman's MAI. No physiological measure of anxiety was utilized at follow-up.

Description of Treatments

The two treatments, cognitive restructuring and modified progressive relaxation, were administered by trained counselors. Both counselors were seniors at Mary Baldwin College with expertise in biofeedback, behavior modification, as well as individual and group counseling techniques.

Subjects assigned to experimental group I, Cognitive Restructuring (CR), were divided into two groups which met with a counselor once each week for six weeks. During these sixty-minute sessions the underlying assumptions of CR were explained. Subjects learned to identify distorted cognitive styles (e.g., emotional reasoning, overgeneralization, personalization, and all-or-nothing thinking). A self-assessment quiz was given during each session to test and to strengthen subjects' understanding of distorted cognitive styles. In addition to learning to recognize the irrationality of certain beliefs, group participants were taught that unrealistic or irrational cognitions mediate emotional arousal. During these sessions the counselor played the role of devil's advocate. The subjects were to assume that the counselor actually held certain maladaptive beliefs and then generate as many reasons as possible why it may be irrational or unreasonable to hold onto such beliefs. During the last few minutes of each session, while working a series of math-related problems, participants were instructed to use this list of positive coping self-statements to practice changing their own maladaptive cognitions.

Subjects in experimental group II, Modified Progressive Relaxation (MPR), met individually with a counselor once each week for six weeks. Subjects were informed that the purpose of each thirty-minute session was to help them learn to inhibit dysponetic activity, thereby increasing their performance in mathematics. MPR was presented as a coping skill for dealing with unwanted physiological arousal. At the beginning of each session, the counselor assisted each subject in identifying and locating twelve major muscle groups (e.g., frontalis, trapezius, rectus abdominis, and gastrocnemius). When a subject was comfortably seated, she was instructed to breathe easily and smoothly, tightening only the muscles that she is directed to tighten, letting the rest of her body remain relaxed. The counselor then guided the subject through a fifteen-minute tape recorded script. An excerpt from this script is given below:

> "Get in a comfortable position and relax. Now clench your right fist, tighter and tighter, studying the tension as you do so. Keep it clenched and notice the tension in your fist, hand and forearm. Now relax. Feel the looseness in your right hand, and notice the contrast with the tension. Repeat this procedure with your right fist again, always noticing

as you relax that this is the opposite of tension. Relax and feel the difference. Repeat the entire procedure with your left fist, then both fists at once."

During the last few minutes of each session, the subject was given a series of math-related problems to work and instructed to use progressive relaxation to cope with unwanted physiological arousal.

Data Analysis

Eight dependent measures were used to compare the relative effectiveness of the two treatments: the six subscales of Sandman's Mathematics Attitude Inventory, a 27-item scale obtained from a linkage analysis of Sandman's MAI, and a measure of skeletal muscle tension.

The following research questions were investigated:

(1) When administered over a six-week treatment period, are Cognitive Restructuring and Modified Progressive Relaxation equally effective in reducing mathematics anxiety among female college students?

(2) Are any combinations of treatment and level of achievement in mathematics characterized by lower levels of anxiety than other combinations?

(3) Are any combinations of treatment and level of

participation in mathematics characterized by lower levels of anxiety than other combinations?

(4) To what extent do physiological indicators of mathematics anxiety and paper-and-pencil assessments measure the same construct?

Research questions 1-3 suggest the use of the following multiple regression model: $E(Y) = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_1X_2 + B_6X_2X_3 + B_7X_2X_4 + B_8X_1X_3 + B_9X_1X_4$. In this model E(Y) represents the mean level of mathematics anxiety; X_1 is the level of achievement in mathematics (SAT); X_2 is a dummy variable used to identify the two treatments; X_3 and X_4 are dummy varibles used to identify the three levels of participation; X_1X_2, X_2X_3, X_2X_4, X_1X_3, and X_1X_4 are the two-way interaction terms; and the Bs are population regression coefficients.

Research Question 1

To determine whether sufficient evidence exists to conclude that the mean levels of mathematics anxiety differ for the two interventions, the following null and alternative hypotheses were tested at the .05 level of significance:

H_0: $B_2 = B_5 = B_6 = B_7 = 0$

H_1: At least one beta parameter is nonzero.

Research Question 2

Are any combinations of treatment and level of achievement in mathematics characterized by lower levels of anxiety than other combinations? In order to test for two-way interaction between treatment and level of achievement, the following null and alternative hypotheses were tested at the .05 level of significance:

H_0: $B_5 = 0$

H_1: B_5 is not equal to zero.

Research Question 3

Are any combinations of treatment and level of participation in mathematics characterized by lower levels of anxiety than other combinations? To determine whether the data provide sufficient evidence to conclude that treatment and level of participation interact, the following null and alternative hypotheses were tested at the .05 level of significance:

H_0: $B_6 = B_7 = 0$

H_1: At least one beta parameter is nonzero.

Research Question 4

To determine whether a positive correlation exists between physiological measures of mathematics anxiety and paper-and-pencil assessments, the following null and alternative hypotheses were tested at the .05 level of significance: $H_0: P = 0$ and $H_1: P > 0$. The parameter P represents the correlation coefficient for the bivariate population of MAI and EMG scores, and measures the strength of the linear relationship between the two variables.

Two-Month Follow-Up

To test for differences in long-term maintenance of treatment effects, the MAI was administered to all subjects in a delayed posttest fashion during Spring semester, 1986. No physiological measure of anxiety was obtained. The proposed regression model, $E(Y) = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_1X_2 + B_6X_2X_3 + B_7X_2X_4 + B_8X_1X_3 + B_9X_1X_4$, was fit to the data and, for each of the eight dependent measures, with the exception of skeletal muscle tension, operational hypotheses corresponding to research questions 1-3 were tested at the .05 level of significance.

Chapter III

Results

The purpose of this investigation was to compare two mathematics anxiety interventions, cognitive restructuring (CR) and modified progressive relaxation (MPR). In addition to the treatment variable, data were collected on two other independent variables: (1) level of achievement in mathematics, and (2) level of participation in mathematics. To compare the relative effectiveness of the two treatments, data were collected on the following dependent variables: (1) anxiety toward mathematics, (2) self-concept in mathematics, (3) enjoyment of mathematics, (4) motivation in mathematics, (5) perceived value of mathematics in society, and (6) perception of the mathematics teacher.

The purpose of this chapter, which is organized into four sections, is to summarize the findings of this study. In part I, numerical descriptive measures of central tendency and dispersion are reported and regression techniques are employed to organize and summarize the sample data. In addition, the findings obtained from a linkage analysis of Sandman's MAI are reported. In part II, inferential methods are used to either reject or retain the operational hypotheses corresponding to each research question. The results of a two-month follow-up study are reported in Part III. The final section, Part IV, includes a summary of major findings, conclusions, limitations, and recommendations for future research.

Part I: Descriptive Statistics

Linkage Analysis

Linkage analysis (McQuitty, 1961) is a technique for converting a matrix of intercorrelations into clusters or types. The first step in a linkage analysis is to identify two items which are more strongly related to each other than either is to any other item; this is accomplished by locating the largest entry of the entire matrix. The rows of these two items are then examined in order to identify other items that correlate meaningfully with these two items. This process is continued until all items are assigned to at least one cluster or type.

Using the immediate posttest data, a linkage analysis was performed on the matrix of intercorrelations among the forty-eight items of

Sandman's Mathematics Attitude Inventory (MAI), and a resultant cluster of 27 items emerged. This 27-item attitude scale (Appendix C), together with a measure of skeletal muscle tension and the original six scales of Sandman's MAI, served as a set of dependent measures for determining the relative effectiveness of the two treatments.

Intercorrelations among the scores on the original six MAI scales, the 27-item attitude scale, and the EMG posttest are reported in Table 2. All but three of the fifteen intercorrelations among the six MAI scales were significant at the .05 level. The three nonsignificant correlations occurred between the teacher subscale and the self-concept, enjoyment, and motivation subscales, respectively. The most highly correlated subscales were anxiety, self-concept, and enjoyment of mathematics, which suggests that self-concept and enjoyment of mathematics may be conceptually related to the anxiety construct and to each other, i.e., individuals who are math-anxious by and large do not enjoy the study of mathematics and do not perceive themselves as competent learners of mathematics, and conversely. Moreover, the 27-item attitude scale constructed from a linkage analysis of the MAI was strongly correlated with the anxiety, enjoyment, and self-concept scales.

The correlations between scores on the EMG posttest

Table 2

Intercorrelations Among Eight Dependent Measures

Scale	1	2	3	4	5	6	7	8
1. Teacher	1.000							
2. Anxiety	-.285	1.000						
3. Value	.292	-.360	1.000					
4. Self-concept	.087	-.795	.373	1.000				
5. Enjoyment	.205	-.829	.419	.838	1.000			
6. Motivation	.203	-.396	,359	.392	.589	1.000		
7. 27-item	.199	-.914	.425	.921	.960	.513	1.000	
8. EMG	-.033	-.007	.054	.062	.008	-.102	.019	1.000

and each of the MAI subscale scores were consistently low, which suggests that the correspondence between physiological and paper-and-pencil assessments of anxiety may be more complex than a straight-line relationship.

