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Personality type and mathematics anxiety factors affecting remedial college freshman

Akey, Wayne L., Jr., Ph.D.
The Ohio State University, 1991
PERSONALITY TYPE AND MATHEMATICS ANXIETY FACTORS AFFECTING REMEDIAL COLLEGE FRESHMAN

DISSERTATION

Presented in Partial Fulfillment of the requirement for the Degree Doctor of Philosophy In the Graduate School of the Ohio State University

By
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The Ohio State University
1991

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1991
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Studies in Mathematics Education
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Chapter I

INTRODUCTION

Many persons openly admit to being anxious in mathematical situations. Much attention has been given recently to the effects of mathematics anxiety and treatment programs are somewhat common. Having mathematics anxiety is probably not a recent phenomenon, but it has become the focus of much thought and study. This study looked at the relationship of mathematics anxiety with a person's personality type, as well as investigating what combination of additional variables might best predict a change in a person's mathematics anxiety level.

The feeling that one's competence in mathematics is not adequate to handle the manipulation of mathematical symbols or to find the solution of a mathematics-related problem has led numerous individuals to feel tense and anxious when confronted with almost any mathematical situation. This state of anxiety has been termed mathematics anxiety or more commonly "math anxiety". The origination of this phrase has been credited to Sheila Tobias, a leading feminist. Tobias, in the early 1970s, became a focal point for the public consciousness of mathematics anxiety.
with her introduction of mathematics anxiety clinics designed to help reduce the mathematics anxiety of the participants. Her book, *Overcoming Math Anxiety*, (1978) helped to inform the general public of this phenomenon. Another early catalyst for this attention was sociologist Lucy Sells (1975) who, during her work on her doctoral thesis, published results of research that indicated that the mathematics avoidance, developed in the presence of mathematics anxiety, exhibited by women students was severely limiting their careers.

Much of the early attention on mathematics anxiety was due to the concern of the feminists and others on the effect of mathematics anxiety on women. A significant number of studies were conducted concerning the relationship of mathematics anxiety and a person's gender. Becker (1987) found that elementary education majors, predominantly female, had higher mathematics anxiety than a group of astronomy students that was less feminine-dominated. In 1986, she identified affective factors, especially mathematics anxiety, that had made a gender difference in the enrollment in mathematics classes with females having a less equitable enrollment ratio. Fennema, Wahlberg, and Marrett (1985) described similar findings.

Bander and Betz (1981) reported that females had higher levels of general anxiety than males. Mathematics anxiety associated with the stereotype that mathematics is a male domain had the greatest influence on this difference. Bohuslov (1980)
found that women had high mathematics anxiety, had pronounced negative feelings toward mathematics, and responded more than men that mathematics was a male domain. Brown (1979) found that females had more negative attitudes toward mathematics and higher mathematics anxiety.

Feminists, in particular, argued that much of this behavior was learned by women in interaction with a sexist society. They cited societal expectations that see females in roles of play and work which require such attributes as nurturing, generosity, and being verbal, societal norms that reward members of the feminine sex for participating in such activities as doll-playing, nursing, and elementary school teaching. On the other hand, females are discouraged from engaging in activities such as playing with toys that provide opportunities to determine why "they work", or aspiring to areas of engineering and science that require logic, persistence, and intellect, purported to be male attributes.

While there is much evidence that members of the feminine gender can be severely handicapped by feelings of inadequacy in the realm of mathematics, the reality that members of the male gender also exhibit these anxieties has caused some researchers to expand beyond the initial feminist concerns. Buckley and Ribordy (1982) found no gender-role identification that related significantly to mathematics anxiety. Likewise, Wooley (1982) found no significant gender-related difference with mathematics anxiety among sixty seventh, eighth, and ninth grade mathematics students.
Persons such as Hackworth (1985), Hilton (1980), and even Tobias (1978), wrote that mathematics anxiety is no respecter of gender, that perhaps the roots of mathematics anxiety are less gender-oriented than the feminists proclaimed. Hackworth, although concurring that mathematics anxiety is learned, felt that prior negative experiences are the producers of mathematics anxiety, that these are experienced by members of both sexes. He stated, "those individuals who suffer 'math anxiety' have had experiences which negatively effect their ability to be successful with mathematics." (p. 2) The perception of students that they have no control over learning experiences, he feels, is the major component of their anxiety.

Likewise, Hilton identified prior adverse experiences, emphasizing "poor educational practices", such as inadequate teaching, the extreme reliance of mathematics educators on standardized testing, and the use of textbooks that are badly written, as causes for mathematics anxiety. Greenwood (1984) was especially critical of teaching methodologies: "The real source of the mathematics anxiety syndrome lies in the teaching methodologies . . . skills are too often taught by the 'explain-practice-memorize' teaching paradigm. This teaching methodology, by its nature, isolates facts from reason and from the process of problem-solving itself. It concentrates on procedures of producing answers and is not particularly concerned with the developing of logical thought process nor the type of reasoning that is at the basis of
computational algorithms and more abstract symbolic transformations" (p. 663).

Hackworth's perspective can lead one to an awareness of the personal character of mathematics anxiety, that whatever societal or curricular factors may contribute to the anxiety, the anxiety itself is intensely personal with strong feelings of self-doubt and self-denigration. Tobias (1978) wrote, "The first thing people remember about failing at math is that it felt like sudden death...the autobiographies of math anxious college students and adults reveal that no matter how much the teacher reassured them, they sensed that from that moment on, as far as math was concerned, they were through...whether it (the failure) occurred in elementary school, high school, or college, victims felt that a curtain had been drawn, one they would never see behind..." (p. 44-45).

This intense feeling suggests a profound psychological event in the life of the victim. Perhaps a sense of loss of control could be at least a partial explanation as to why there is a reaction of such finality. Hence, Hackworth and others (Mitchell (1984), Frankenstein (1984) and Kogelman and Warren (1979)) tried to use counseling approaches to aid the victims of mathematics anxiety. Self-analysis is often the keystone of the program, bringing recognition of the adverse negative reactions to mathematics that are present, and trying to acknowledge the influences of the past. These activities are referred to as "systematic desensitization", as they attempt to intentionally
desensitize the influence of the past. There is a strong effort to replace the "I can't" attitude with an "I can" attitude, frequently using group support and new programs, many times involving technology such as calculators and computers, designed to instill success.

Another type of mathematics anxiety reduction program addressed such concerns as Hilton's. These attempt to teach mathematics in new ways, trying to make it more interesting. Spatial skills are learned, visualization ability is stressed, and often physical manipulatives are used with adult students.

Hembree (1990), in a meta-analysis on the research about mathematics anxiety, concluded that the counseling approach was effective in the relief of mathematics anxiety, especially when it used systematic desensitization as Hackworth had. He concluded that curricular changes as a means of reducing mathematics anxiety did not seem effective. Reyes (1984) reported that although some programs had been effective in reducing levels of mathematics anxiety, very few had been effective in improving mathematics achievement scores or increasing mathematics course election.

As the awareness of this personalization of the effects of mathematics anxiety increases, one might ponder, "Why does one person become a victim and another not, although each may have endured the same treatments of 'inadequate teaching', 'excessive societal pressure for a particular gender role' or whatever other global explanation for mathematics anxiety that may be advanced?"
Or even more to the core of the issue, "Are there particular individual characteristics that make it more likely for one student to become more anxious about mathematics than another?"

Significant progress has been made in developing programs to treat mathematics anxiety, but less effort has been used to understand its psychological bases. Some attempt has been made to establish the components of math anxiety. The Mathematics Anxiety Rating Scale (MARS), designed by Richardson and Suinn (1972), consists of a 98-item instrument that has become frequently used in studies involving mathematics anxiety. Rounds and Handel (1980) performed a factor analysis on MARS, retaining only two factors, thus suggesting that perhaps the 98 items could be shortened to about 30 items. They labeled the two factors that they found as "Mathematics Test Anxiety" and "Numerical Anxiety". Ferguson (1985) constructed "PHOBOS", a 30-item instrument, that consists of 10 items from MARS on mathematics test anxiety, 10 items from MARS on numerical anxiety, and 10 items that he constructed, grouping them as "Abstraction Anxiety". His factor analysis established this last category as a third component of mathematics anxiety. Resnick, Viehe, and Sanford (1982) also identified three factors on MARS. They labeled them as "evaluation anxiety", "social responsibility anxiety", and "arithmetic computation anxiety". No doubt further study and research need to be carried out to verify these and to see if more components can be determined.
Anxiety is a construct broadly defined to be a state of emotion underpinned by qualities of fear and dread (Lewis, 1970). Spielberger (1972) discussed two forms of anxiety - state anxiety and trait anxiety. State anxiety is the "unpleasant emotional state or condition which is characterized by activation or arousal of the autonomic nervous system". (p. 482) State anxiety is time- and situation-specific and is aroused when an individual perceives a situation as potentially harmful or threatening. Trait anxiety is neither situation- or time-specific; Spielberger described it as a relatively stable personality trait of being prone to anxiety. Thus, a highly trait-anxious person has anxiety more severely and in a broader range of situations than a less trait-anxious person.

Two subconstructs of anxiety, test anxiety and mathematics anxiety, seem to be of such nature so as to enhance the increase of trait anxiety in a person with less trait anxiety. Mathematics anxiety becomes generalized, that is, it affects behavioral situations which are increasingly remote from the situation that might have influenced a person to feel the original state anxiety. For example, a person who experiences mathematics anxiety about a new mathematical concept in the classroom may eventually feel anxious about this same mathematical idea in situations far removed from the classroom.

Test anxiety and mathematics anxiety have a number of parallel properties. Hembree (1990) indicates that: (1) mathematics and test anxieties both have a relationship to general
anxiety; (2) anxiety level differences in both types of anxiety have similar correlations to such traits as ability, gender, and ethnicity; (3) performance is often affected in a negative manner when a person possesses trait anxiety as the form of either test or mathematics anxiety; (4) both kinds of anxiety respond to the same treatment modes, responding most from behavioral-related methods; and (5) improved performance is related to the lessening of each type of anxiety.

It appears, however, that mathematics anxiety is not a specific form of test anxiety. Hembree found in his analysis that the correlation of mathematics anxiety and test anxiety was 0.61, a moderate value. This would mean that 37 percent of mathematics anxiety's variance is predictable from the variance of test anxiety.

Mathematics anxiety seems to be more than a fear of tests; rather it expands to fear of contact with mathematics in the classroom in general and often to mathematical situations outside the classroom.

Liebfritz (1990) concluded that while there is a relationship of mathematics anxiety to test anxiety, "mathematics anxiety" is a phrase in need of greater clarification than to label it as "test anxiety" alone.

One of the outcomes of anxiety is that anxiety victims frequently view their control of the anxiety-producing situation as extremely tenuous or nonexistent. The fear of failure is punctuated by judgments as to what is causing the situation. The causes
attributed to the situation are more critical than reality as they influence self-concept, expectations for the future, feelings of adequacy, and subsequent motivation to put forth effort. While other factors may affect the intention of a person to expend effort, perceptions of causality provide an important prompt to one's motivation (Hunter and Barker, 1987).

From the theory of social psychology, the theory of attribution emerged to formalize this search by persons for causes of success and failure. In American culture, four factors are attributed to a person's success or failure: native ability, effort, task difficulty, and luck. Native ability and effort are deemed to be able to dominate the factors of task difficulty and luck. The four attributions can be considered to be on three continuums: locus, stability, and controllability (Werner, 1972).

The location of the cause may be internal, ability or effort, or it may be external, task difficulty or luck. If success is attributed to an internal cause, the results are increased self-esteem. If an internal cause is the attribution for a failure, shame (lack of ability) or guilt (lack of effort) are the outcomes.

The second dimension of these four attributions is their stability. Ability and task difficulty are seen to be stable (unchanging) while luck and effort are unstable (changing or changeable). An individual's future expectations of success or failure can be determined in reference to this dimension of attributions. If the cause for success or failure is perceived to be
stable, the change of expectations will be greater than when unstable factors are seen as the cause. Thus, if success is attributed to luck, the increase in expectancy for future success in that situation will be smaller than if the success had been attributed to ability. Likewise, when failure is seen as caused by the difficulty of the task, the drop of expectancy for success in future performances of the task is greater than when the failure is attributed to a lack of effort (Werner, 1979).

The third dimension of the attributions is the extent of a person's control of them, or their controllability. The only causal attribution that a person can control is effort. The other three, ability, task difficulty, and luck are beyond one's power as one attempts to complete a task.

It is this dimension of attributions that those who use the counseling approach to the treatment of mathematics anxiety (such as Hackworth) are responding to in their attempts to change the mathematics anxiety victim's conviction about his/her ability to do mathematics from an "I can't" to an "I can" attitude. An extreme example of the "I can't" attitude is the person who exhibits what is termed "learned helplessness". Learned helplessness students feel that they have no control over success or failure on many academic tasks (Dweck and Goetz, 1978).

Learned helplessness mathematics students attribute success to external factors of ease of task or luck, and failure to the internal factor of ability. After failing on a mathematics task, these students
see failure as inevitable on similar tasks. In contrast, mastery-oriented students, who attribute failure to a lack of effort, tend to persist or even improve performance in the face of failure.

Since failure is inevitable from the attribution of a learned helpless victim, they will regularly avoid mathematics, not making an effort. Failure without effort is perceived as less painful than failure when an effort to succeed has been made.

Attributions seem to be closely related to anxiety. Wahl and Besag (1986) found that students who had low mathematics anxiety attributed their success more often to their ability than those who had high mathematics anxiety. Those students with low mathematics ability attributed failure to the characteristics of the task rather than to their own ability or effort.

The number of other possible correlates with mathematics anxiety is extensive. Numerous studies have been made about the correlation of mathematics anxiety and achievement. Adams and Holcomb (1986) found that mathematics anxiety and achievement in statistics were negatively correlated. Gliner (1987), however, reported that a relationship between mathematics achievement and mathematics anxiety could not be found.

Betz (1978) reported a negative correlation between mathematics anxiety and the mathematics background of the student. In the same study, she found negative correlations of mathematics anxiety with confidence levels of learning
mathematics, the belief of the usefulness of mathematics, and parental influence.

Other attitudes toward mathematics have been identified which relate to mathematics anxiety. Austin-Martin, Waddell, and Kincaid (1980) found that mathematics anxiety correlated with the belief that mathematics was a male domain. Hembree (1990) reported that enjoyment of mathematics negatively correlated with mathematics anxiety. Pedro, Wolleat, Fennema, and Becker (1981) found that mathematics anxiety was negatively correlated to future mathematical plans of students.

Lipsett (1986) found no significant difference in mathematics anxiety levels between groups taught using physical manipulatives and those taught by an expository method. The relationship of other mathematics classroom and curricular areas with mathematics anxiety has been explored. Scott (1978) found that teachers, especially male, interact with female students in mathematics classes so as to lower their self-esteem which produces more anxiety. Nelson (1977) found sexual stereotyping in elementary mathematics textbooks. These depicted females in nonmathematical roles, thus reinforcing the belief that mathematics is a male domain, which contributes to mathematics anxiety in females.

One possible correlate with mathematics anxiety that has not been studied thoroughly by researchers is the personality profile of students. Some correlates of mathematics anxiety have been
studied with personality constructs. Frary and Ling (1983) found that negative mathematics attitudes were independent of personality variables. Behrens and Vernon (1978) showed that achievement and personality traits have some correlation. Most intriguing of these studies are those which relate achievement to personality type.

C.G. Jung (1923) proposed a theory of psychological types in which behaviors that are seemingly different and random can be systematized into orderly and consistent patterns if considered by standards of basic differences by which individuals prefer to use their perception and judgment. By perception, Jung referred to the ways that awareness of things, people, happenings, or ideas come to people. Judgment activities involve ways of coming to conclusions about the perceptions that have been made.

Two basic mental functions, called sensing (S) and intuition (N), can be used to classify all perceiving activities. Perception activities are described as irrational functions in that these are attuned to the flow of events and operate most broadly when not constrained by rational direction. The sensing mode of perception is the reliance on using one or more of the five senses to make known observable facts or happenings; while the intuition mode indicates reliance on less obvious processes of reporting meanings, relationships, and/or possibilities that have been worked out beyond the realm of the conscious mind.
Judgment activities can be called either thinking (T) or feeling (F). Jung used the terms thinking and feeling in specialized ways, referring to them as rational functions that are directed toward bringing life events into harmony with the laws of reason. The contrasting ways of judgment involve a primary reliance on deciding impersonally on the basis of logical consequences (thinking) or the reliance mainly on the basis of personal or social values (feeling).

In addition, Jung classified individuals as extroverts (E) or introverts (I), based on the preference of individuals to direct their perceptions and judgments on the external world (E) or the world of ideas or interior world (I). Individuals in some phase of their lives operate in each of these categories, but Jung insisted that everyone has a basic preference in each of the dichotomous listings, one that they "lean to".

Myers and Briggs (1962) adapted Jung's categories into the Myers-Briggs Type Indicator (MBTI), a personality instrument which classifies individuals into one of sixteen categories, each described by four letters. For example, "ESTJ" indicates extrovert, sensing, thinking, and judging while "INFP" indicates introvert, intuitive, feeling, and perceiving. The first three letters of the title categorize the individual in terms of Jung's dichotomous ideas of extrovert and introvert, sensing and intuitive perceptions, and thinking and feeling judgments; the last letter, however seems somewhat incongruous as the descriptors (perception and
judgment) indicated to Jung sequential processes of seeing what is in a situation and then deciding what to do about it.

Briggs, however, saw them as descriptors of how one deals with the outer world, that is, the extroverted part of life, as each individual, even an introvert, must make some response to his/her environment. These are dichotomous in the fact that one cannot do both at once. Those who exhibit a judgment (J) preference tend to be ready to make judgments on the outer world, while those with a perceptive (P) preference want to be in a perceiving mode in the outer world, that is, being ready to acquire additional information before making judgments.

The fourth letter is indicative of which of the four processes will act as "dominant" and which will be "auxiliary". For an extroverted person, this fourth letter indicates which of the subscales, intuitive-sensing (P) or thinking-feeling (J) contains the dominant process. For example in ESTJ, the dominant process will be a judging subscale preference. Since this type has a "T" on that subscale, and this "T" refers to thinking, this type's dominant process is thinking. The preference for acting in the interior world will then be on the perception subscale, which for this letter scheme indicates an "S". The "S" process (sensing) is called his auxiliary process. When this type is operating in the interior world (which is not "the place" where they prefer to operate), they will probably be using a sensing mode.
An "ESTJ" person has a personality that is extroverted, prefers to respond to the outer world based on logical thinking, whose interior world is basically controlled by an auxiliary process of sensing (Myers, 1987). A person of this type will "see the realities; be matter-of-fact, practical, realistic, factually-minded, concerned with here and now; is more curious as to new things than new ideas; prefers to have ideas, plans, etc. based on solid fact; may need an intuitive around to sell him on the value of new ideas." (p. 10).

For an introvert, the fourth letter is indicative of his auxiliary process, as his dominant process will be in his inner world, thus making his preference for dealing with outer world the auxiliary process. For an "INFP" person, the auxiliary process will come from the perception (P) subscale, which is either intuitive (N) or sensing (S). Since this person is an "N", he will prefer to operate on the exterior world in an "intuitive mode", that is, his plans concerning his exterior world will probably not be based on "solid facts". However, this type prefers to act in the inner world and this is where his dominant process will be found. The dominant process will be found on the "J-subscale" (thinking-feeling continuum). Since this type indicates an "F", the dominant process is that of feeling. The "INFP" person's personality is dominated by making interior decisions based mostly on values.

INFP people "see the possibilities; like to concentrate on a project and dislike all details not relevant to any deep interest; are
marked by insight and long range vision, curious about new ideas, and are interested in books and language; are likely to have a gift of expression, especially in writing; and are ingenious and persuasive on the subject of their enthusiasms, which are quiet but deep-rooted." (Myers, 1987, p. 17).

Numerous studies have been made involving the MBTI and possible correlates of mathematics anxiety. For example, Prillwitz (1983) considered achievement and MBTI personality types. Among her findings was that successful women in mathematics and mathematics-related careers have common characteristics of I (introvert) and J (judging). Golliday (1975) found that S (sensing) students improved significantly more in attitude with mathematics laboratory materials.

In the literature search, however, no direct studies involving mathematics anxiety and MBTI personality type were found. This lack of research relating mathematics anxiety and MBTI personality type provided an impetus for this study.

Moreover, in view of the research with other possible correlates of mathematics anxiety, one might expect that each type of personality could have a differing set of conditions that has some determination as to the amount of mathematics anxiety that type might have. For each personality type, there could be one set of individual characteristics such as age or attitude which associate strongly with mathematics anxiety, while these characteristics might not relate to mathematics anxiety with another personality
type. In like manner, each personality type might have a set of experiences, such as not being able to master certain mathematics concepts or having had a disturbing relationship with a mathematics teacher, that relate similarly to mathematics anxiety.

Characteristics such as age or attitude were called background variables in this study and were characterized by having their origin within the person himself; characteristics such as current mathematics knowledge and the quality of relationships with present mathematics teachers were classified as experiential variables, being characterized by having their origin in the current mathematical experiences that a student is having. With regard to these suppositions, the following statement of problem is made:

**Statement of the Problem**

The problem of this research was to determine the relationship between an individual's personality type as indicated by the Myers-Briggs Type Indicator and the amount of mathematics anxiety as measured on a mathematics anxiety rating scale. With this known, a determination was made as to which combination of background and experiential variables best predicted the occurrence and change of mathematics anxiety for each individual.

The hypotheses examined were:

Hypothesis (i): Persons whose personality types are either ESFJ (extrovert-sensing-feeling-judging) or ESFP (extrovert-sensing-feeling-perceiving)
should be more likely to exhibit higher mathematics anxiety than any other personality type.

Hypothesis (ii): There is a set of background characteristic variables that significantly predict mathematics anxiety change.

Hypothesis (iii): There is a set of experiential variables that significantly predict mathematics anxiety change.

Hypothesis (iv): There is a combination of background and experiential variables that significantly predict mathematics anxiety change.

Subjects for this study were 203 students enrolled in Math 102 at a midwestern university in the fall of 1988. This course is the lowest entry level mathematics class for the university, similar to algebra one in high school mathematics. These remedial classes did not have the traditional instructor-led format, but the material was taught in a quasi-self-study, self-paced instructional mode. Students in each class were randomly assigned to smaller groups, each group becoming the responsibility of a "mathematics proctor". The proctor's responsibility was to answer questions for the students about concepts and methods of working problems. All Math 102 classes were overseen jointly by the course coordinator and a senior faculty member of the mathematics department.
Past interviews with previous enrollees in this course indicated a majority of the students would possess mathematics anxiety at the time of entrance into the course.

The instructional mode used in Math 102 is based on the Personalized System of Instruction (PSI), or what is commonly called the "Keller Plan". In conventional, lecture-type instruction, the pace and difficulty level is the same for all students, allowing for no individualization. Alternatives to this lack of individualization are called adaptive instruction, of which PSI is an example. Adaptive instruction tailors or selects or prescribes educational experiences in accord with the unique characteristics of the learner.

One of the earliest forms of adaptive instruction developed was Programmed Instruction (PI) developed in the 1950s by B. F. Skinner. It was characterized by learning frames, teacher-developed units of instruction that use positive reinforcement and immediate feedback.

F. S. Keller, a follower of Skinner, developed in the mid-1960s, PSI, which has the following components: (1) self-pacing; (2) unit perfection; (3) former students as proctors; (4) emphasis on written materials; (5) criterion-reference testing and grading; and (6) retesting for achieving mastery (Daly and Robertson, 1978).

On the first day of class in the fall of 1988, Math 102 students filled out the mathematics anxiety inventory, an information sheet about background and experiential variables, and
completed the Myers-Briggs Type Indicator. Five weeks later, the students filled out the mathematics anxiety inventory again. Participation was voluntary with three students in the eight classes declining to participate.

Chapter II will be a literature review, ending with a rationale based on the literature review for the hypotheses stated in this chapter. Chapter III will discuss the design of the study and the processes and instrumentation involved. Chapter IV will provide analyses of the data obtained, and Chapter V will provide a summary discussion.
CHAPTER II
LITERATURE REVIEW

The literature related to mathematics anxiety and MBTI personality is reviewed in three sections: literature summarizing the relationship of mathematics anxiety to possible correlates, literature concerning the relationship of MBTI personality type with these correlates, and literature relating anxiety and MBTI personality type. Since no research was found concerning mathematics anxiety and MBTI personality type, conjectures supporting the hypotheses of Chapter I are given in the light of the other research in this chapter.

Correlates of Mathematics Anxiety

Historically the first correlate of mathematics anxiety that received attention was gender. Feminists saw mathematics avoidance, induced by mathematics anxiety, as a practice that needed to be redressed in order to give members of the feminine gender their rightful place in society. Many studies examined the correlation of mathematics anxiety and gender.

Studies by Becker (1987), Fennema, Wahlberg, and Marrett (1985), Bander and Betz (1981), Bohuslov (1980), and Brown (1979) were cited previously indicating that women are more likely
to admit possessing mathematics anxiety and will probably practice more mathematics avoidance. Voit (1983) found that the attrition rate of students in a community college algebra course was significantly higher for mathematics-anxious females than for mathematically-anxious males. Llabre and Suarez (1985) reported that women showed higher levels of mathematics anxiety in a study of 112 female and 72 male private university students.

However, previously cited studies by Buckley and Ribordy (1982) and Wooley (1982) reported that they could find no significant gender-related differences in mathematics anxiety. Preston (1986), using MARS with 173 students reported no significant differences existed when comparing gender with mathematics anxiety. Hembree (1990) in his meta-analysis on research about mathematics anxiety indicated that precollege levels mathematics anxiety effects are more prevalent in male than in female students.

Prior achievement in mathematics has been studied as a possible predictor of mathematics anxiety. Bassareau (1986) found that prior mathematics achievement was a strong predictor of current mathematics course achievement, but that it did not predict mathematics anxiety. Gliner (1987) found that mathematics achievement was not a significant factor in predicting mathematics anxiety. Adams and Holcomb (1986), Buckley and Ribordy (1982), Betz (1978), and Aiken (1972), however, all found a negative relationship of prior mathematics achievement with mathematics
anxiety, that is high achievement is related with low anxiety and low achievement is related to high anxiety. Crosswhite (1972), in a longitudinal study for students in grades 4-12, also found a negative correlation of prior mathematics achievement and mathematics anxiety.