Each of the eight dependent measures listed in Table 2 was regressed on nine predictor variables representing a linear combination of level of achievement, type of intervention, level of participation, and all two-way interactions. The coefficients of determination corresponding to each dependent measure are reported in Table 3. A linear combination of level of achievement, type of intervention, level of participation, and all two-way interactions accounted for more variability in subscale II scores, Anxiety Toward Mathematics, than in any of the other scales.

Paper-and-Pencil Assessment

Measures of central tendency and dispersion for subjects' immediate posttest scores on subscale II of Sandman's MAI are reported in Tables 4-6. The minimum and maximum possible scores are 6 and 24, respectively. A high score indicates a high level of self-reported anxiety. Inferential methods of hypothesis testing will be deferred to Part II of this chapter.

Table 3

Coefficients of Determination

Scale	R^2
1. Teacher	19.9%
2. Anxiety	46.2%
3. Value	13.2%
4. Self-concept	32.8%
5. Enjoyment	32.1%
6. Motivation	15.6%
7. 27-item attitude	40.7%
8. EMG	30.1%

For CR and MPR subjects the mean posttest scores on subscale II of Sandman's MAI were 10.62(SD=4.52) and 12.15(SD=4.92), respectively, indicating that CR subjects as a group reported lower levels of anxiety than MPR subjects as a group.

For Math 130, Math 160, and Math 213 subjects the mean posttest scores on subscale II of Sandman's MAI were 13.91(SD=5.27), 10.29(SD=3.23), and 8.85(SD=3.69), respectively, indicating that subjects at lower levels of participation in mathematics experienced higher levels of self-reported anxiety.

The measures of central tendency reported in Table 6 suggest that CR may be superior to MPR for subjects at advanced levels of participation in mathematics, although it is not clear which intervention is superior at intermediate and remedial levels of participation. The relationship among the six cell means is depicted in Figure 3.

Physiological Assessment

In addition to a paper-and-pencil assessment of anxiety, an electromyograph was utilized to obtain a measure of skeletal muscle tension. Measures of central tendency and dispersion for subjects' EMG posttest scores are presented in Tables 7-9. Readings are reported in microvolts.

Table 4

Immediate Posttest Scores on Subscale II of

Sandman's MAI for each Treatment Group

	CR	MPR
Range	6-23	6-20
Sample Size	42	20
Mean	10.62	12.15
Median	9.00	10.00
Standard Deviation	4.52	4.92

Table 5

Immediate Posttest Scores on Subscale II of Sandman's MAI for each Level of Participation

	Math 130	Math 160	Math 213
Range	6-23	6-16	6-20
Sample Size	22	20	20
Mean	13.91	10.29	8.85
Median	13.50	9.00	7.50
Standard Deviation	5.27	3.23	3.69

Table 6

Immediate Posttest Scores on Subscale II of Sandman's MAI for each Combination of Treatment and Level of Participation

	Range	N	Mean	Median	Stdev
MPR-Math130	8-20	7	14.57	16.00	5.03
CR -Math130	6-23	15	13.60	12.00	5.53
MPR-Math160	6-16	7	10.14	8.00	4.10
CR -Math160	6-16	13	10.38	10.00	2.84
MPR-Math213	7-20	6	11.67	9.50	5.24
CR -Math213	6-14	14	7.64	7.00	2.02

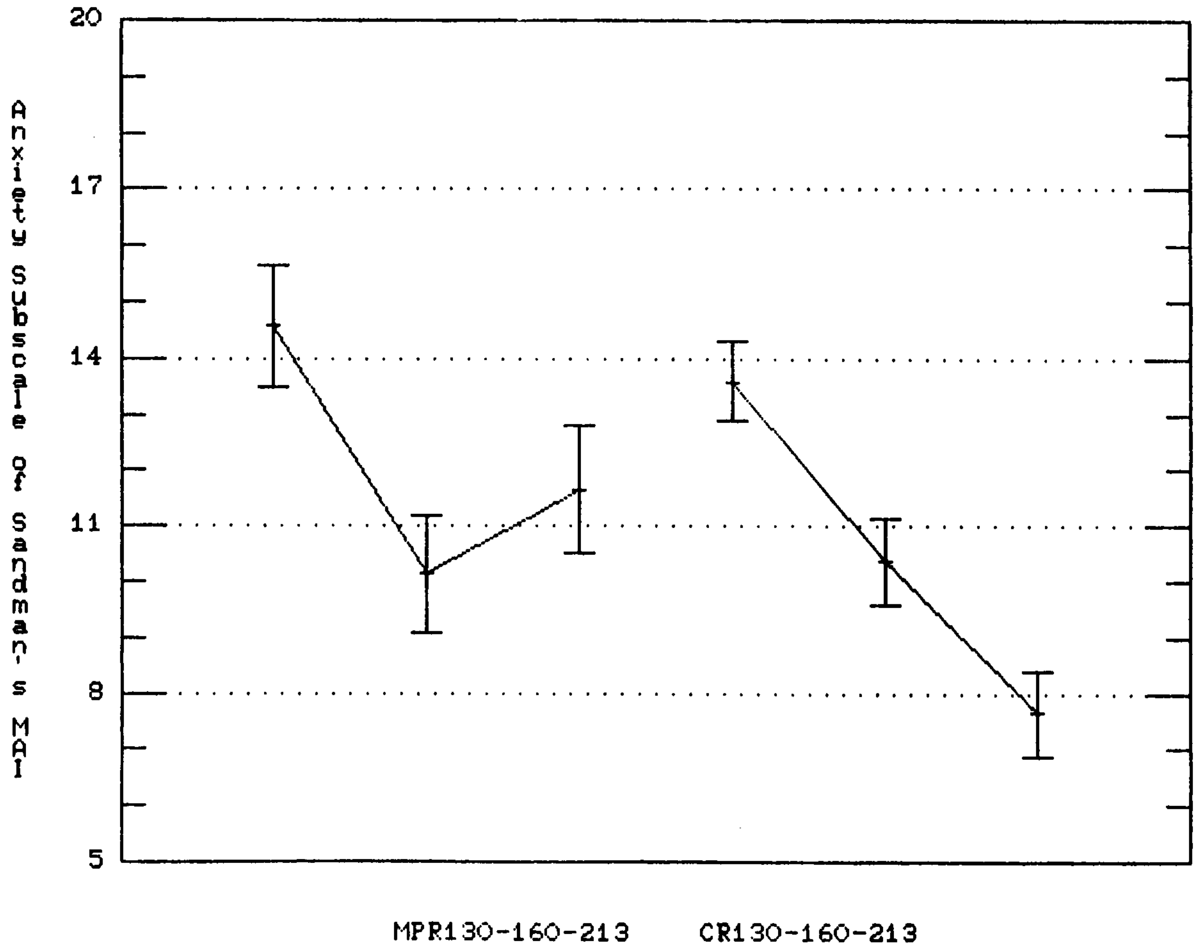

Figure 3. Comparison of Treatment by Level of Participation Cell Means

Table 7

Electromyographic (EMG) Scores on Immediate Posttest for each Treatment group

	CR	MPR
Range	0-739	0-813
Sample Size	41	20
Mean	118.0	165.0
Median	54.0	112.0
Standard Deviation	161.0	203.0

Table 8

Electromyographic (EMG) Scores on Immediate Posttest for each Level of Participation

	Math 130	Math 160	Math 213
Range	0-739	0-259	0-813
Sample Size	22	19	20
Mean	134.0	89.3	174.0
Median	58.0	60.0	114.0
Standard Deviation	196.0	91.5	209.0

Table 9

Electromyographic (EMG) Scores on Immediate Posttest for each Combination of Treatment and Level of Participation

	Range	N	Mean	Median	Stdev
MPR-Math130	0-378	7	92.0	48.0	137.0
CR -Math130	0-739	15	154.0	68.0	220.0
MPR-Math160	0-325	7	101.4	121.0	91.8
CR -Math160	0-259	12	82.2	43.0	94.7
MPR-Math213	0-813	6	323.0	304.0	286.0
CR -Math213	0-463	14	110.0	53.0	132.0

When skeletal muscle tension is used as a measure of mathematics anxiety, the immediate posttest data suggest that CR may be superior to MPR, although the dispersion in the scores is quite large for both groups. The mean EMG posttest scores for the two treatment groups are 118.0(SD=161) and 165.0(SD=203), respectively.

For Math 130, Math 160, and Math 213 subjects the mean EMG posttest scores are 134.0(SD=196.0), 89.3(SD=91.5), and 174.0(SD=209.0), respectively. The skeletal muscle tension data do not indicate that mathematics anxiety is more severe for students at lower levels of participation in mathematics. In fact, an examination of the median scores suggests that subjects at <u>higher</u> levels of participation may experience a <u>greater</u> degree of skeletal muscle tension than subjects at lower levels of participation in mathematics.