Classroom conditions, such as teacher behaviors and textbooks, have not been studied extensively as possible correlates of mathematics anxiety. Becker (1980) and Scott (1978) found that teachers, especially male, tend to see mathematics as a male domain. No determination of anxiety was made, but as Bander and Betz (1981) showed a strong association between mathematics anxiety in female students and the belief that mathematics is a male domain, one could expect that these male teachers might provide a fertile situation where anxiety might exist. Fennema (1981) discovered that mathematics teachers initiated more interaction with boys than girls, and asked more questions of boys than girls. The boys in the study were found to have a greater confidence level of their ability to do mathematics and to have lesser mathematics anxiety. Fox (1982) found that girls who were extremely talented in mathematics were not viewed as unusually gifted or unique by their teachers.

Jay (1973) found sexual stereotyping in elementary mathematics textbooks. Kepner and Koehn (1977) discovered similar results, concluding that such a situation helps perpetuate the myth of mathematics being a male domain. Chapline (1981)
indicated success in reducing mathematics anxiety in females by developing materials which increase the perception of female acceptance into the field of mathematics.

Resek and Rupley (1980) found that helping students to change from being rule-oriented in their mathematics classes to being more concept-oriented lessened their mathematics anxiety. Hendel (1980) found that students who had played mathematics games as children had lower mathematics anxiety scores. Lipsett (1986) found no significant difference in mathematics anxiety between those taught with a "hands-on" approach and those taught mathematics by an expository method.

Another external background factor that correlates with mathematics anxiety is parental influence. Betz (1978) found a strong negative correlation for this association. Students whose parents had negative feelings about mathematics tended to have higher levels of mathematics anxiety. Yee and Eckles (1988) found that these conditions also extend into a negative influence on a student's achievement. Influence of one's father was found to be a factor in mathematics avoidance by Chisholm (1980). DeBronac-Meade and Brown (1982) indicated that less parental encouragement to study mathematics relates to more mathematics anxiety for students, especially females.

Hembree (1990), in his meta-analysis of the research about mathematics anxiety, found 14 studies correlating the students' perceptions of their fathers' attitudes toward mathematics with
mathematics anxiety. The correlations had a mean correlation value of -0.39 for studies involving students in grades 9-12 and -0.25 for studies involving college students. Similarly, Hembree found respective correlations of -0.37 and -0.23 when these students' perceptions of their mothers' attitudes about mathematics were compared with math anxiety. The students' perceptions about their mathematics teachers' attitudes toward mathematics correlated with mathematics anxiety as follows: for students in grades 9-12, -0.49; for male college students, -0.47; and a value of -0.41 for female college students.

The background of previous mathematical experiences is another external variable that has been studied in relationship to its association to mathematics anxiety. Calvert (1981), as did Betz (1978), found that mathematics anxiety occurs less frequently as the mathematics backgrounds of students are strengthened. Ohlson and Mein (1977) reported less mathematics anxiety for undergraduate mathematics majors than for nonmathematics majors. Shanklin (1978) found that students in higher mathematics content majors had significantly lower mathematics anxiety scores than those students in lower mathematics content majors and vice versa. Hembree's meta-analysis reviewed 28 studies relating the number of high school mathematics courses with mathematics anxiety. His results showed a mean correlation of the 28 studies of -0.31.
Butler (1981) found no relationship between mathematics anxiety and the number of mathematics courses taken, but did find that the most highly mathematics-anxious students were the least confident in their mathematics skills.

In terms of internal correlates of mathematics anxiety, the confidence level of learning has been studied extensively. Crosswhite (1972) reported correlations between confidence and mathematics achievement scores ranging from 0.19 to 0.37. Fennema and Sherman (1978) found a positive correlation of 0.40 between mathematics and confidence for students in grades 6-12. Dowling (1978) found a correlation of 0.54 between total confidence and total mathematics performance scores.

Armstrong (1980) examined confidence/mathematics achievement correlations for a nationwide sample of 13-year-olds and twelfth graders. She found low to moderate correlations for the 13-year-olds and moderate correlations for the twelfth graders.

Hembree's (1990) meta-analysis of mathematics anxiety found 4 studies in grades 6-11 and 19 studies involving college students concerning correlations of self-confidence in mathematics with mathematics anxiety. These showed a very strong negative correlation; students in grades 6-11 had a mean correlation of -0.82 and college students had a mean correlation of -0.65.

The theory of attribution which emerged from the field of social psychology was discussed previously in Chapter I. Four factors are attributed to a person's success or failure: native ability,
effort, task difficulty, and luck. Native ability and effort are deemed to be able to dominate the factors of task difficulty and luck. The four attributions are considered on three continuums: locus or location of the cause, which is either internal as in ability or effort, or external as in task difficulty or luck; stability, which can be stable as in ability and task difficulty, or unstable, as in luck and effort; and controllability by the individual. The individual controls only his effort; ability, task difficulty or luck are factors over which he has no control.

Attributions by students of the causes of success/failure have been related to mathematics achievement and anxiety. Studies by both Wolleat, Pedro, Becker, and Fennema (1980) and Parsons, Meece, Adler, and Kaczala (1981) reported that males see success as more of a matter of ability, while females see it more as a matter of effort. The latter study found that for failure this pattern was reversed, while the former study found a very weak relationship between attributions and achievement.

In research involving possible correlates of mathematics anxiety and attributions, Weiner (1979) discovered a positive relationship between attributions and achievement-related behaviors such as persistence, effort, and choice of challenging tasks.

Wohl and Besag (1986) reported that students with high mathematics anxiety and low self-esteem attributed success externally and failure internally. They also found that those
students who had low mathematics anxiety attributed their successes to their ability and their failures to the difficulty of the task rather than to their own ability or effort more than students with high mathematics anxiety. Powers, Choroszy, and Douglas (1984) found that achievement motivation was not related to mathematics anxiety and was negatively correlated with attributions of failure to a poor educational environment.

Attitudes toward mathematics have been associated with mathematics anxiety. Butler (1981) did not find a clear relationship between mathematics attitudes and mathematics anxiety, but studies relating specific attitudes and mathematics anxiety have been more successful. Armstrong and Price (1982) reported how useful students perceive mathematics to be, generally called the usefulness of mathematics, was an important factor on whether students liked or disliked mathematics, how good or bad they perceived themselves to be in mathematics, and whether they would avoid taking more mathematics courses. Ling (1982) found that nonmathematical majors had high mathematics anxiety, with the degree of this anxiety being due to the belief that they considered mathematics to be confusing rather than useful. Austin-Martin, Waddell, and Kincaid (1980) found that females with lower mathematics anxiety saw mathematics as more useful than females with higher mathematics anxiety. Pedro, Wolleat, Fennena, and Becker (1981) reported that mathematics anxiety was negatively correlated to the future mathematical plans of students.
Miller (1981) and Payton and Lloyd (1984) both found that mathematics anxiety was negatively correlated with the enjoyment and liking of mathematics. Brown (1979) reported that negative attitudes towards mathematics correlated with high degrees of mathematics anxiety, as did Kincaid and Austin-Martin (1981).

Mathematical self-concept has been shown to have a significant relationship with mathematics anxiety. Gourgey (1982) defined mathematical self-concept as beliefs, feelings, or attitudes about one's capacity to understand or perform in mathematical situations. She found that mathematical self-concept had a moderately strong negative correlation with mathematics anxiety. Furoto and Long (1982) found that teaching strategies designed to help the student build a positive and realistic mathematical self-concept made a significant difference in the amount of mathematics anxiety that a student possesses.

Hembree's meta-analysis found 24 studies relating the usefulness of mathematics to mathematics anxiety; the mean correlation value of these studies was -0.37. He reported 15 studies relating the enjoyment of mathematics with mathematics anxiety; the mean was -0.75 for studies in grades 5-12 and -0.47 for studies of college students. In terms of self-concept in mathematics and mathematics anxiety, there were 6 studies with a mean correlational value of -0.71.

Kincaid and Austin-Martin (1981) found that current achievement was positively related to mathematics anxiety in low
mathematics-anxious students, and was unrelated to the mathematics anxiety of high mathematics-anxious students. Meece (1981) found that mathematics anxiety was negatively associated with higher grades in mathematics courses for 250 junior and senior high school students. Sachs (1982) found a significant correlation for mathematics anxiety level and mathematics test performance.

In the current study, the Math 102 classes were designed so that the format modeled the Personalized System of Instruction (PSI), or as it more commonly called the "Keller Plan". Watson (1986) found a greater retention of mathematical concepts for students taking a traditional lecture course with a final examination than those taking a Keller Plan course. Fell (1989) found that nursing students using the PSI course in an introductory nursing course achieved significantly higher grades than those taking the same course by receiving traditional instruction; he also found that student acceptance of PSI was adequate. King and Hossain (1984) found PSI students to have higher achievement in a required sophomore engineering course than did those taking the course where the instruction was expository. Jackman (1982) found that using the Keller Plan for teaching a biochemistry laboratory course was successful; this conclusion coming from the comparison of the results in the Keller Plan course with those taking the course where the instruction was traditional. No research was found comparing the anxiety levels of students in PSI classes with students in classes
that are more traditionally taught. A design assumption of PSI advocates has been that PSI courses were less anxiety-laden.

To review the research about mathematics anxiety and its correlates, it seems likely that mathematics anxiety and mathematics avoidance are less gender-oriented and society-fostered than was indicated by the rhetoric of the feminists. Research involving mathematics achievement and curricular concerns has not been extensive but does suggest that present conditions tend to establish higher mathematics anxiety for females, which does give some credence to the feminists' claim of sexism in the mathematics classroom. There is some support that concept-oriented teaching relates to less mathematics anxiety than does rule-oriented teaching.

Other external background correlates of mathematics anxiety that have been studied include parental influence, previous mathematical experiences, and prior mathematical achievement. The research involving the relationship of mathematics anxiety and prior mathematical achievement appears to be mixed; some studies show a relationship while others do not. The relationship of current achievement and mathematics anxiety appears to be more clear: high anxiety levels correlate with low achievement.

Parental influence seems to have a positive relationship with mathematics anxiety, while previous mathematical background relates negatively.
Internal background correlates with mathematics anxiety include confidence, attitudes, student attributions, and mathematical self-concept. These affective factors related negatively with mathematics anxiety, often with a substantial correlation.

**MBTI with Correlates of Mathematics Anxiety**

Studies involving achievement and human personality show that, in general, personality has some correlation to achievement. Cauthen (1979), Behrens and Vernon (1978), and Horn and Turner (1973) all found that personality characteristics such as persistence, optimism, and effort were positively correlated to achievement.

A number of studies have been made concerning achievement and personality-type as defined by the MBTI. The MBTI classifies individuals into sixteen categories, each described by four letters. Each of the four letters signifies a continuum. The first letter of the sequence classifies the individual on the E-I (extrovert-introvert) continuum, indicating whether the person prefers to operate in the external world of society (extrovert) or the internal world of his/her mind when making perceptions and judgments (introvert).

The second letter indicates a preference for making perceptions, that is, acquiring knowledge. A sensing (S) person prefers to use the five senses to do this. An intuitive (N) person uses less obvious processes of reporting meanings, relationships,
and/or possibilities that have been worked out beyond the realm of the conscious mind.

The third letter indicates the preference for judging; that is, coming to conclusions about the perceptions that have been made. Thinking (T) individuals prefer to make conclusions impersonally on the basis of logical consequences, while feeling (F) individuals have a preference for making conclusions based on values, personal and/or social.

The fourth letter, judging (J) or perceiving (P) indicates the preference individuals have in operating in their external world. Judging individuals prefer to make "quick" conclusions about their external world, but perceiving individuals prefer to approach conclusions more cautiously, often seeking additional perceptions.

In studies of MBTI personality types and achievement, Prillwitz (1983) found that successful women in mathematics and mathematics-related careers have common characteristics of I and J and share ISTJ and INTJ as personality types. Kyle (1985) found that among 8th- and 9th-grade social science students, the EI and JP subscales were not related to academic achievement, that N and T classifications related positively to high achievement, while S and T classifications related negatively to high achievement. Hoover (1984) found that individuals classified as N and F had higher performances on the Cornell Critical Thinking Test. Hargett (1981) found that grade-point average related significantly to the classifications of T, S, and N.
Kramer (1977) found that a classification of N appeared to be associated with higher achievement in expository writing and with interest and achievement in creative writing. Creative writers apparently combine T and/or F with N, while better expository writers combine T and/or J with N. Fish (1984) found that a combination of I and N related to positive achievement in economics. Hart (1984) found that scales ESFP and INFJ related to highest gains in achievement, while subscales NJ and NF had significantly higher final grades. Leising (1986) found that students classified as N had a much more significant improvement from pretest to posttest in science achievement that did students classified as S. Charlton (1981) found that ES students' performances on both a "modern biology" test and a "criterion-referenced" test were significantly lower, while IN and IS students did better on the modern biology test, while IN and EN were better on the criterion-referenced test. Iverson (1985) found that non-recipients of teaching excellence awards tended to be classified more as F than T.

Howard (1986), Werth (1985), Miller (1983), Angus (1972), Batten (1982), and Plog (1980) found no significant relationship between MBTI personality type and academic or clinical success.

The relationships of other possible mathematics anxiety correlates with MBTI personality types have also been studied. For example, Conwell (1983) found that attitudes improved and anxiety lessened when instructional activities were designed to match the
student's personality type. Hendrickson (1987) found the achievement for students classified as N and students from the IN subscale improved more when learning activities matched the student's personality type than it did for students on the IS or ES subscale. Golliday (1975) found that students classified as S improved significantly more, both in attitude and achievement, with laboratory materials. Caldwell (1965) found that styles of learning correlate significantly with personality type.

The MBTI typing of mathematics teachers in relationship with their students has been the focus of research studies, indicating different values and preferences for teachers of differing types. Rudicill (1973) found that sensing mathematics teachers gave higher mean ratings on "overall value" and "how students feel" when using a laboratory approach for teaching mathematics, extrovert teachers higher means on "overall value", "how students feel", and "personal usefulness" when using self-paced instruction, and perceptive teachers higher on "personal usefulness" when using questioning techniques when teaching math. Story (1973) found that mathematics teachers classified as N favored having students classified as N while the preferences of mathematics teachers classified as S were less rigid.

In other MBTI related research, Conner (1980) found that persons classified as I, S, F, and J had higher job satisfaction in the medical technology field than those classified as E, N, T, and F, respectively, while attitudes toward coworkers was highest with
persons typing ESFJ. Evans (1976) found an orientation toward the past for persons classified as F, for the present for persons with an S classification, toward the future of persons classified as N, and no significant temporal orientation for persons classified as T.

To summarize the research relating MBTI personality types and achievement, the studies suggest that students classified as N relate more positively to achievement than those classified as S; students classified as I seem to achieve more than those classified as E; students with a classification of T have higher achievement than those with an F classification except where creativity and relating to persons are concerned; and nothing was found to differentiate between students classified as J or P.

The research relating MBTI and the other mathematics anxiety correlates indicates that attitudes improved when mathematical activities were designed to match the student's personality type. Students classified as S appear to gain both in achievement and attitude when mathematics instruction is concretely-oriented. Mathematics teachers classified as N favor a like classification of their students while teachers classified as S are more flexible. These results suggest that students classified as S could benefit from mathematical instruction more concretely-oriented and that educational programs for mathematics teachers should emphasize the needs of sensing students.
Anxiety and MBTI

No studies whose major emphasis was the correlation of mathematics anxiety and MBTI personality types were found. However, a few studies relating MBTI to other categories of anxiety, some of which may have implications relative to mathematics classroom activities, were found. Pfeifer (1981) found that the relationship of writing anxiety to writing performance is influenced by personality especially on the E-I (extrovert-introvert) continuum and the T-F (thinking-feeling) continuum. She found that extroverts and thinking types tended to have more anxiety. Stancill (1972) found that introverts were no more highly anxious than extroverts on tasks involving verbal ability and verbal problem solving. Graff (1976) found that with general test anxiety and worry test anxiety, thinking males and feeling females experienced greater significant anxiety reduction from pretest to posttest when undergoing systematic desensitization of their anxiety. She found that feeling males and thinking females did not significantly have test anxiety reduction and that no significant anxiety reduction occurs with any of the studied subscales in the area of emotional anxiety.

This literature review leads to some plausible conjectures concerning the personality types of MBTI and mathematics anxiety. These were stated in the hypotheses of Chapter I and will now be rationalized in light of the literature research.
A stereotype of the discipline of mathematics is that it is an area to be learned by symbolic manipulation, heavily relying on the interior world of ideas. While current thought stresses the need of concrete experiences for the proper development of concepts, many of those outside the mathematics education profession, including students, still view mathematics as a mental activity. Thus students who are extroverts, preferring the outer world experience of people and things, should be more anxious about their mathematical abilities than should introverts. Prillwitz' findings that successful women in math areas have the characteristic of being introverted lends some support to this conjecture. Fish's and Charlton's findings in other academic fields that students classified as I achieved better in the fields of economics and science gives credence to the supposition that introverts will have less anxiety in academic areas.

Sensing students should have more mathematics anxiety than intuitive students. Golliday's results of sensing students having better attitudes in the mathematics lab context seems to imply that, as many mathematics teachers teach by a lecture mode, sensing students would tend to feel more uncomfortable in the mathematics classroom, and thus be more anxious. The orientation toward the present by sensing types as found by Evans could mean that sensing students might have difficulty with the implications of the many "if-then" areas in mathematics. Story's research that mathematics teachers typing as N prefer N-type students, while
mathematics teachers typing as S are much more flexible, most likely translates into an awareness of S students that they are not "as welcome" as N students in many mathematics classrooms as more mathematics teachers are classified as N than S, and could translate into anxiety for them.

Mathematics is often based on logical reasoning, so one could conjecture that thinking types would feel more comfortable with mathematics than feeling types. Evans' finding that feeling types have a temporal orientation toward the past could indicate a greater tendency to let past negative experiences with mathematics effect them more, and thus have more likelihood of mathematics anxiety. Rudicill found that sensing teachers give higher ratings on "overall value" and "how students feel"; this provides a possibility of more anxiety for feeling types. Since most mathematics teachers are intuitive, they have a tendency not to integrate values like these in their teaching, and hence would tend to "alienate" feeling type students more. In mathematics classes, students generally do less writing than in other classes, so with Pfeifer's findings, thinking types would have less anxiety in mathematics classes, while feeling types might tend to have more.

Finally, the "JP" subscale of the MBTI seems to lend itself less to definitive conjectures. One might argue that the decisiveness of the judging preference would seem to be a better "fit" with the perceived orderliness of mathematics; Prillwitz' successful women had this judging characteristic. However, the preference for the
perceiving mode would seem useful in the process of collecting data and reserving judgment that is often critical in mathematics problem-solving skills.

Most of the above conjectures cannot be argued decisively. What is needed is some empirical data to weigh them against. Since a review of the literature indicates that direct studies relating MBTI personality type and mathematics anxiety have not been done, it is a primary focus of this study to do so.
CHAPTER III
PROCEDURES

The Study

The purpose is to determine possible correlations between mathematics anxiety and the differing types of personalities as determined by the MBTI. The second purpose is to determine what combination of background and experiential variables would best predict a change in mathematics anxiety for each personality type.

The Setting

The study took place in September, 1988 at a midwestern university. The university was a suburban university located in a metropolitan area with a population of approximately 800,000 people. The university had an approximate enrollment of 16,000 students in September, 1988. Only a small number of the university's students lived on-campus. Many students had employment in the metropolitan area and lived off-campus, several in the home of their parents. Some of the off-campus students commuted several miles to the university, traveling upwards to fifty miles one way. Non-traditional students (students with some time lapse between high school graduation to college enrollment) are common at the university.

The university appeared to be representative of many urban
universities which have students who spend a great deal of their daily lives away from the university setting. Math 102 was chosen as the classroom setting for the study because of the wide infusion of non-traditional students in its enrollment. Such students tend to exhibit mathematics anxiety, especially within their first few weeks of college mathematics, and often later show fewer symptoms of it. It was judged that this population of students would provide a fertile setting for finding changes of mathematics anxiety.

The researcher was an adjunct instructor at the university in the mathematics department in the fall of 1988, teaching courses that are subsequent to Math 102.

The Course

Students who enrolled in Math 102 at the university in the fall quarter of 1988 were the subjects for this study. Math 102, as described in Chapter I, is a low-achievement, entry-level course in mathematics. The course, considered to be a developmental mathematics course, had content similar to that of beginning algebra in most high school curricula.

The mode of instruction in Math 102 was an adaptation of Personalized System of Instruction (PSI) or what is often referred to as the "Keller Plan". F. S. Keller (1975) developed PSI which incorporates self-pacing, unit perfection, former students as proctors, emphasis on written materials, criterion-reference testing and grading, and retesting for achieving mastery. Math 102 had all of these characteristics.
The students, using a textbook as reference, worked through a series of worksheets, at times working with other students in close physical proximity. Periodically, after mastering the material to the approval of their proctors, the students took written tests about that portion of the course.

Students contracted when they would finish the course, having the option of taking more than one term for completion. All contracts had to be fulfilled by the end of the summer session for each year. Thus, in the fall of 1988, there were no students in Math 102 who were finishing a contract to complete the course.

A common problem that often develops in PSI-based classrooms is that of student procrastination. Although Keller argued against any kind of time deadlines in PSI, many educators implementing PSI in their classrooms have felt it necessary to impose a time structure for completion of units. Math 102 had these kinds of restrictions; for example, to qualify for permission to use more than one term to complete the course, the first three of the six units had to be completed by the end of the quarter. Likewise, there were corresponding deadlines for units one and two to help students structure their efforts to meet the end of quarter deadline.

Some PSI implementers impose restrictions on achievement based on the number of attempts of mastery; for instance, a "C" grade might be the highest grade attainable if it took three
attempts to master a certain unit test. Math 102 students had no such restrictions on their achievement potential.

The Population

The initial population for this study was 392 students of the 450 enrolled in Math 102 for the fall quarter of 1988. These were the students who attended the first day of class. For most, this was their first experience in the course, but some had enrolled in prior years and had either dropped or had previously failed the course. However, all students made new contracts to complete the course.

Definition of Terms

YFOM (Your Feelings on Mathematics):
A 35-item mathematics anxiety inventory which is second-generation derivative of the Mathematics Anxiety Rating Scale (MARS) which was described previously.

Mathematics Anxiety:
Mathematics anxiety is assumed to be "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary and academic situations." (Richardson and Suinn, 1972, p. 552). Operationally, mathematics anxiety is the subject's score on YFOM.
MBTI (Myers-Briggs Type Indicator):

A personality instrument which classifies individuals into one of sixteen categories based on four subscales, each designated by a letter.

Personality Type:

One of the sixteen categories determined by the subject's responses to the MBTI.

Background Variables:

Possible contributors and/or indicators to the amount of mathematics anxiety a subject has. These are characteristics whose origin occurred prior to the current study. For this study, these are gender, years since High School mathematics, High School mathematics background, recidivism in Math 102, feelings about mathematics, perceived "importance of mathematics", parental influence, influence of secondary mathematics teachers, and the university mathematics placement score.

Experiential Variables:

Possible contributors and/or indicators to the amount of mathematics anxiety a subject has. These are characteristics whose origin occurred during or immediately after the student's participation in Math 102. For this study, these are Math 102
instructor's influence, absenteeism in Math 102, and Math 102 achievement.

Mathematics Anxiety Change:
The difference of a subject's score on YFOM, given near the middle of the class term, and the score on the original response to YFOM, given at the beginning of the quarter.

**Design**
The experiment was designed to accomplish two purposes. The first was to determine the correlation of mathematics anxiety with personality type. The second purpose was to determine what combination of the specified background and experiential variables could best predict mathematics anxiety change for each personality type.

The first part of the experiment was an ex-post facto study of the relationship of mathematics anxiety and personality type. The second part consisted of establishing a combination model of background and experiential variables which would predict the expected change in mathematics anxiety in the PSI-based course.

**Instrumentation**
In the first part, each of the variables, mathematics anxiety and personality type, was measured by a personal inventory-type instrument. The mathematics anxiety was measured by YFOM (see Appendix A) which has been previously defined. YFOM is an adaptation of PHOBOS, which was described in
Chapter I. Most of the changes from PHOBOS were minor, changing words and phrases so that they seem more appropriate for the locale. There were two changes that appear to be more significant: item 3 was replaced; and items 31-35 were added. A new item 3 was inserted to introduce a reaction to common fractions, since many people express anxiety about them. Items 31-35 were added on the rationale that the usage of the hand-held calculator is so prevalent that perhaps a new kind of anxiety has been produced relating to doing mathematics when the calculator is unavailable or the format of the problem does not encourage the use of the calculator. YFOM was used in a pilot study in the spring of 1987 and registered a reliability of Cronbach's alpha of 0.81.

The variable personality type was measured by the Myers-Briggs Type Indicator (MBTI). The MBTI is an internationally-acclaimed instrument whose reliability and validity have been verified in numerous studies.

Students were advised that on both instruments, the YFOM and the MBTI, that first reactions were often most valid, and that in both of the areas of feelings and preferences, long deliberations of individual items would not be fruitful. Observations by the researcher indicated that students were faithful to this intent.

For the second part, most of the data for the background variables was obtained by using a self-reporting information sheet denoted as IS (Information Sheet). The IS instrument, located in Appendix A, was composed to find out information on many of the
background variables. Students gave their names and class section in Item I on the IS instrument. Items II-IX provided information on some of the background variables as is described below in Table 1. Item X was included on IS because the researcher wanted to give the students an immediate "payoff" for participating in the study. Students were told that their MBTI type could be available to them, but only if they purchased a booklet explaining the meaning of the MBTI. The monetary amount listed represented the cost to the researcher for purchasing these booklets.

Data on one background variable, the university mathematics placement score, were not obtained on IS. This score was the student's score on the mathematics placement examination given by the university mathematics department, and was obtained from university records.

This variable was scaled as the mathematics placement examination had been categorized: a "1" for the lowest scores, and "2s" and "3s" for the next higher categories. No student in Math 102 had scored in the top three achievement categories (4, 5, and 6) on the mathematics placement exam.