The summary statistics reported in Table 9 suggest that CR may be more effective in relieving the symptoms of mathematics anxiety (i.e., in softening or moderating skeletal muscle tension) for subjects at intermediate and advanced levels of participation in mathematics, whereas MPR may be a better palliator for subjects at remedial levels of participation in mathematics.

<u>Modeling</u>

A regression model relating the mean level of mathematics anxiety, E(Y), to level of achievement (SAT) for two different treatments (CR and MPR), and three different levels of participation (M130, M160, and M213) was used to describe the sample data, i.e., to parcel out the various relationships that exist among the variables. The model posits that the straight lines relating level of anxiety to level of achievement differ for each combination of treatment and level of participation, i.e., the rate of decrease in mean level of anxiety per unit increase in level of achievement depends on the particular combination of treatment and level of participation. The model is given by $E(Y) = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_4X_4 + B_5X_5 + B_6X_6 + B_7X_7 + B_8X_8 + B_9X_9$, where the Bs are regression coefficients and the Xs are defined as follows:

(1) The variable X_1 denotes a subject's level of achievement in mathematics, and is defined as her score on the mathematics portion of the Scholastic Aptitude Test (SAT).

(2) The treatment variable, X_2, is a dummy vector of zeros and ones. Subjects in MPR were assigned zeros while subjects in CR were assigned ones.

(3) The variables X_3 and X_4 are dummy vectors of zeros and ones used to represent the three levels of

participation. Subjects in Math 130 were assigned zeros in both vectors; Math 160 subjects were assigned ones in vector X_3; Math 213 subjects were assigned ones in vector X_4.

(4) The variable $X_5 = X_2 X_1$ denotes the interaction between type of intervention and level of achievement.

(5) The variables $X_6 = X_2 X_3$ and $X_7 = X_2 X_4$ denote the interaction between type of intervention and level of participation.

(6) Finally, the variables $X_8 = X_1 X_3$ and $X_9 = X_1 X_4$ denote the interaction between level of achievement and level of participation.

Two instruments were used to measure each subject's level of mathematics anxiety. Y_1 denotes a subject's score on subscale II of Sandman's MAI, and Y_2 denotes a subject's baseline to learning period increment in skeletal muscle tension as measured by an electromyograph.

<u>Subscale II of Sandman's MAI</u>. The coefficient of determination for the model $E(Y_1) = B_0 + \Sigma B_i X_i$ was .462, indicating that 46.2% of the variability in MAI posttest scores is attributable to a linear combination of level of achievement, type of intervention, level of participation, and the two-way interactions among these variables. The sample regression equation is given by

$Y_1 = 38.581 - .06425\ X_1 - 6.460\ X_2 - 11.610\ X_3 - 21.999\ X_4 + .01155\ X_5 + 0.123\ X_6 - 2.205\ X_7 + .03005\ X_8 + .05221\ X_9$.

For MPR subjects in Math 130, Math 160, and Math 213 the regression lines are $Y_1 = 38.581 - .06425\ X_1$, $Y_1 = 26.971 - .0342\ X_1$, and $Y_1 = 16.582 - .01204\ X_1$, respectively. For CR subjects in Math 130, Math 160, and Math 213 the regression lines are $Y_1 = 32.121 - .0527\ X_1$, $Y_1 = 20.634 - .02265\ X_1$, and $Y_1 = 7.917 - .00049\ X_1$, respectively. The slope of each of the six regression lines is negative, indicating that subjects at lower levels of achievement tend to experience higher levels of self-reported anxiety. At each level of participation the rate of decrease in average level of anxiety per unit increase in level of achievement is larger for MPR subjects than CR subjects, and ranges from a minimum of approximately zero MAI points per 100 point increase in level of achievement for CR subjects in Math 213, to a maximum of 6.4 MAI points per 100 point increase in level of achievement for MPR subjects in Math 130.

At each level of participation, CR is superior to MPR for low to moderate levels of achievement, but at higher levels of achievement the regression lines converge, suggesting that both treatments are equally effective regardless of the level of participation. An examination of Figure 4 indicates that for Math 130 subjects the CR and MPR regression lines intersect at $X_1 = 559$, for Math 160 subjects the CR and MPR regression lines intersect at $X_1 = 548$, and for Math 213 subjects the CR and MPR regression lines intersect at $X_1 = 750$.

<u>EMG Measure</u>. In addition to a self-report inventory, an electromyograph was used to obtain a physiological measure of anxiety. The coefficient of determination for the model $E(Y_2) = B_0 + \Sigma B_i X_i$ was .301, indicating that 30.1% of the variability in EMG posttest scores is attributable to a linear combination of level of achievement, type of intervention, level of participation, and the two-way interactions among these variables. The sample regression equation is given by $Y_2 = - 531 + 1.7892 X_1 + 251.3 X_2 + 150.2 X_3 + 657.9 X_4 - 0.7184 X_5 + 114.0 X_6 - 185.2 X_7 - .8343 X_8 - 1.3093 X_9$. For MPR subjects in Math 130, Math 160, and Math 213 the regression lines are $Y_2 = - 531.0 + 1.7892 X_1$, $Y_2 = - 380.8 + 0.9549 X_1$, and $Y_2 = 126.9 + 0.4799 X_1$, respectively. For CR subjects in Math 130, Math 160, and Math 213 the regression lines are $Y_2 = - 279.7 + 1.0708 X_1$, $Y_2 = - 15.5 + 0.2365 X_1$, and $Y_2 = 193.0 - 0.2385 X_1$, respectively.

With one exception, the slope of each of the six regression lines is positive, implying that subjects at

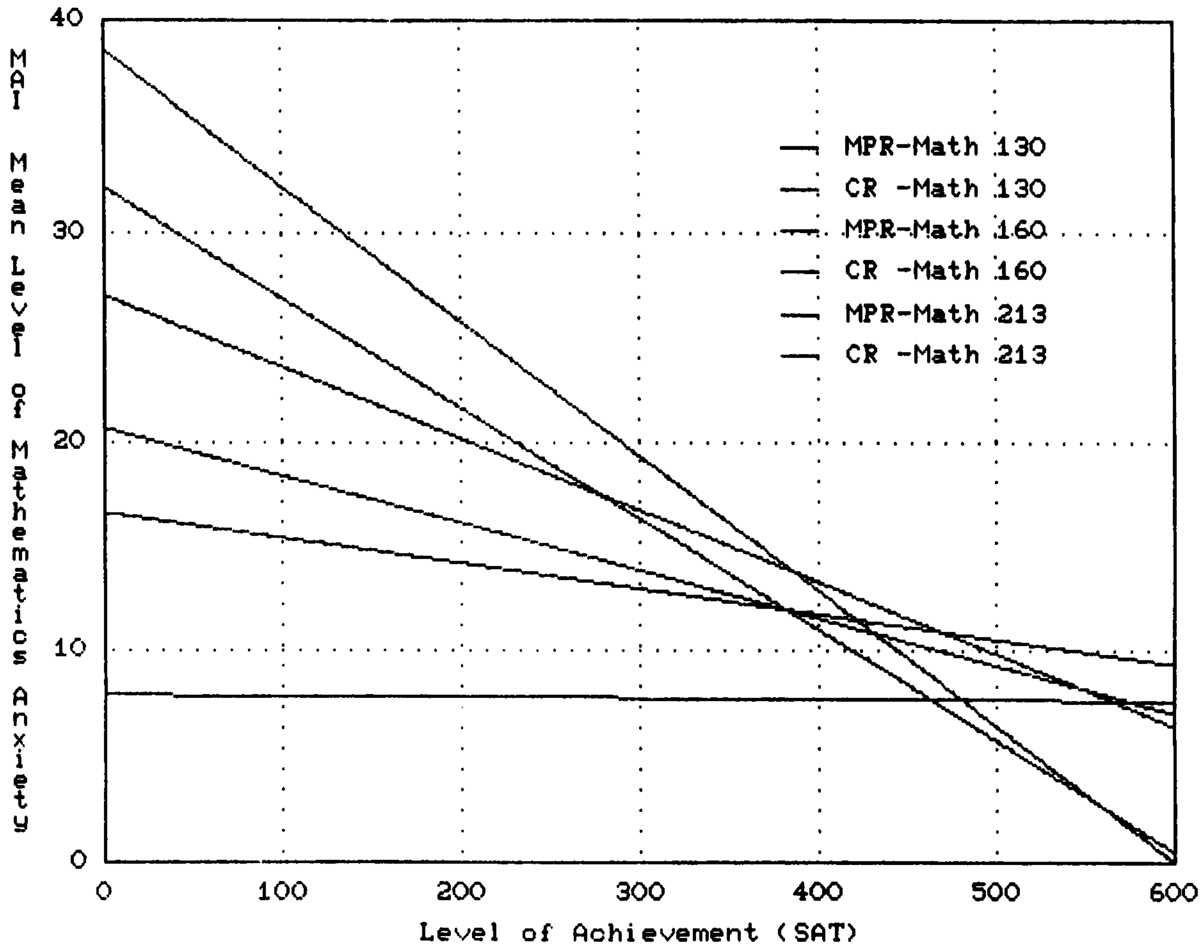

Figure 4. Six Treatment X Level of Participation Regression Lines

lower levels of achievement experience less skeletal muscle tension than subjects at higher levels of achievement. However, for Math 213 subjects assigned to cognitive restructuring the slope of the regression line was negative; in particular, an examination of Figure 5 indicates that the average rate of decrease in skeletal muscle tension for Math 213 subjects assigned to the cognitive restructuring group was approximately 24 microvolts per 100 point increase in level of achievement.