Data for the three experiential variables, Math 102 instructor's influence, absenteeism in Math 102, and Math 102 achievement were based on course records of the university mathematics department. At the end of the quarter the researcher obtained course grades and attendance information from the course coordinator.
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<thead>
<tr>
<th>VARIABLE</th>
<th>ITEM NUMBER</th>
<th>SCALING DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>II</td>
<td>1 = female, 2 = male</td>
</tr>
<tr>
<td>Years since H.S. mathematics</td>
<td>III</td>
<td>1 = taken h.s. math previous&lt;br&gt;2 = two or three years ago&lt;br&gt;3 = four years or more ago</td>
</tr>
<tr>
<td>H.S. mathematics background</td>
<td>IV</td>
<td>1 = student had completed at most only general, business or consumer math&lt;br&gt;2 = highest level was algebra I and/or a combination of general, business or consumer math&lt;br&gt;3 = highest level was algebra II and/or geometry&lt;br&gt;4 = highest level was precalculus</td>
</tr>
<tr>
<td>Recidivism in Math 102</td>
<td>V</td>
<td>1 = first enrollment in the course&lt;br&gt;2 = no more than 2 enrollments had resulted in withdrawals&lt;br&gt;3 = previous course attempt resulted in a failure&lt;br&gt;4 = more than 1 previous failure or more than 2 prior withdrawals</td>
</tr>
<tr>
<td>Feelings about mathematics</td>
<td>VI</td>
<td>1 = second response&lt;br&gt;2 = third response&lt;br&gt;3 = first response</td>
</tr>
</tbody>
</table>
"Table 1 (Continued)"

| Importance of mathematics | VII | 1 = third response  
|                           |     | 2 = second response  
|                           |     | 3 = first and second response  
| Parental Influence       | VIII | 1 = second or third response  
|                           |     | 2 = fourth response  
|                           |     | 3 = first response  
| Secondary teacher's Influence | IX | 1 = third response  
|                               |     | 2 = second response  
|                               |     | 3 = first response  

As students had daily contact with their proctors rather than the course coordinator who, by university records, was their instructor for the course, it was decided to make the Math 102 instructor's influence variable a "proctor effectiveness" variable, rather than an "instructor effectiveness" variable. It was thought that daily contact with the proctor might have had more effect on mathematics anxiety; the effectiveness of the proctor would influence the anxiety level of the student more than the effectiveness of the instructor.

The measurement of proctor effectiveness came essentially from the researcher's study of department forms filled out by the students at the end of the term evaluating the instruction and course content and procedures. Since the contact between proctors
and students was extremely informal, the relationships between proctors and students were very personal. In addition, proctors had very little influence on the course grade obtained by the student, so the students tended to feel more at ease with their proctors than they might have with the usual course instructor. Hence, students' rating of their proctors tended to be rather high. The researcher decided to consult with the course coordinator, and using a combination of this consultation and the students' ratings, made an evaluation of proctor effectiveness. Due to the nature of the subjectiveness of this evaluation, it was decided to scale the Math 102 instructor's influence variable dichotomously as either 1 = "not effective" or 2 = "effective".

The coding for the experiential variables is summarized in Table 2.

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>SCALING DEFINITION</th>
</tr>
</thead>
</table>
| Math 102 Instructor's Influence | 1 = not effective  
                           2 = effective |
| Absenteeism in Math 102 | 1 = less than three absences from class  
                               2 = three or four absences from class  
                               3 = five or more absences from class |
| Math 102 Achievement | 1 = D or F course grade  
                               2 = C or I (incomplete) course grade  
                               3 = A or B course grade |
Gathering of Data

On the first day of the fall term in 1988 at the university, students were asked to participate in the study. It was explained to them that this was an experimental study concerning mathematics anxiety and that it was hoped that it would help provide some understanding of mathematics anxiety that might be useful in alleviating mathematics anxiety. Students were informed that the study was voluntary (as per guidelines with human subjects at the university) and that the researcher would return in about five weeks to request their continued participation. The five weeks time span was negotiated with the mathematics department at the university. It was felt that the data collection in the fifth week would have the least interference with the regular classroom activities. In the eleven classes of Math 102, spread over two days, three students declined to participate.

It was necessary to use two days because of the nature of the program at the university. Seven of the classes were on a time format of "MWF" which met 50 minutes each day, while four of the classes were on a "TR" format with classes meeting 75 minutes each day. Students were asked to take the YFOM, the MBTI, and to fill out a third instrument called "Information Sheet (IS)", a copy of which is located in Appendix A. Instructions to the students were to first fill out IS, then YFOM, and finally MBTI. This proved to be a fairly full schedule as a few minutes at the beginning of
class were taken up by either the course coordinator or senior faculty member who briefly described Math 102 and introduced the researcher. This was especially true for the MWF students, with the result that a number of them were not able to complete the MBTI. As the promise had been made to provide an opportunity to obtain the MBTI type for the students, the researcher came back on the second day of class and gave those students who had not completed the MBTI the opportunity to do so if they wished. It was felt that failure to honor this promise might influence further participation by any of the students in the study.

All TR students completed all three forms on the first day since their normal class period had an additional 15 minutes as compared to the MWF class format. An analysis was made using the T-TEST procedure of the SAS statistical program to find out if there might have been a significant increase in the anxiety scores for the MWF students as opposed to the TF students because of the time constraint difference. The results of this analysis showed that there was not.

The data of those students who did not complete all three instruments on the first day were not used in this study, as the researcher felt that this increased time interval might introduce factors that might contaminate the data. This decreased the population size by about one-third.
The researcher circulated among the students as they were filling out all three forms, answering any questions that the students had about completing the instruments, and collecting them as they finished.

The second aspect of this study was to try to find a linear model between a combination of background and/or experiential variables and the change of mathematics anxiety for each personality type. To do this, a second administration of the YFOM was needed for those students having complete data. As indicated above, it was decided that the optimal time for this would be at the end of five weeks. The rationale for choosing this time frame was that it would be a time interval of sufficient length so that changes in mathematics anxiety could take place, while on the other hand, it would not run into the more hectic pace at the close of the quarter. It was further decided that this second application of YFOM should take place informally; the researcher would come back to the classes and ask each individual who had completed all three forms on the first day to complete the YFOM again. This would involve less use of the class time and would not be as taxing on the learning taking place in Math 102. This was feasible as the average length of time to complete YFOM was about 5 minutes. Those students who had not completed all three forms on the first day who inquired why they were not being asked to complete YFOM again were told that it had been decided not to use their data but that they could complete YFOM a second time if they so desired.
Due to absences, testing, withdrawals, etcetera., 54 students who had completed the three forms on the first day were not available to complete YFOM the second time. This, in addition to the deletion of students who did not complete the three forms the first day, left a total of 203 subjects out of the original 392 students who had filled out at least the mathematics anxiety form on the first day of class. The SAS T-TEST procedure was used to find out if the scores on the first anxiety data collection of the 203 participants of the study were significantly different those of the students who were dropped out of the study. The results showed no significant difference on the first anxiety measure scores between the two groups.
Chapter IV
DATA ANALYSES

In this chapter the results of the data collection described in Chapter III will be presented. The frequencies of the MBTI types and the means and standard deviations of the independent and dependent variables are presented initially. Then data will be presented sequentially for each hypothesis. A conclusion about the acceptance or lack of acceptance of each hypothesis will be made. If the hypothesis is not accepted, conjectures as to what the data signifies will be presented.

The anxiety pretest and the MBTI were administered on Wednesday and Thursday, September 16 and 17, 1988, at which time the information sheet was also completed. The anxiety posttest was administered Wednesday and Thursday, October 13 and 14, 1988.

Using the SAS statistical package, frequencies were obtained for the sixteen personality types of MBTI. These are reported in Table 3.

Using the Frequency subprogram of the SAS statistical package, the means and standard deviations were obtained for the background and experiential independent variables from the information sheet and university records. These are reported in Table 4.
The percentages of MBTI types in the sample on two continuums, the thinking-feeling and the judging-perceiving, approximated the population in general according to Myers (1987). On the extrovert-introvert continuum there was a higher percentage of introverts, while on the sensing-intuitive continuum, there was a higher percentage of intuitive students. There were 60.3% classified as extroverts as opposed to 39.7% introverts; 63.5% sensing students as opposed to 36.5% intuitive students; 54.0% feeling students as opposed to 46.0% thinking students; and 52.4% perceiving students as opposed to 47.6% judging students. Myers reports in general, 75% extroverts, 75% sensing, 50% feeling, and 50% perceiving.

TABLE 3
FREQUENCIES OF MBTI TYPES

<table>
<thead>
<tr>
<th>MBTI TYPE</th>
<th>FREQUENCY</th>
<th>PERCENT</th>
<th>MBTI TYPE</th>
<th>FREQUENCY</th>
<th>PERCENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENFJ</td>
<td>6</td>
<td>3.1</td>
<td>INFJ</td>
<td>9</td>
<td>4.8</td>
</tr>
<tr>
<td>ENFP</td>
<td>26</td>
<td>13.8</td>
<td>INFP</td>
<td>6</td>
<td>3.2</td>
</tr>
<tr>
<td>ENTJ</td>
<td>6</td>
<td>3.2</td>
<td>INTJ</td>
<td>4</td>
<td>2.1</td>
</tr>
<tr>
<td>ENTP</td>
<td>8</td>
<td>4.2</td>
<td>INTP</td>
<td>4</td>
<td>2.1</td>
</tr>
<tr>
<td>ESFJ</td>
<td>13</td>
<td>6.9</td>
<td>ISFJ</td>
<td>17</td>
<td>9.0</td>
</tr>
<tr>
<td>ESFP</td>
<td>17</td>
<td>9.0</td>
<td>ISFP</td>
<td>8</td>
<td>4.2</td>
</tr>
<tr>
<td>ESTJ</td>
<td>21</td>
<td>11.1</td>
<td>ISTJ</td>
<td>14</td>
<td>7.4</td>
</tr>
<tr>
<td>ESTP</td>
<td>17</td>
<td>9.0</td>
<td>ISTP</td>
<td>13</td>
<td>6.9</td>
</tr>
<tr>
<td>VARIABLES</td>
<td>MEAN</td>
<td>S.D.</td>
<td>RESPONSE NUMBER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------------------</td>
<td>------</td>
<td>------</td>
<td>-----------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Gender</td>
<td>1.53</td>
<td>0.50</td>
<td>47.6</td>
<td>52.4</td>
<td></td>
</tr>
<tr>
<td>Years since H.S. mathematics</td>
<td>2.57</td>
<td>0.73</td>
<td>13.2</td>
<td>14.8</td>
<td>72.0</td>
</tr>
<tr>
<td>H.S. mathematics background</td>
<td>2.02</td>
<td>0.54</td>
<td>12.2</td>
<td>74.1</td>
<td>13.6</td>
</tr>
<tr>
<td>Recidivism in Math 102</td>
<td>1.09</td>
<td>0.46</td>
<td>95.2</td>
<td>2.1</td>
<td>1.6</td>
</tr>
<tr>
<td>Feelings about mathematics</td>
<td>2.07</td>
<td>0.86</td>
<td>23.2</td>
<td>46.6</td>
<td>30.2</td>
</tr>
<tr>
<td>Importance of mathematics</td>
<td>2.25</td>
<td>0.71</td>
<td>15.3</td>
<td>44.5</td>
<td>40.2</td>
</tr>
<tr>
<td>Parental influence</td>
<td>1.34</td>
<td>0.56</td>
<td>67.7</td>
<td>28.0</td>
<td>4.3</td>
</tr>
<tr>
<td>Secondary teachers' influence</td>
<td>1.73</td>
<td>0.72</td>
<td>43.4</td>
<td>41.3</td>
<td>15.3</td>
</tr>
<tr>
<td>University mathematics placement score</td>
<td>2.00</td>
<td>0.16</td>
<td>0.7</td>
<td>98.3</td>
<td>1.0</td>
</tr>
<tr>
<td>Math 102 instructor's influence</td>
<td>1.70</td>
<td>0.46</td>
<td>30.2</td>
<td>69.8</td>
<td></td>
</tr>
<tr>
<td>Absenteeism in Math 102</td>
<td>1.28</td>
<td>0.24</td>
<td>79.4</td>
<td>13.2</td>
<td>7.4</td>
</tr>
<tr>
<td>Math 102 achievement</td>
<td>1.65</td>
<td>1.16</td>
<td>46.8</td>
<td>41.0</td>
<td>12.2</td>
</tr>
</tbody>
</table>
Likewise, the types themselves approximated the general pattern. The only exceptions were ESFJ having 6.9% compared to 13% and ENFP having 13.8% compared to 5%. Appendix B gives the complete type percentage breakdown according to Myers (1987).

The variable "Gender" was scaled as 1 = "female" and 2 = "male". The mean reported in Table 4 for this variable would indicate that slightly more than half of the students in the study were male. The variable "Years since High School mathematics" was scaled as 2 = "two or three years" and 3 = "four years or more" since a student had taken his last high school mathematics class. Table 4 indicates that for the average student in this study it had been at least two years since the last high school mathematics course, with a likelihood that it was longer than that. The variable "High School mathematics background" was scaled as 1 = "Student had completed at most only general, business, or consumer math" and 2 = "Highest level was beginning algebra and/or a combination of general, business or consumer math". Table 4 indicates that the students on the average had a high school background of algebra I. The variable "Recidivism in Math 102" was scaled 1 = "First enrollment in the course" and 2 = "No more than 2 enrollments had resulted in withdrawals". Table 4 indicates that most students were taking the course for the first time.