Part II: Inferential Statistics

A set of eight dependent measures was used to compare the relative effectiveness of the two treatments. The data were analyzed using multiple regression techniques. For research questions 1-3, full and reduced models were fit to the data, and the corresponding drop in residual sum of squares was used to construct the appropriate test statistic. The full model included vectors for level of achievement, treatment, level of participation, and all two-way interaction terms. The reduced model corresponding to research question 1 included vectors for level of achievement, level of participation, and the interaction between these two variables. For research question 2,

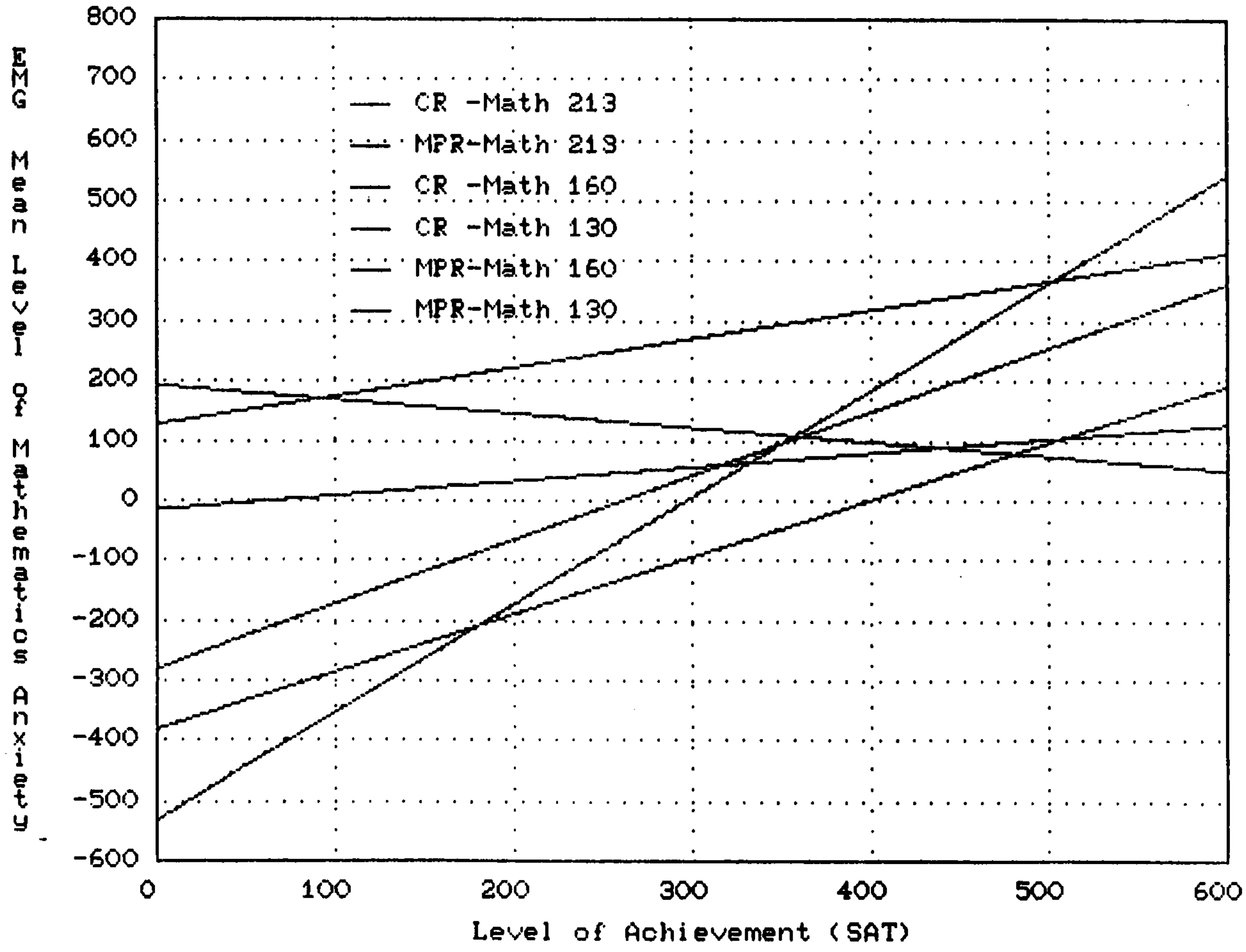

Figure 5. Six Treatment X Level of
Participation Regression Lines

the reduced model included vectors for level of achievement, treatment, level of participation, and all two-way interactions with the exception of the interaction between treatment and level of achievement. The reduced model corresponding to research question 3 included vectors for level of achievement, treatment, level of participation, and all two-way interactions with the exception of the interaction between treatment and level of participation. Summary statistics for the immediate posttest are presented in Tables 10-12.

Research Question 1

It was hypothesized that CR and MPR would be equally effective in reducing mathematics anxiety. On the anxiety subscale of Sandman's MAI mean posttest scores were 10.62 (SD=4.52) and 12.15 (SD=4.92) for CR and MPR subjects, respectively. When mathematics anxiety was measured with a paper-and-pencil inventory, a multiple regression analysis ($F=1.58$, $\delta_1=4$, $\delta_2=46$) did not detect a statistically discernible difference between the two treatments ($p = .196$). Similar results were obtained for the other seven dependent measures with one exception; mean EMG posttest scores were 118.0(SD=161) and 165.0(SD=203) for CR and MPR subjects, respectively. When anxiety is operationally defined as skeletal muscle tension and measured with an electromyograph, a regression analysis ($F=2.81$, $\delta_1=4$, $\delta_2=45$) revealed that CR leads to significantly greater reductions in anxiety than MPR ($p = .036$).

Research Question 2

It was hypothesized that there would be no interaction between type of intervention and level of achievement. Separate regression analyses were performed on the immediate posttest data for each dependent measure. No synergism was detected. In each case, the null hypothesis was retained.

Research Question 3

It was hypothesized that type of intervention and level of participation would not interact. The immediate posttest data for subscale II of Sandman's MAI yielded an F-ratio of 0.496 ($\delta_1=2$, $\delta_2=46$), which was not significant ($p = .612$). Similar results were obtained for the other seven dependent measures with one exception; the EMG posttest data yielded an F-ratio of 3.925 ($\delta_1=2$, $\delta_2=45$, $p = .027$). For CR subjects in Math 130, Math 160, and Math 213, the mean EMG scores were 154.0(SD=220), 82.2(SD=94.7), and 110.0(SD=132), respectively. For MPR subjects in Math 130, Math 160, and Math 213, the mean EMG scores were 92.0(SD=137), 101.4(SD=91.8), and 323.0(SD=286), respectively. A

Table 10

Research Question 1

Y	R^2 Full	R^2 Reduced	F	p
Teacher	.199	.103	1.376	.257
Anxiety	.462	.388	1.58	.196
Value	.132	.062	0.93	.455
Self-concept	.328	.283	0.77	.550
Enjoyment	.321	.290	0.53	.714
Motivation	.156	.115	0.57	.686
27-item	.407	.359	0.926	.457
EMG	.301	.127	2.81 *	.036

* Difference is statistically significant ($p < .05$)

Table 11

Research Question 2

Y	R^2 Full	R^2 Reduced	*F*	*p*
Teacher	.199	.195	0.18	.678
Anxiety	.462	.457	0.46	.508
Value	.132	.098	1.823	.184
Self-concept	.328	.322	0.45	.513
Enjoyment	.321	.318	0.237	.634
Motivation	.156	.138	1.00	.323
27-item	.407	.403	0.29	.599
EMG	.301	.284	1.10	.300

Table 12

Research Question 3

Y	R^2 Full	R^2 Reduced	F	p
Teacher	.199	.152	1.32	.277
Anxiety	.462	.450	0.496	.612
Value	.132	.124	0.20	.819
Self-concept	.328	.305	0.805	.453
Enjoyment	.321	.314	0.24	.788
Motivation	.156	.150	0.16	.853
27-item	.407	.396	0.423	.658
EMG	.301	.180	3.925 *	.027

* Difference is statistically significant ($p < .05$)

synergistic effect resulted because MPR was less effective than CR for Math 213 subjects.

Research Question 4

To what extent do physiological indicators of mathematics anxiety and paper-and-pencil assessments measure the same construct? To determine whether a positive correlation exists between the two dependent measures, the following null and alternative hypotheses were tested at the .05 level of significance: $H_0: P = 0$ and $H_1: P > 0$. The parameter P represents the correlation coefficient for the bivariate population of MAI and EMG scores, and measures the strength of the linear relationship between the two variables. The magnitude of the sample correlation coefficient was .007. Consequently, there is insufficient evidence to indicate that a linear relationship exists between the two dependent measures.