The variable "Feeling about mathematics" was scaled as 2 = "Concerning mathematics, (I have) no particular feelings " and 3 = "Concerning mathematics, I like math ". Table 4 suggests, that
basically, students had no particular feelings about mathematics, with a slight skewness toward liking mathematics. The variable "Importance of mathematics" was scaled as 2 = "Concerning my intended future, math is necessary" and 3 = "Concerning my intended future, math is useful and necessary". The data from Table 4 indicates that most students considered mathematics as necessary in their majors or careers. The variable "Parental influence" was scaled 1 = "Concerning my parents, one or more of my parents felt that math was unimportant" and 2 = "Concerning my parents, one of more of my parents had no significant effect on my math feelings and math achievement". Table 4 implies that students tended to see a negative input from their parents on their feelings about mathematics. The variable "Secondary teachers' influence" was scaled as 1 = "Concerning my high school and junior high mathematics teachers, they were were poor teachers" and 2 = "Concerning my high school and junior high mathematics teachers, the number of effective about balanced the number of poor teachers". The evidence from Table 4 indicates that most students thought that they had about the same number of good teachers as poor teachers, with a tendency to rate their teachers as poor.

The scale on the variable "University mathematics placement score" was the same as used by the mathematics department at the midwestern university. The score on the placement test which largely determined that students were to take Math 102 was a "2" which not surprisingly turned out to be the mean for the variable
for the students in this study. Some of the variance for this variable was due to some students who scored a "3" on the placement test and chose to take Math 102 rather than a higher level course and a few students who scored a "1" but were enrolled due to other mitigating circumstances.

The variable "Math 102 instructor's influence" was scored dichotomously as previously indicated with 1 = "effective" and 2 = "not effective". Table 4 indicates that most students found their instructors to be effective. The variable "Absenteeism in Math 102" was scaled as 1 = "two or less absences from class" and 2 = "three or four absences". The mean for this variable from Table 4 indicates that on the average, students had about two absences. The variable "Math 102 achievement" values had 1 = "a D or F grade in Math 102" and 2 = "a C or I (incomplete) grade in Math 102". Students in this study averaged less than a C.

Using the SAS statistical package, the means and standard deviations were obtained for the mathematics anxiety dependent variables, the mathematics anxiety pretest score (PREAX), the mathematics anxiety posttest score (POSTAX), and the difference of these two scores (AXDIFF). These are reported in Table 5.

AXDIFF scores were calculated by subtracting POSTAX scores from corresponding PREAX scores. The T-test procedure from the SAS statistical package established that the AXDIFF scores were significant at \( p < 0.0001 \), with a "T score" of -9.67.
Mathematics anxiety decreased significantly during the time interval of the study, perhaps indicating that the informal and nurturing conditions which characterize the Math 102 classroom setting can contribute to a decrease in mathematics anxiety.

Hypotheses

The hypotheses to be tested were as follows:

(i) Persons whose personality types are either ESFJ or ESFP should be more likely to exhibit higher mathematics anxiety than persons of other types.

(ii) There is a set of background characteristic variables that will significantly predict mathematics anxiety change for persons of all personality types.

(iii) There is a set of experiential variables that will significantly predict mathematics anxiety change for persons of all personality types.
(iv) There is a combination of background and experiential variables that will significantly predict mathematics change for persons of all personality types.

Hypothesis (i)

Hypothesis (i) predicted a correlation between mathematics anxiety and MBTI types, specifically that the types ESFJ or ESFP would be more likely to exhibit higher mathematics anxiety levels than any other personality type. To test this hypothesis, a null hypothesis was formed stating that the correlation of mathematics anxiety level with persons having ESFJ or ESFP personality types would not be significantly different than the correlation with other personality types. To test this null hypothesis, correlations of MBTI types were calculated with PREAX, POSTAX, and AXDIFF by using the CORR subprogram of the SAS statistical package. These are reported in Table 6.

Neither the MBTI type ESFJ nor the type ESFP correlated significantly with mathematics anxiety on either the pretest or the posttest. Thus, the null hypothesis was not rejected.

As the information of Table 6 indicates, none of the MBTI types correlated strongly with mathematics anxiety. The strongest correlations, at an alpha level of 0.05, were ESTJ and ISFJ with POSTAX; and INFJ and INFP with PREAX. Using Davis' (1971) taxonomy for correlations, even these were low correlations. This would suggest, for this sample, MBTI types were not good predictors of mathematics anxiety.
TABLE 6
CORRELATIONS OF MBTI TYPES
WITH MATHEMATICS ANXIETY MEASURES

<table>
<thead>
<tr>
<th>MBTI TYPE</th>
<th>PREAX</th>
<th>P</th>
<th>POSTAX</th>
<th>P</th>
<th>AXDIFF</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENFJ</td>
<td>-0.02</td>
<td>0.802</td>
<td>0.07</td>
<td>0.322</td>
<td>0.13</td>
<td>0.076</td>
</tr>
<tr>
<td>ENFP</td>
<td>0.04</td>
<td>0.626</td>
<td>0.05</td>
<td>0.499</td>
<td>0.02</td>
<td>0.734</td>
</tr>
<tr>
<td>ENTJ</td>
<td>-0.12</td>
<td>0.103</td>
<td>-0.13</td>
<td>0.085</td>
<td>-0.03</td>
<td>0.729</td>
</tr>
<tr>
<td>ENTP</td>
<td>-0.07</td>
<td>0.373</td>
<td>-0.04</td>
<td>0.630</td>
<td>0.03</td>
<td>0.635</td>
</tr>
<tr>
<td>ESFJ</td>
<td>0.02</td>
<td>0.763</td>
<td>0.01</td>
<td>0.929</td>
<td>-0.02</td>
<td>0.788</td>
</tr>
<tr>
<td>ESFP</td>
<td>-0.02</td>
<td>0.764</td>
<td>-0.01</td>
<td>0.900</td>
<td>0.02</td>
<td>0.830</td>
</tr>
<tr>
<td>ESTJ</td>
<td>-0.11</td>
<td>0.144</td>
<td>-0.17</td>
<td>0.015*</td>
<td>-0.12</td>
<td>0.109</td>
</tr>
<tr>
<td>ESTP</td>
<td>-0.05</td>
<td>0.484</td>
<td>-0.06</td>
<td>0.389</td>
<td>-0.02</td>
<td>0.744</td>
</tr>
<tr>
<td>INFJ</td>
<td>0.15</td>
<td>0.044*</td>
<td>0.12</td>
<td>0.094</td>
<td>-0.02</td>
<td>0.828</td>
</tr>
<tr>
<td>INFP</td>
<td>0.16</td>
<td>0.031*</td>
<td>0.11</td>
<td>0.120</td>
<td>-0.16</td>
<td>0.562</td>
</tr>
<tr>
<td>INTJ</td>
<td>0.05</td>
<td>0.485</td>
<td>0.09</td>
<td>0.239</td>
<td>0.06</td>
<td>0.432</td>
</tr>
<tr>
<td>INTP</td>
<td>-0.05</td>
<td>0.513</td>
<td>-0.11</td>
<td>0.133</td>
<td>-0.10</td>
<td>0.189</td>
</tr>
<tr>
<td>ISFJ</td>
<td>0.12</td>
<td>0.095</td>
<td>0.16</td>
<td>0.032*</td>
<td>0.07</td>
<td>0.368</td>
</tr>
<tr>
<td>ISFP</td>
<td>0.07</td>
<td>0.318</td>
<td>0.04</td>
<td>0.582</td>
<td>-0.07</td>
<td>0.605</td>
</tr>
<tr>
<td>ISTJ</td>
<td>-0.13</td>
<td>0.083</td>
<td>-0.08</td>
<td>0.304</td>
<td>0.06</td>
<td>0.431</td>
</tr>
<tr>
<td>ISTP</td>
<td>-0.01</td>
<td>0.919</td>
<td>-0.01</td>
<td>0.938</td>
<td>0.00</td>
<td>0.982</td>
</tr>
</tbody>
</table>

* p ≤ 0.05
Correlations with mathematics anxiety were calculated for subscales of MBTI using combinations of two of the four continua. These were calculated by using the SAS statistical package. Some correlations were not significant. The strongest of these correlations are reported in Table 7, with the complete list of all 24 correlations given in Appendix B.

Correlations with mathematics anxiety were calculated for each of the four continua of the MBTI. These were calculated by using the SAS statistical package. These are reported in Table 8.

Examining the data using Tables 7 and 8, it appears that a classification of "F" on the thinking-feeling continuum of the MBTI has the most robust relationship with mathematics anxiety. It appears in three of the strongest correlations in Table 7 that are significant at an alpha level of 0.05. Its strength is especially evident when paired with I on the IF subscale. Further evidence for this conjecture is found in Table 8 as the TF subscale correlates highest with both the POSTAX and PREAX scores. In each case there is a positive correlation, which when coupled with the fact that this scale was scored with F = 1 and T = 0, means that the correlations of these two test scores were with the classification of F.

The "F" classification was found on three of the four highest correlations in Table 6. The type ISFJ in correlation with POSTAX and the types INFJ and INFP in correlation with PREAX, each having significant correlations at the 0.05 alpha level,
TABLE 7
CORRELATIONS OF MBTI SUBSCALES
WITH MATHEMATICS ANXIETY MEASURES

<table>
<thead>
<tr>
<th>SUBSCALES</th>
<th>PREAX</th>
<th>p</th>
<th>POSTAX</th>
<th>p</th>
<th>AXDIFF</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>EJ</td>
<td>-0.12</td>
<td>0.096</td>
<td>-0.15</td>
<td>0.042*</td>
<td>-0.05</td>
<td>0.454</td>
</tr>
<tr>
<td>ES</td>
<td>-0.10</td>
<td>0.163</td>
<td>-0.16</td>
<td>0.032*</td>
<td>-0.09</td>
<td>0.208</td>
</tr>
<tr>
<td>ET</td>
<td>-0.18</td>
<td>0.011*</td>
<td>-0.23</td>
<td>0.001*</td>
<td>-0.09</td>
<td>0.208</td>
</tr>
<tr>
<td>IN</td>
<td>0.18</td>
<td>0.013*</td>
<td>-0.13</td>
<td>0.074</td>
<td>-0.05</td>
<td>0.494</td>
</tr>
<tr>
<td>IF</td>
<td>0.27</td>
<td>0.000*</td>
<td>0.24</td>
<td>0.001*</td>
<td>0.00</td>
<td>0.991</td>
</tr>
<tr>
<td>IJ</td>
<td>0.10</td>
<td>0.191</td>
<td>0.15</td>
<td>0.039*</td>
<td>0.09</td>
<td>0.209</td>
</tr>
<tr>
<td>NF</td>
<td>0.16</td>
<td>0.031*</td>
<td>0.18</td>
<td>0.016*</td>
<td>0.05</td>
<td>0.518</td>
</tr>
<tr>
<td>NT</td>
<td>-0.10</td>
<td>0.152</td>
<td>-0.10</td>
<td>0.165</td>
<td>-0.01</td>
<td>0.898</td>
</tr>
<tr>
<td>SF</td>
<td>0.11</td>
<td>0.141</td>
<td>0.11</td>
<td>0.119</td>
<td>0.02</td>
<td>0.747</td>
</tr>
<tr>
<td>ST</td>
<td>-0.18</td>
<td>0.016*</td>
<td>-0.20</td>
<td>0.006*</td>
<td>-0.06</td>
<td>0.418</td>
</tr>
<tr>
<td>FJ</td>
<td>0.16</td>
<td>0.027*</td>
<td>0.20</td>
<td>0.006*</td>
<td>0.08</td>
<td>0.287</td>
</tr>
<tr>
<td>TJ</td>
<td>-0.19</td>
<td>0.001*</td>
<td>-0.20</td>
<td>0.006*</td>
<td>-0.04</td>
<td>0.566</td>
</tr>
</tbody>
</table>

*p < 0.05
support the above conjecture. The correlations suggest that the "I" classification on the extrovert-introvert continuum associated with mathematics anxiety better than the remaining classifications. The results in Table 8 support this assertion.

The correlations suggest that the "I" classification on the extrovert-introvert continuum associated with mathematics anxiety stronger than the remaining classifications. The results in Table 8 support this assertion. The extrovert-introvert continuum correlated significantly with both POSTAX and PREAX negatively. Since the scores were scaled with E = 1 and I = 0, this negative correlation means that these tests correlated with the "I" classification.