Part III: Two-Month Follow-Up Study

Eight weeks following the immediate posttest, Sandman's MAI was readministered in a delayed posttest fashion. There was an eighty-seven percent response rate, i.e., 54 of the 62 subjects completed the self-report inventory. No physiological measure of anxiety was used at follow-up.

Descriptive Statistics

Measures of central tendency and dispersion for subjects' delayed posttest scores on subscale II of Sandman's Mathematics Attitude Inventory for each treatment, each level of participation, and each combination of treatment and level of participation are reported in Tables 13-15.

At the time of a two-month follow-up the mean posttest scores for CR and MPR subjects were 11.46(SD=5.03) and 11.65(SD=4.50), respectively, indicating that the average level of self-reported anxiety for CR subjects was slightly lower than the average level of self-reported anxiety for MPR subjects. This finding is consistent with the immediate posttest results reported in Table 4.

For Math 130, Math 160, and Math 213 subjects the mean delayed posttest scores were 15.20(SD=5.51), 10.24(SD=2.91), and 8.47(SD=2.00), respectively, indicating that at the time of follow-up subjects at lower levels of participation in mathematics tended to experience higher levels of self-reported anxiety. This finding is consistent with the immediate posttest results reported in Table 5.

The summary statistics reported in Table 15

Table 13

Delayed Posttest Scores on Subscale II of

Sandman's MAI for each Treatment Group

	CR	MPR
Range	6-24	6-21
Sample Size	37	17
Mean	11.46	11.65
Median	11.00	10.00
Standard Deviation	5.03	4.50

Table 14

Delayed Posttest Scores on Subscale II of

Sandman's MAI for each Level of Participation

	Math 130	Math 160	Math 213
Range	6-24	6-15	6-12
Sample Size	20	17	17
Mean	15.20	10.24	8.47
Median	15.00	10.00	8.00
Standard Deviation	5.51	2.91	2.00

Table 15

Delayed Posttest Scores on Subscale II of Sandman's MAI for each Combination of Treatment and Level of Participation

	Range	N	Mean	Median	Stdev
MPR-130	10-21	6	16.00	17.60	4.15
CR -130	6-24	14	14.86	14.50	6.11
MPR-160	6-14	6	9.00	8.50	2.83
CR -160	7-15	11	10.91	11.00	2.84
MPR-213	7-12	5	9.60	9.00	2.30
CR -213	6-11	12	8.00	7.50	1.76

indicate that at the time of a two-month follow-up CR subjects in Math 130 and Math 213 reported lower average levels of anxiety than corresponding MPR subjects, whereas CR subjects in Math 160 reported a somewhat higher average level of anxiety than corresponding MPR subjects. These findings are consistent with the immediate posttest results reported in Table 6.

In addition to the descriptive statistics reported in Tables 13-15, regression techniques were used to summarize the results of the delayed posttest. Mean level of anxiety, $E(Y_1)$, was related to level of achievement (SAT), type of intervention (CR or MPR), and level of participation (M130, M160, or M213). The coefficient of determination for the model, $E(Y_1) = B_0 + \Sigma B_i X_i$, was .502, as compared with .462 for the immediate posttest, indicating that 50.2% of the variability in MAI delayed posttest scores is attributable to a linear combination of level of achievement, type of intervention, level of participation, and the two-way interactions among these variables. Since R^2 is the fraction of the variation in Y_1 that is explained by the Xs collectively, about 50% of the total variation in Y_1 is due to factors other than treatment, level of achievement, level of participation, and the two-way interactions among these variables. The sample regression equation is Y_1 =

$25.589 - 0.02467 X_1 + 3.424 X_2 - 15.616 X_3 - 21.715 X_4 - 0.01679 X_5 + 5.486 X_6 + 1.827 X_7 + 0.02348 X_8 + 0.03831 X_9$.

The regression lines for MPR subjects in Math 130, Math 160, and Math 213 are $Y_1 = 25.589 - 0.02467 X_1$, $Y_1 = 9.973 - 0.00119 X_1$, and $Y_1 = 3.874 + 0.01364 X_1$, respectively. For CR subjects in Math 130, Math 160, and Math 213, the regression lines are $Y_1 = 29.013 - 0.04146 X_1$, $Y_1 = 18.883 - 0.01798 X_1$, and $Y_1 = 9.125 - 0.00315 X_1$, respectively. An examination of Figure 6 indicates that the rate of change in average level of anxiety ranges from a minimum of approximately - 4 MAI points per 100 point increase in level of achievement for CR subjects in Math 130, to a maximum of +1.4 MAI points per 100 point increase in level of achievement for MPR subjects in Math 213. For both MPR subjects in Math 160 and CR subjects in Math 213, the rate of change in mean level of anxiety per unit increase in level of achievement is virtually zero.

Inferential Statistics

For each research question, full and reduced models were fit to the delayed posttest data, and the corresponding drop in residual sum of squares was used to construct the appropriate test statistic.

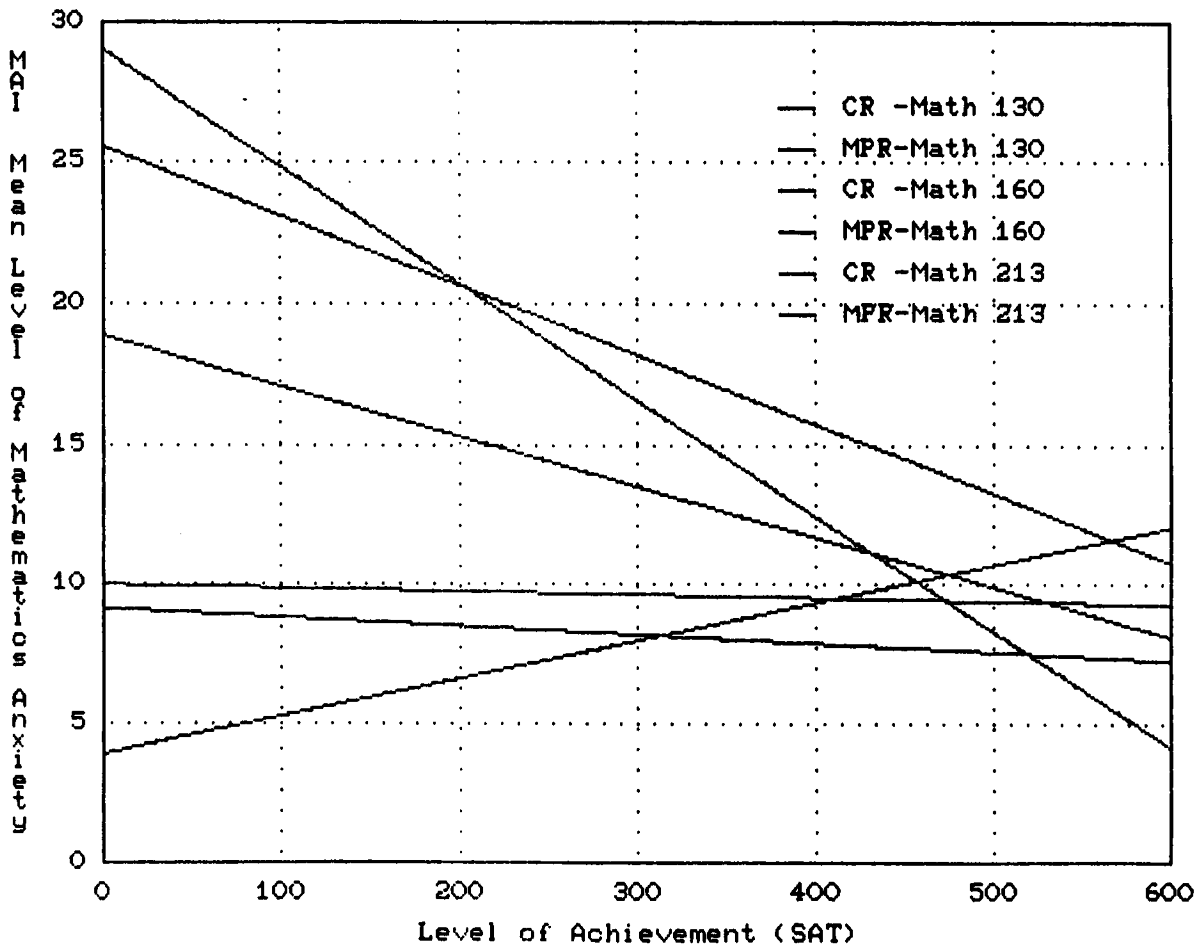

Figure 6. Regression Lines for
Delayed Posttest Data

Research Question 1. With respect to durability or stability of treatment-produced improvement, it was hypothesized that CR and MPR would be equally effective in reducing anxiety. At the end of an eight-week posttreatment period, mean posttest scores on subscale II of Sandman's MAI were 11.46(SD=5.03) and 11.65(SD=4.50) for CR and MPR subjects, respectively. A regression analysis ($F=0.87$, $\delta_1=4$, $\delta_2=37$) failed to detect any discernible difference in durability between the two interventions ($p = .491$). The null hypothesis was retained. Similar findings were obtained for the other dependent measures.

Research Question 2. It was hypothesized that at the end of an eight-week posttreatment period, there would be no interaction between type of intervention and level of achievement. The delayed posttest data for subscale II of Sandman's MAI yielded an F-ratio of 0.83 ($\delta_1=1$, $\delta_2=37$), which was not significant ($p = .378$). Separate regression analyses for the other dependent measures produced similar results.

Research Question 3. It was hypothesized that at the end of an eight-week posttreatment period, type of intervention and level of participation would not interact. The delayed posttest data for subscale II of

Sandman's MAI yielded an F-ratio of 1.29 ($\delta_1=2$, $\delta_2=37$), which was not significant ($p = .287$). The six cell means are reported in Table 15. Similar findings were obtained for the other dependent measures, i.e., no synergism was detected. In each case, the null hypothesis was retained.

Part IV: Conclusion

Summary

The purpose of this investigation was to determine the relative effectiveness of cognitive restructuring and modified progressive relaxation for reducing mathematics anxiety among female college students. The two treatments, CR and MPR, were chosen for comparison since considerable evidence existed and was reported in the literature review to indicate that both intrapsychic (CR) and symptom-directed (MPR) methods are effective as therapeutic interventions for a wide range of stress-related problems. In addition, palliative methods like CR and MPR which equip individuals with coping skills have a higher success rate than direct action methods of intervention. Cognitive restructuring consists of helping subjects identify irrational self-statements and teaching them to substitute more positive, realistic statements. During treatment, math-anxious persons learn to replace maladaptive thoughts with more positive rational thoughts. MPR therapists teach individuals to systematically tense and relax different muscle groups, so that math-anxious persons learn to substitute feelings of relaxation for unwanted physiologcial responses.

Subjects selected to participate in the study were Mary Baldwin College students enrolled in one of three mathematics courses during the 1985 Fall semester. Participants were randomly assigned to one of two treatment groups, CR or MPR. In addition to the treatment variable, there were two other independent variables, level of achievement and level of participation in mathematics. The dependent variable of primary interest was level of mathematics anxiety. At the end of a six-week treatment period, each subject's level of anxiety was measured using two instruments, Sandman's MAI and an electromyograph.

Since social learning theory predicts that coping behaviors may be easily extinguished unless strong expectations of personal efficacy are induced by the treatments, a two-month follow-up was conducted to test for stability of treatment effects. Four research hypotheses were tested: (1) There is no difference in mean level of anxiety between CR and MPR subjects; (2) There is no synergism between treatment and level of achievement; (3) There is no synergism between treatment and level of participation; and (4) There is no linear relationship between paper-and-pencil and physiological measures of mathematics anxiety.

The experimental data were analyzed using multiple regression techniques. Initial descriptive statistics indicated that CR subjects experienced lower levels of anxiety than MPR subjects, a trend which is in keeping with previous findings (Deitch, 1981; Trent, 1985). However, inferential methods produced no clear method of choice.

Research Question 1. Are cognitive restructuring and modified progressive relaxation equally effective in reducing mathematics anxiety among female college students? Analyses of the immediate posttest data revealed that CR is superior to MPR in reducing mathematics anxiety when anxiety is defined as skeletal muscle tension and measured with an electromyograph. However, when a self-report inventory was utilized no differences between the two treatments were detected .

To test for durability of treatment-produced improvement Sandman's MAI was readministered at the end of an eight-week posttreatment period. Analyses of the delayed posttest data failed to detect any discernible differences between the two treatments.

Research Question 2. Are any combinations of treatment and level of achievement characterized by lower levels of anxiety than other combinations? Separate regression analyses were performed on the immediate posttest data for each dependent measure; no interaction was detected. Similar results were obtained for the delayed posttest.

Research Question 3. Are any combinations of treatment and level of participation in mathematics characterized by lower levels of anxiety than other combinations? Research question 3 addressed the issue of interaction or synergism between type of intervention and level of participation in mathematics. Figure 3 displays the relationship among the MAI cell means for the immediate posttest data. Inferential methods failed to detect a statistically discernible difference among the cell means ($F = .496$, $p = .277$). Similar findings were obtained for the delayed MAI posttest also. Immediate posttest data pertaining to skeletal muscle tension are summarized in Figure 7. An examination of the six EMG cell means suggests that CR is superior to MPR for subjects at advanced levels of participation in mathematics. Inferential methods indicated that the interaction between treatment and level of participation

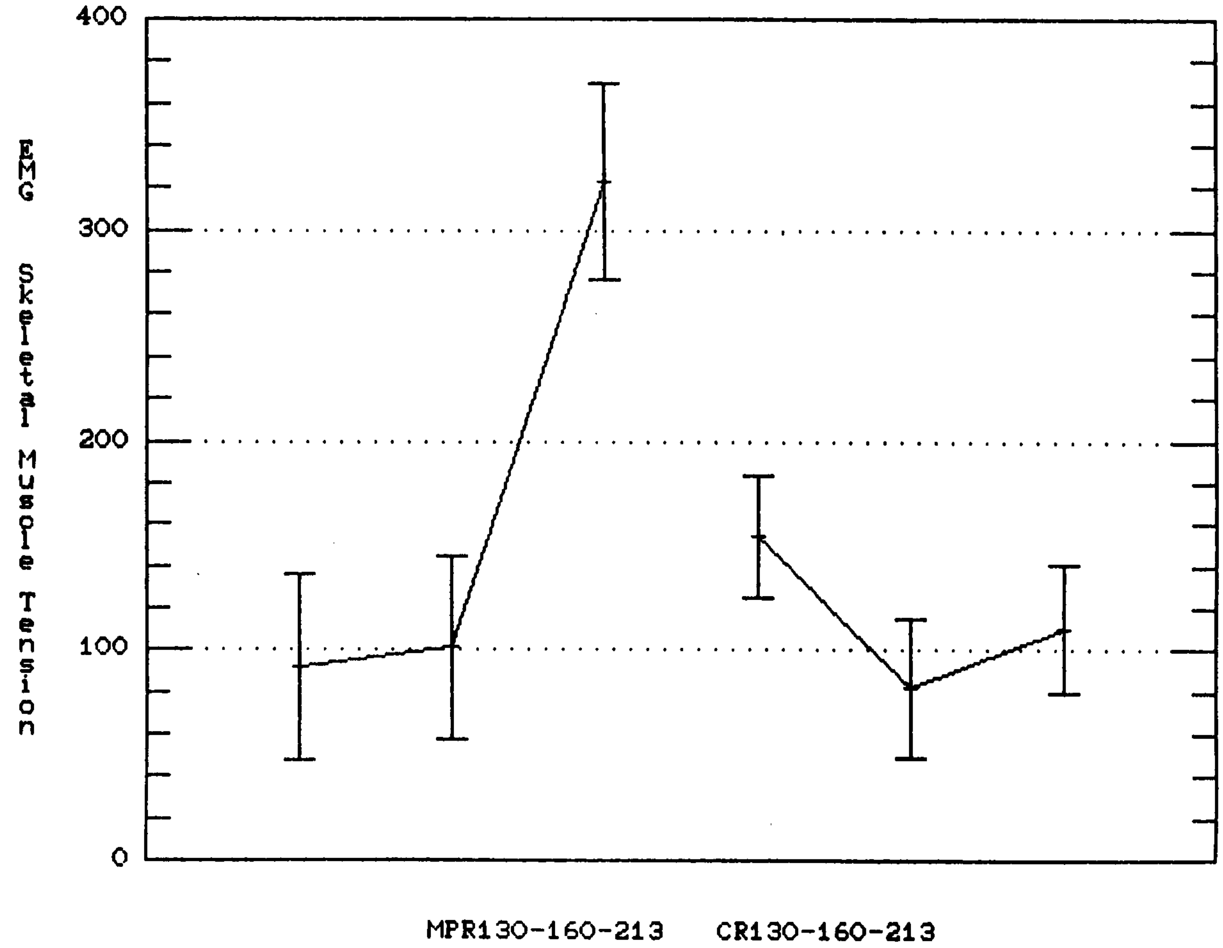

Figure 7. Comparison of Treatment by Level of Participation Cell Means

was statistically discernible ($F = 3.925$, $p = .027$).

Research Question 4. To what extent do physiological indicators of mathematics anxiety and paper-and-pencil assessments measure the same construct? To determine whether a positive correlation exists between the two dependent measures, the following null and alternative hypotheses were tested at the .05 level of significance: $H_0: P = 0$ and $H_1: P > 0$. The parameter P represents the correlation coefficient for the bivariate population of MAI and EMG scores, and measures the strength of the linear relationship between the two variables. The magnitude of the sample correlation coefficient was .007. Consequently, there is insufficient evidence to indicate that a linear relationship exists between the two dependent measures. Moreover, the correlations between scores on the EMG posttest and each of the MAI subscale scores were consistently low, which suggests that the correspondence between physiological and paper-and-pencil assessments of mathematics anxiety and/or mathematics attitude may be more complex than a straight-line relationship.