Conjectures about the remaining two continuums, the sensing-intuitive and the judgment-perception seem less justified,

### TABLE 8

**CORRELATIONS OF CONTINUUMS WITH MATHEMATICS ANXIETY MEASURES**

<table>
<thead>
<tr>
<th>CONTINUUMS</th>
<th>PREAX</th>
<th>p</th>
<th>POSTAX</th>
<th>p</th>
<th>AXDIFF</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>E or I</td>
<td>-0.15</td>
<td>0.038*</td>
<td>-0.15</td>
<td>0.037*</td>
<td>-0.02</td>
<td>0.774</td>
</tr>
<tr>
<td>N or S</td>
<td>0.07</td>
<td>0.330</td>
<td>0.09</td>
<td>0.220</td>
<td>0.04</td>
<td>0.621</td>
</tr>
<tr>
<td>F or T</td>
<td>0.23</td>
<td>0.001*</td>
<td>0.26</td>
<td>0.000*</td>
<td>0.06</td>
<td>0.393</td>
</tr>
<tr>
<td>J or P</td>
<td>-0.02</td>
<td>0.676</td>
<td>0.00</td>
<td>0.998</td>
<td>-0.03</td>
<td>0.566</td>
</tr>
</tbody>
</table>

* p < 0.05
although three of the four significantly-related types had a "J" classification as opposed to one "P" classification. This lack of justification stems mostly from the fact that neither continuum correlated significantly with either POSTAX or PREAX scores.

**Hypothesis (ii)**

Hypothesis (ii) predicted there to be a set of background characteristic variables whose combination would significantly predict mathematics anxiety change as measured by the dependent variable, AXDIFF. Background variables in this study were the personality type of the student as measured by MBTI, gender, high school mathematics background, recidivism for Math 102, years since high school mathematics, feelings about mathematics, perceived importance of mathematics, parental influence, secondary mathematics teachers' influence, and university mathematics placement score. The MBTI score was divided into its continuums of extrovert-introvert (E or I), intuitive-sensing (N or S), feeling-thinking (F or T), and judgment-perception (J or P) so that its values were ordered.

To test this hypothesis, a null hypothesis was constructed stating that the combination of the above background variables would not significantly predict mathematics anxiety change as measured by the dependent variable, AXDIFF. To test this null hypothesis, a linear model was constructed using the GENERAL LINEAR MODELS subprogram of the statistical package SAS, with above background variables as independent variables and AXDIFF
as the dependent variable. Table 9 reports the model incorporating these variables.

Linear models were constructed using the statistical package SAS, with the above background variables as the independent variables, and PREAX and POSTAX as the dependent variables. Tables 10 and 11 report the models incorporating these variables.

The linear model incorporating the background variables as the independent variables and AXDIFF as the dependent variable as reported in Table 9 indicates that only approximately 7% of the variance can be predicted by the model. Therefore, the above null hypothesis was not rejected.

None of the background variables served as a treatment on the mathematics anxiety from the time of the pretest to the posttest, so it seems likely what the model was indicating is that these variables have little correlation to the change in the mathematics anxiety (AXDIFF), as there was no intentional effort to have them influence it. Viewed in this manner, the results of Table 9 seem to be consistent.

The examination of the models of Tables 10 and 11, however, provides evidence that a linear combination of these background variables did significantly predict the variance found on the dependent variables, PREAX and POSTAX, that is, the mathematics anxiety pretest and posttest.
### TABLE 9
**LINEAR MODEL RELATING BACKGROUND VARIABLES TO THE DEPENDENT VARIABLE AXDIFF**

<table>
<thead>
<tr>
<th>PREDICTORS</th>
<th>$E$</th>
<th>$R$</th>
<th>R-SQUARE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0.26</td>
<td>0.07</td>
</tr>
<tr>
<td>E or I</td>
<td>0.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N or S</td>
<td>0.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T or F</td>
<td>0.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>J or P</td>
<td>0.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>0.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years since H.S. Math</td>
<td>1.27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prior Math Background</td>
<td>0.19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math 102 Recidivism</td>
<td>0.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feelings about Math</td>
<td>0.83</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Importance of Math</td>
<td>0.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parental Influence</td>
<td>0.01</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary Teachers' Influence</td>
<td>0.93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WSU Math Placement Score</td>
<td>0.02</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PREDICTORS</td>
<td>F</td>
<td>R</td>
<td>R-SQUARE</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>-------</td>
<td>-------</td>
<td>----------</td>
</tr>
<tr>
<td>E or I</td>
<td>5.78</td>
<td>0.64</td>
<td>0.41</td>
</tr>
<tr>
<td>N or S</td>
<td>1.90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T or F</td>
<td>12.54</td>
<td></td>
<td></td>
</tr>
<tr>
<td>J or P</td>
<td>0.21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>2.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years since H.S. Math</td>
<td>0.88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prior Math Background</td>
<td>6.51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math 102 Recidivism</td>
<td>0.60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feelings about Math</td>
<td>21.41</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Importance of Math</td>
<td>0.31</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parental Influence</td>
<td>1.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary Teachers' Influence</td>
<td>0.48</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WSU Math Placement Score</td>
<td>0.42</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## TABLE 11

LINEAR MODEL RELATING BACKGROUND VARIABLES TO THE DEPENDENT VARIABLE POSTAX

<table>
<thead>
<tr>
<th>PREDICTORS</th>
<th>E</th>
<th>R</th>
<th>R-SQUARED</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.61</td>
<td>0.37</td>
<td></td>
</tr>
<tr>
<td>E or I</td>
<td>5.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N or S</td>
<td>2.65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T or F</td>
<td>13.86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>J or P</td>
<td>0.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>3.87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years Since H.S. Math</td>
<td>2.28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prior Math Background</td>
<td>4.24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math 102 Recidivism</td>
<td>1.23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feelings about Math</td>
<td>12.51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Importance of Math</td>
<td>0.63</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parental Influence</td>
<td>1.08</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary Teachers' Influence</td>
<td>1.03</td>
<td></td>
<td></td>
</tr>
<tr>
<td>WSU Math Placement Score</td>
<td>0.44</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
On PREAX, this combination significantly accounted for about 41% of the variance at $p < 0.05$. Four of the independent variables contributed significantly to the variance at this level. Two scales of the MBTI were among these four variables, the E-I (extrovert-introvert) and the T-F (thinking-feeling) continuums. Based on the correlations presented in Hypothesis (i), one could conclude that the inclusion of I and F in the personality type of the student in the combination of background variables would help to predict that the student will exhibit mathematics anxiety. The F-type especially contributed strongly to this prediction of mathematics anxiety.

The two non-MBTI independent variables which contributed significantly to the variance of PREAX were feelings about mathematics and prior mathematics background. Feelings about mathematics made a particularly strong contribution to the variance, having by far the highest "F value" of all of the independent variables, while the strength of the contribution of prior mathematics background was comparable to that of the E-I continuum of the MBTI.

These results were verified by the results of the linear combination model of these background variables with the dependent variable POSTAX. 37% of the variance at $p < 0.05$ of POSTAX was accounted for by a linear combination of the background variables. This was a slight decrease from the PREAX model.
As with the PREAX model, the T-F continuum of the MBTI and the variable feelings about mathematics were the strongest contributors to variance, while the E-I continuum's and prior mathematics background's F scores were the highest of the rest of the variables. All of the values were slightly lower than the corresponding scores of the PREAX model, suggesting the "Keller Plan" format of the course could at least be changing the contributors to the mathematics anxiety if not lessening the anxiety itself.

The evidence implies that this particular combination of background variables significantly predicts the existence of mathematics anxiety in these students. Two occurrences, an "F" classification of the T-F continuum of the MBTI and the possession of negative feelings about mathematics are especially strong predictors of mathematics anxiety.

**Hypothesis (iii)**

Hypothesis (iii) predicted there to be a set of experiential variables whose combination would significantly predict the mathematics anxiety change as measured by the dependent variable, AXDIFF. Experiential variables for this study were Math 102 course achievement, Math 102 attendance, and the Math 102 instructor influence.

To test this hypothesis, a null hypothesis was constructed stating that the combination of the above experiential variables would not significantly predict mathematics anxiety change as
measured by the dependent variable, AXDIFF. To test this null hypothesis, a linear model was constructed using the SAS statistical package, with the above experiential variables as independent variables, and AXDIFF as the dependent variable. Table 12 reports the model incorporating these variables.

Linear models were constructed using the statistical package SAS, with the above experiential variables as the independent variables, and PREAX and POSTAX as the dependent variables. Tables 13 and 14 report the models incorporating these variables.

The linear model incorporating the experiential variables as the independent variables and AXDIFF as the dependent variables as reported in Table 12 indicates that only approximately 3% of the variance can be predicted by the model. Therefore, the above null hypothesis was not rejected.

Tables 13 indicates that only approximately 8% of the variance with PREAX as the dependent variable can be predicted by the model. Likewise, Table 14 indicates that only approximately 10% of the variance with POSTAX as the dependent variable can be predicted by the model. It appears that the linear combination using these experiential variables does not significantly predict the existence of mathematics anxiety. In addition, each of the three experiential variables exhibited no significant predictability on any of the three models.
### TABLE 12
LINEAR MODEL RELATING EXPERIENTIAL VARIABLES TO THE DEPENDENT VARIABLE AXDIFF

<table>
<thead>
<tr>
<th>PREDICTORS</th>
<th>$F$</th>
<th>$R$</th>
<th>R-SQUARE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 102 Course Achievement</td>
<td>0.16</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Math 102 Attendance</td>
<td>1.56</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math 102 Instructor Influence</td>
<td>0.13</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### TABLE 13
LINEAR MODEL RELATING EXPERIENTAL VARIABLES TO THE DEPENDENT VARIABLE PREAX

<table>
<thead>
<tr>
<th>PREDICTORS</th>
<th>$F$</th>
<th>$R$</th>
<th>R-SQUARE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 102 Course Achievement</td>
<td>4.59</td>
<td></td>
<td>0.08</td>
</tr>
<tr>
<td>Math 102 Attendance</td>
<td>0.37</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math 102 Instructor Influence</td>
<td>1.48</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### TABLE 14
LINEAR MODEL RELATING EXPERIENTAL VARIABLES TO THE DEPENDENT VARIABLE POSTAX

<table>
<thead>
<tr>
<th>PREDICTORS</th>
<th>$F$</th>
<th>$R$</th>
<th>R-SQUARE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math 102 Course Achievement</td>
<td>5.40</td>
<td></td>
<td>0.10</td>
</tr>
<tr>
<td>Math 102 Attendance</td>
<td>1.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Math 102 Instructor Influence</td>
<td>1.99</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Hypothesis (iv)

Hypothesis (iv) predicted there to be a set of background and experiential variables whose combination would significantly predict the mathematics anxiety change as measured by the dependent variable, AXDIFF. The background and experiential variables used for this hypothesis were those described above in hypotheses (ii) and (iii). To test this hypothesis, a null hypothesis was constructed stating that the combination of the above background and experiential variables would not significantly predict mathematics anxiety change as measured by the dependent variable, AXDIFF.

As the experiential variables in hypothesis (iii) seemed to be weak or nonpredictors of the change of mathematics anxiety or even the occurrence of mathematics anxiety, it was felt that the results of using the linear model of the SAS program on this null hypothesis of hypothesis (iv) would give similar results as those found in hypothesis (ii). This was found to be true, so the above null hypothesis was not rejected.

One implication of the evidence of Hypotheses (ii), (iii), and (iv) would be that the background variables significantly predict the existence of mathematics anxiety, especially the T-F continuum of the MBTI and feelings about mathematics. The addition of the three experiential variables increase the ability to predict the existence of mathematics anxiety only slightly. Neither the background variables nor the experiential variables nor their
combination significantly predict a change in the amount of mathematics anxiety.

With reference to Hypothesis (i), the evidence indicates that the MBTI types themselves are not significantly correlated to the existence of mathematics anxiety, but certain continuums and combinations of these are. In particular, a classification of F (feeling) on the T-F continuum significantly correlates with the existence of mathematics anxiety. To a lesser extent, this is true for a classification of I (introvert) on the E-I continuum. A classification of IF gives the greatest correlation to mathematics anxiety of all of the subscales of the MBTI types. This implication is strengthened in its agreement with the evidence of Hypotheses (ii) and (iii).
CHAPTER V

SUMMARY, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS FOR FURTHER STUDY

Summary

Understanding and alleviating mathematics anxiety is an important goal of mathematics education. Hembree (1990) indicated that mathematics anxiety in the form of a trait anxiety often affects performance in a negative manner. Trait anxiety is anxiety that is a relatively stable personality characteristic indicative of being prone to anxiety rather than only feeling anxious in situations for which there is a clear threat. The alleviation of mathematics anxiety should enhance performance in mathematical situations. Understanding factors and causes relating to mathematics anxiety should help the profession to find more effective ways of reducing mathematics anxiety.

Constructing a profile of characteristics of mathematically-anxious persons is one aspect of the understanding of mathematics anxiety. Research about mathematics anxiety has involved many possible correlates of mathematics anxiety which are useful in constructing the aforementioned profile. However, one personal characteristic which has received little attention is that of a
person's personality. Evidence from research (Prillwitz, 1983; Gollday, 1975) indicate that Myers-Briggs personality types can characterize students in such areas as achievement and attitudes. It was hypothesized for this study that such personality types could help characterize persons who would tend to exhibit mathematics anxiety.

The Myers-Briggs continuums which seemed most likely to help diagnose those susceptible to mathematics anxiety are those involving perceiving and judging, that is the S-N(sensing-intuitive) and the T-F(thinking-feeling) continuums. Persons who prefer to perceive information in a sensing mode and to make judgments about that information in a feeling mode would seem to be especially at risk to acquire mathematics anxiety. Mathematical instructional techniques have tended toward logical verbal presentations which model intuitive perceptions and thinking judgments (Greenwood, 1984). Likewise, mathematics instructors are most likely to be classified as "NT" on a subscale involving perceptions and judgments (Myers, 1987). To a lesser extent, it was felt that those classified as an "extrovert" on the E-I (extrovert-introvert) continuum might be more likely to exhibit mathematics anxiety in that mathematics, especially as it is currently taught, tends to favor the interior world of ideas.