Discussion

When mathematics anxiety was measured with a paper-and-pencil inventory, for both the immediate and delayed posttests, the difference between the mean levels of self-reported anxiety for CR and MPR subjects was not statistically discernible. When anxiety was operationally defined as skeletal muscle tension and measured with an electromyograph, immediate posttest results indicated that CR subjects as a group experienced significantly lower levels of anxiety than MPR subjects as a group ($F = 2.81$, $p = .036$). An inspection of Figure 7 suggests a possible reason for this finding: MPR is less effective with students at more advanced levels of participation in mathematics. Alternatively, CR subjects who met in small groups may have developed a sense of community that was of secondary therapeutic value and hence facilitated the treatment process. Anecdotal comments from CR subjects at the end of the treatment period indicate that this may have been the case, e.g., "I have enjoyed this lab because I realize that other people have the same problems I do." Moreover, the impact of exhortative (CR) and emotive (MPR) information on self-efficacy depends on the perceived credibility of the counselors; CR subjects may have perceived their counselor in a more positive way than MPR subjects. Further, Bandura's concept of reciprocal determinism implies that the relationships among the cognitive, behavioral, and environmental components of the math-anxiety syndrome are dynamic rather than static. Although intrapsychic (CR) methods impact principally upon the cognitive component, their influence is not limited exclusively to this domain.

When anxiety was assessed with a self-report inventory, results from both the immediate and delayed posttests failed to detect any synergism between type of intervention and level of participation, although the EMG posttest data offered qualified support for the conclusion that cognitive restructuring is more effective with students at advanced levels of participation in mathematics.

An interesting and somewhat surprising result from this study is that physiological (EMG) and paper-and-pencil (MAI) measures of anxiety were not strongly correlated. The Pearson product-moment correlation coefficient between EMG and MAI posttest scores was virtually zero. An examination of Figure 8 reveals that most subjects in the study experienced relatively low levels of skeletal muscle tension, but at each EMG level the corresponding dispersion in self-reported anxiety was large. Perhaps anxiety and muscular relaxation are compatible states. Alternatively, the two instruments may be tapping different dimensions of the math-anxiety construct.

The results of this study suggest additional

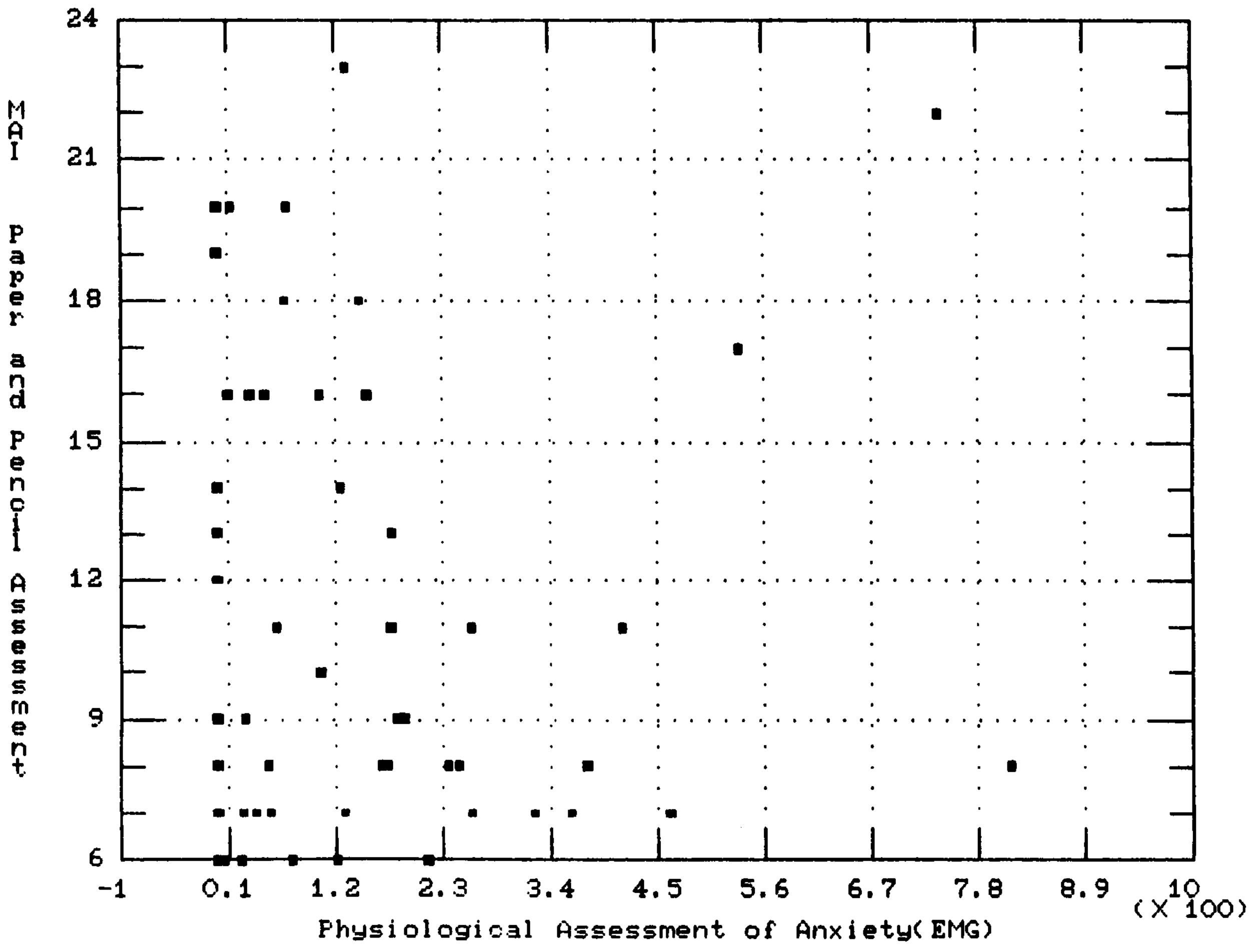

Figure 8. MAI vs EMG Posttest Scores

questions. For example, the largest coefficient of determination reported in this study was 50.2%, indicating that approximately half of the total variation in level of mathematics anxiety is due to factors other than treatment, level of achievement, and level of participation. What are these other factors?

What types of direct action interventions are most effective with students experiencing outcome-based anxiety? What types of palliative interventions are most effective with individuals experiencing efficacy-based anxiety? Does a reduction in anxiety lead to a corresponding increase in achievement, other things being equal? At what levels of participation in mathematics is skeletal muscle tension facilitative rather than debilitative? Under what conditions does the law of diminishing returns govern the relationship between treatment length and treatment efficaciousness?

What are the sources of mathematics anxiety in the curriculum and pedagogy of mathematics? How is mathematics anxiety transmitted in the educational process? In particular, how widespread is mathematics anxiety among public school teachers?

Is mathematics anxiety a unidimensional or multidimensional construct? What are the relationships among mathematics anxiety, mathematics avoidance, and mathematics incompetence?

Limitations of the Study

The subjects in this investigation were students at Mary Baldwin College, a small private liberal arts college for women. Consequently, the generalizability of any findings to coed institutions, large universities, male students, or a more heterogeneous population is necessarily limited.

One of the most important components of the learning environment is the instructor. Blackburn (1983) found a "very strong positive correlation between students' attitudes toward mathematics and students' perceptions of teacher quality." One cooperating teacher was employed in the study being reported, and although the treatments were not embedded in the instructional process, the effectiveness of a particular intervention may be related to the cooperating teacher's style of instruction.

An assumption of this study is that the two instruments used, Sandman's Mathematics Attitude Inventory and an electromyograph, yield accurate measures of mathematics anxiety. The MAI is a paper-and-pencil test and is therefore subject to possible bias in self-reporting. In addition, forearm muscle tension may not be an accurate measure of total body tension, since low forearm tension is compatible with high levels of tension in the remainder of the body (Fuller, 1980).

Recommendations

The following recommendations are intended to be contributions to a continuing discussion.

With regard to basic research, a working definition of mathematics anxiety needs to be developed and widely adopted by researchers, since a lack of uniformity makes it difficult to synthesize research findings. In addition, valid and reliable instruments for assessing mathematics anxiety need to be developed and compared with existing instruments. In the study being reported, Sandman's Mathematics Attitude Inventory was used to obtain a self-report measure of mathematics anxiety. Due to the transparency of this instrument, it's possible that subjects' responses when they are aware of assessment may differ substantially from their responses when they are unaware of assessment. The use of unobtrusive measures (Kazdin, 1980) that do not arouse any suspicions that assessment is being conducted would add a strong component to future studies.

In addition to Sandman's MAI, an electromograph, a device for monitoring skeletal muscle tension, was used to obtain a physiological measure of mathematics anxiety. Since low levels of forearm tension are compatible with high levels of tension in the rest of the body, the use of multiple electrodes would yield a more accurate assessment of overall muscle tension (Fuller, 1980). Furthermore, the use of an electromyograph during the posttest may have elicited elevated levels of muscle tension, resulting in inordinately high baseline readings for some of the subjects. Multiple resting baseline levels could be taken in order to obtain a more reliable assessment of each subjects' true baseline prior to introducing math-related stimuli (Katkin and Goldband, 1980).

Large and significant correlations were observed among mathematics anxiety, enjoyment of mathematics, and self-concept in mathematics. Further investigation is necessary to learn if these are separate entities or simply different facets of the same construct.

This study should be extended utilizing similar interventions, but at differing levels of participation to determine to what extent mathematics anxiety is task specific. In particular, factorial experiments designed to investigate the synergistic relationship between type of intervention and level of participation need to be conducted.

Due to practical constraints this study utilized an unbalanced design which resulted in small sample sizes for some of the factor combinations. As a result, the probability of committing a Type II error may have been excessive. Future studies, if possible, should use a balanced design and a larger sample size to increase the power of the inferential methods.

In order to eliminate pretest sensitization, a randomized posttest-only design was utilized. The lack of a pretest raises the possibility that group differences at the end of the treatment period may have resulted from differences between groups that existed prior to treatment. If a sufficient number of subjects were available, Solomon's four-group design would be superior to both the pretest-posttest and posttest-only designs, since it permits the researcher to directly assess the effects of pretesting (Kazdin, 1980).

CR subjects as a group experienced a slight increase in self-reported anxiety during the eight-week interim between the immediate and delayed posttests, whereas MPR subjects as a group experienced a slight decrease in self-reported anxiety over the same eight-week period. We cannot assume that subjects will automatically persist in the use of coping skills learned during the treatment period; it is important that subjects be specifically trained to do so, since those who cease their coping efforts prematurely will retain their self-debilitating expectations (Bandura, 1977).

Techniques for enhancing the treatment effects of palliative methods like CR and MPR need to be systematically examined. For instance, biofeedback equipment could be used to facilitate the relaxation response.

Longitudinal studies and qualitative investigations need to be designed and implemented. For example, future studies could be embedded in the classroom setting and administered over longer periods of time to gain the benefits of long-term intensive training in cognitive restructuring and modified progressive relaxation.

A closer working relationship between universities and the public schools needs to be developed that would be mutually beneficial. In particular, special consultants need to be trained and dispersed to assist public school teachers in curtailing the problem of mathematics anxiety in the developmental stages before students begin to avoid mathematics altogether, thus initiating a vicious circle of anxiety, avoidance, and low achievement. Perhaps public school teachers should be required to have a rudimentary knowledge of both direct action and palliative methods of intervention in order to better deal with math-anxious students.

Better more efficient means of dissemination of research findings need to be developed to assist practitioners actively involved in the mathematical rehabilitation of women.

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APPENDIX A

Sandman's Mathematics Attitude Inventory

MATHEMATICS ATTITUDE INVENTORY

Directions

The following statements are about the study of mathematics. Please read each statement carefully and decide whether it describes the way you feel about mathematics.

If you agree with the statement, circle 1.

If you tend to agree with the statement, circle 2.

If you tend to disagree with the statement, circle 3.

If you disagree with the statement, circle 4.

Be sure to circle only one number for each statement.

Be sure to answer every question. You will need about 20 minutes to complete the 48 statements of the inventory. Remember to answer each statement according to the way you feel at the present time.

Mathematics Attitude Inventory Items Grouped by Subscales

Subscale I — Perception of the Mathematics Teacher

Item	Number on Scale
My mathematics teacher shows little interest in the students.	5
My mathematics teacher makes mathematics interesting.	17
My mathematics teacher presents material in a clear way.	21
My mathematics teacher knows when we are having trouble with our work.	27
My mathematics teacher doesn't seem to enjoy teaching mathematics.	31
My mathematics teacher is wiling to give us individual help.	40
My mathematics teacher knows a lot about mathematics.	44
My mathematics teacher doesn't like students to ask questions.	46

Subscale II — Anxiety Toward Mathematics

Item	Number on Scale
I feel tense when someone talks to me about mathematics.	20
Working with numbers upsets me.	34
It makes me nervous to even think about doing mathematics.	36
I would rather be given the right answer to a mathematics problem than to work it out myself.	37
It scares me to have to take mathematics.	39
If I don't see how to work a mathematics problem right away, I never get it.	48

Subscale III	Value of Mathematics in Society
Item	**Number on Scale**
Mathematics is useful for the problems of everyday life.	1
There is little need for mathematics in most jobs.	9
Most people should study some mathematics.	12
Mathematics is helpful in understanding today's world.	15
Mathematics is of great importance to a country's development.	23
It is important to know mathematics in order to get a good job.	24
You can get along perfectly well in everyday life without mathematics.	33

Subscale IV	Self-Concept in Mathematics
Item	**Number on Scale**
I don't do very well in mathematics.	4
Mathematics is easy for me.	10
I usually understand what we are talking about in mathematics class.	16
No matter how hard I try, I cannot understand mathematics.	19
I am good at working mathematics problems.	30
I remember most of the things I learn in mathematics.	35

Subscale V	Enjoyment of Mathematics
Item	**Number on Scale**
Mathematics is something which I enjoy very much.	2
Working mathematics problems is fun.	6
When I hear the word mathematics, I have a feeling of dislike.	11
I would like to spend less time in school doing mathematics.	13
I would like a job which doesn't use any mathematics.	26
I have a good feeling toward mathematics.	43
I have a real desire to learn mathematics.	47

Subscale VI	Motivation in Mathematics
Item	**Number on Scale**
I would like to do some outside reading in mathematics.	8
Sometimes I read ahead in our mathematics book.	14
I enjoy talking to other people about mathematics.	28
Sometimes I work more mathematics problems than are assigned in class.	32

APPENDIX B

Participation Levels

Math 130. Basic Mathematical Concepts.

This course is designed for students who have not passed the mathematics competency examination. The course includes the following topics: whole numbers, fractions, decimals, ratio and proportion, percents, signed numbers, and an introduction to algebra.

Math 160. Finite Mathematics with Applications.

Designed for students in the natural, social, behavioral, and managerial sciences. The purpose of this course is to give students an understanding of some of the key ideas in contemporary mathematics. A liberal arts approach suitable for the twentieth century citizen and appropriate for the decade of the 1980s will be stressed. Topics of importance include sets, logic, informal and coordinate geometry, matrices, probability, game theory, graph theory, and BASIC programming.

Math 213. Introduction to Statistics.

This course introduces students to the basic techniques of statistical decision-making. It is strongly recommended for students in the behavioral, social, managerial, and physical sciences. Topics to be covered include: central tendency, dispersion, skewness, kurtosis, probability distributions and mathematical expectation, binomial and normal random variables, sampling distributions, central limit theorem, confidence intervals, one and two-sample tests of hypotheses, simple linear regression and/or analysis of variance, use of the Minitab computer package.

Prerequisite: Math 160. Finite Mathematics.

APPENDIX C

Results of Linkage Analysis

Item	Number on Scale
Mathematics is something which I enjoy very much.	2
I like the easy mathematics problems best.	3
I don't do very well in mathematics.	4
Working mathematics problems is fun.	6
I feel at ease in a mathematics class.	7
Mathematics is easy for me.	10
When I hear the word mathematics, I have feeling of dislike.	11
I would like to spend less time in school doing mathematics.	13
I usually understand what we are talking about in mathematics class.	16
I don't like anything about mathematics.	18
No matter how hard I try, I cannot understand mathematics.	19
I feel tense when someone talks to me about mathematics.	20
I often think, "I can't do it," when a mathematics problem seems hard.	22
It doesn't disturb me to work mathematics problems.	25
I would like a job which doesn't use any mathematics.	26
I like to play games that use numbers.	29
I am good at working mathematics problems.	30
Working with numbers upsets me.	34
I remember most of the things I learn in mathematics.	35

It makes me nervous to even think about doing mathematics.	36
I would rather be given the right answer to a mathematics problem than to work it out myself.	37
It scares me to have to take mathematics.	39
The only reason I'm taking mathematics is because I have to.	41
I have a good feeling toward mathematics.	43
Mathematics is more of a game than it is hard work.	45
I have a real desire to learn mathematics.	47
If I don't see how to work a mathematics problem right away, I never get it.	48

APPENDIX D

Mental Arithmetic Exercises

1. SERIAL SEVEN TEST: Beginning at 1000, count backwards by sevens for a period of one minute.

2. ADD: 23,109 + 816,790

   a) 839,899
   b) 104,788
   c) 839,889
   d) 820,376

3. SUBTRACT:

```
   83,005
 -  9,637
   -------
```

   a) 74,378
   b) 73,368
   c) 74,368
   d) 92,372

4. MULTIPLY:

```
   876
 x   7
   ----
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   a) 5692
   b) 5132
   c) 6142
   d) 6132

5. DIVIDE: 4263 ÷ 7

   a) 69
   b) 508
   c) 67
   d) 609

6. SIMPLIFY: 15 - (16 ÷ 4)(3) + 3

   a) 6
   b) 36
   c) 11
   d) 15

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