Subjects in this study were inventoried as to their mathematics anxiety level and their Myers-Briggs personality types. The data for their mathematics anxiety levels were collected
at two different times, first at their initial entrance into the classroom situation, and then again approximately five weeks later. A difference for these two scores was calculated for each of the subjects. Each subject responded to the Myers-Briggs Type Indicator (MBTI) at the time of collection of the initial mathematics anxiety instrument administration. Material was obtained at this time about the background variables of gender, years since high school mathematics, high school mathematics background, course recidivism, feelings about mathematics, perceived importance of mathematics, parental influence, and secondary mathematics teachers' influence. Data were obtained from school officials concerning the background variable of the subjects' mathematics placement scores at the university, and the experiential variables of the influence of course instructor, absenteeism from the course, and grade achievement in the course.

The data were analyzed for correlations with the MBTI type and levels of mathematics anxiety. Linear models were constructed to search for a combination of background variables, a combination of a combination of experiential variables, and a combination of background and experiential variables that could predict a change of mathematics anxiety. The details and results of the data analysis are presented in Chapter IV.

**Conclusions**

The results of the data analysis support several conclusions. The generalizability of these conclusions is influenced by the
characteristics of the sample, the experimental setting, and the measurement variables.

1. For this study, MBTI types themselves exhibited at best weak correlations with mathematics anxiety.

2. Some specific classifications by continuums, however, exhibited significant correlation with mathematics anxiety for both administrations of the anxiety instrument. In particular, a classification of "F" on the thinking-feeling continuum correlated substantially in a positive sense with mathematics anxiety. To a lesser extent, the classification of "I" on the extrovert-introvert continuum was significant in like manner.

3. A linear combination of background variables and/or experiential variables did not have significant predictive power on the change of mathematics anxiety.

4. A linear combination of background variables, however, did exhibit significant predictive power on the possession of mathematics anxiety for both administrations of the anxiety instrument.

5. One background variable, "feelings about mathematics", in particular, exhibited a strong association with mathematics anxiety.

6. Mathematics anxiety decreased during the five weeks between measures.
Implications

MBTI types themselves did not correlate well with mathematics anxiety. However, with the additional information provided by correlation of mathematics anxiety and the four continuums of the MBTI, it appears that a person's MBTI type indicators can be useful in predicting susceptibility to mathematics anxiety. The classification of an MBTI type for a person appears to not be as crucial for their susceptibility to mathematics anxiety as is their classification on specific subscales. In particular, a classification of an "F" on the thinking-feeling continuum and an "I" on the extrovert-introvert, or what is called the "IF" subscale had the highest correlation with mathematics anxiety on both administrations of the anxiety instrument. A classification of "F" in subscales "NF" and "FJ" had moderate correlation with mathematics anxiety on both administrations of the anxiety instrument. Further evidence for the significance of the "IF" and "NF" subscales comes from the observation that their "complement" subscales, "ET" and "ST" both had moderate negative correlations with mathematics anxiety on both administrations of the anxiety instrument.

In Chapter I it was conjectured that a classification of "S" on the N-S (intuitive-sensing) continuum and of "E" on the E-I (extrovert-introvert) continuum would have significant correlations with mathematics anxiety. Neither conjecture was supported by the evidence in this study. In each case, the percentages of students classified into these categories were below the percentages
of the general population (Myers, 1987); for the extrovert classification, it was 60.3% as compared to the general population percentage of 75%, while for the sensing classification, it was 63.5% as compared to the general population percentage of 75%. A sample more representative of the general population might give results different than those found by this study.

In the case of the "S" (sensing) classification, the case for suggesting that a classification of "S" would significantly correlate with mathematics anxiety appeared to be strong. Mathematics is generally taught by a mode of instruction that relies heavily on non-sensing perceptions. The mode of instruction is usually a verbal presentation by the instructor. While students may use their visual and auditory senses to perceive the information that the instructor is imparting, they are required to use generalizations and intuitive thought processes to master the subject. This last activity would require S-type students to perceive the information in a manner that they do not prefer. These students would be in an anxiety-producing situation in that they are in a domain where they would not feel comfortable.

A possible explanation of why a strong correlation between mathematics anxiety and the preference for sensing as the mode of perception did not occur may be the emphasis in the mathematics curriculum on computation proficiency. The "how to" procedures of mathematical calculations and problems are stressed to the deprivation of "why" and "when" questions relating to mathematics
understanding and problem solving. Learning of mathematics may be viewed as a rote-learning situation by many students, and the symbols of computation may have come to have a sensory reality that has little relationship to the mathematics that the symbols are supposed to represent.

Sensing students may accommodate mathematics symbols and their computational procedures as part of their visual and auditory world and not feel the anxiety that was predicted. Mathematics anxiety autobiographies often indicate that victims can identify their initial mathematics anxiety feelings occurring at those stages of the mathematics curriculum where the material seems to increase to higher levels of abstractness, such as the computation of fractions or beginning the study of algebra. This may mean that for sensing students, mathematics computations in these areas are no longer a part of their sensing world. Indeed, it might be conjectured that this strong emphasis on "sensory" mathematical computation could cause N (intuitive)-classification students (the complement classification of "S"-classification) to raise their anxiety levels in that they are not allowed to perceive mathematics in the way that they prefer to, that is, processing this information in intuitive ways. Hence, the mathematics anxiety they felt may have been more than was previously considered, and any strong mathematics anxiety that sensing students felt was somewhat negated in the correlation of mathematics anxiety.
Perhaps a better conjecture for sensing students would be that if mathematics were taught by stressing its concepts, and not its computational procedures, then there would be a strong correlation between mathematics anxiety and the classification of "S" on the perceiving subscale.

The case for a strong correlation of mathematics anxiety and a classification of "E" on the extrovert-introvert continuum did not seem as strong, and its lack of correlation did not seem as surprising as was the case for the lack of an S-classification correlation. The emergence of a positive correlation of its complement classification, an I-classification, with mathematics anxiety was somewhat more surprising. This correlation might, however, be explained by viewing current methods of instruction in mathematics as was done in the discussion of the intuitive-sensing continuum. The extreme emphasis on computational mastery might cause mathematics to be viewed as part of the external world, rather than an activity of the internal world as was proposed in Chapter I. Introverts would feel anxiety in being asked to participate in the external world, rather the internal world. The logic of mathematics might further intimidate those introverts who preferred to make judgments on their perceptions on a feeling basis rather than a thinking basis. This would help interpret why the "IF" subscale was so strong in its correlation with mathematics anxiety.
Hypotheses (ii), (iii), and (iv) were based on a rationale that indicated the need for a search for linear combinations of variables to predict the change of mathematics anxiety. The results of this search are summarized in the third, fourth, and fifth conclusions in the conclusion section of this chapter. The discussion of the data in Chapter IV relating to this search speculated that the failure in this study to find combinations might be explained by noting that no specific treatment depending upon the variables indicated was made to change the anxiety level from one administration of the anxiety instrument to the next. Hence, the change in mathematics anxiety would probably have little correlation to the combination of these variables. The change might be the result of such factors as maturation or the occurrence of personal historical events outside the classroom situation.

The result that a linear combination of the background variables did show significant predictive power on the possession of mathematics anxiety gives validity to the search for factors and causes of mathematics anxiety. Some of the variables used in this study did not contribute heavily to the predictive power. This indicates that the particular list of variables used in this study can be improved upon, with the deletion of some of the variables and the addition of different ones.

The strong association of the background variable, "feelings about mathematics" with mathematics anxiety provides evidence for the consideration of affective factors in the causation of
mathematics anxiety. This result, along with the strong correlation of the "F" classification of the MBTI with mathematics anxiety, suggests that the mathematics education profession should begin to consider how best it can meet the needs of those students for whom affective factors are important, including those who prefer to make judgments about their perceptions on a value basis. The increasing use of technology in areas traditionally considered nonmathematical, such as the fine arts and the language arts, mandates that knowledge of mathematics is a necessity for students in these fields. Students in these areas sometimes exhibit high mathematics anxiety, often relating stories of themselves showing mathematics avoidance. Their apparent impression of mathematics is that of a field of rigidity and precision, never having been introduced to the creativeness of such activities as problem solving.

All implications in this study about mathematics anxiety and mathematics anxiety change need to be made in an atmosphere that is mindful of the limitations of the mathematics anxiety instrument used. The instrument attempts to quantify the anxiety that exists and is scaled so that high anxiety is reflected by a high score on the scale. What it cannot differentiate is to whether this anxiety is "state anxiety" or "trait anxiety". This is especially crucial concerning the sixth conclusion above. This conclusion states the evidence of the research without implying that the use of the modified Keller Plan in Math 102 helped to lower the mathematics
anxiety of the students in the course. The anxiety change may have
been a decrease of the state anxiety that students might have felt
at the beginning of a new mathematics course, and for many of
them, the beginning of their collegiate experience, rather than the
reduction of a trait anxiety towards mathematics.

Recommendations for Further Study

Further studies of the factors and causes of mathematics
anxiety would be beneficial.

1. Further studies concerning the MBTI types and
mathematics anxiety should be made. Other age groups
and differing settings would give more validity to the
findings of this study.

2. The relationship of "S" classification students and
mathematics anxiety should be given thoughtful analysis,
designing studies that focus on some of the issues brought
forth in the prior discussion. For example, studies might
be designed for students near the time of introduction of
topics known to bring anxiety such as common fractions
and the introduction to algebra.

3. Mathematics anxiety instruments need to be developed
that can differentiate between state and trait anxieties.
These would probably have to be given over time lapses
to distinguish what is temporary state anxiety and the
more permanent trait anxiety.

4. The list of background and experiential variables needs to
be refined. Studies constructing linear models with the most predictive variables of this study and perhaps new variables such as those based on attributions might help provide needed information on the factors of mathematics anxiety.

5. Subjects in this study were from a medium-sized university in a suburban setting. Future studies could involve students in both larger and smaller student population sizes, as well as students from more traditional settings such as those living away from home on campuses.

6. Future studies should be made concerning mathematics anxiety and mathematics courses designed around the Keller Plan. These should be carefully designed to account for as many state anxiety effects as is possible.

7. Mathematics anxiety in students in traditional nonmathematical areas such as the fine arts should be studied. The focus of such studies should include attempts to find ways of relating mathematics to these students.

The present study provides evidence that the Myers-Briggs personality classifications can provide information on the likelihood of possessing mathematics anxiety. The present study should give more impetus to the search for finding the factors and causes of
mathematics anxiety. Further research could expand this knowledge base about mathematics anxiety.
INFORMATION SHEET     RESPONSE SHEET

NUMBER__________

I. PERSONAL: NAME___________ CLASS TIME____ DAYS____
   (Last,1st,M.I.)

II. GENDER: (check one)  Female ___  Male ___

III. Calender Year of H.S. graduation ___  Was this a GED? ___

IV. Circle the grade in H.S. that you took these math courses(if you did)
    Algebra  8 9 10 11 12 Transition to  9 10 11 12
    College Math
    Geometry  9 10 11 12 General Math  9 10 11 12
    Algebra II  9 10 11 12 Business Math  9 10 11 12
    Precalculus  9 10 11 12 Consumer Math  9 10 11 12
    Computer Math  9 10 11 12 Calculus  9 10 11 12
    Trigonometry  9 10 11 12 Other ______________________
       (State what & what year)

V. Concerning this math course, M102:
   This is the first time I have enrolled in it: yes ___ no ___
   If no, the number of times I have enrolled before is: ___
   The number of times that I have failed this course is: ___

VI. Concerning math: (Check one)
   I like math ___ I dislike math ___ No particular feelings ___

VII. Concerning my intended future, math is: (Check all that apply)
   Useful ___ Necessary ___ Has no particular significance ___
"INFORMATION SHEET (Continued)"

VIII. Concerning my parents, one or more of my parents:

- Felt that math was important & helped me
- Felt that math was unimportant, but helped me
- Felt that math was unimportant & did not help me
- Had no significant effect on my math feelings & math achievement

IX. Concerning my high school & junior high math teachers:

- They were effective teachers
- The number of effective about balanced the number of poor teachers

X. For $1.25, I would like to find out my personality type
A SURVEY ON YOUR FEELINGS ABOUT MATHEMATICS

On each of the items below on the left, choose a number on the right. Use as the basis for your choice how much the statement causes you to feel tense or brings about feelings of not being adequate. Even if you have not experienced what is said, imagine the event and record the amount of your unease. Use the 5-point scale on the right as follows:

1 = (feel calm or at ease)---TO---5 = (feel quite tense or anxious)

FOR EXAMPLE: (Researcher's Responses)

<table>
<thead>
<tr>
<th>FEEL CALM OR AT EASE</th>
<th>FEEL QUITE TENSE OR ANXIOUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example 1: Listening to a radio station that features &quot;nice and easy&quot; music</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>Example 2: Hearing sportscaster Dick Vitale chat noisily on TV</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>1. Determining the amount of change you should get back after buying several items*</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>2. Figuring how much sales tax there will be on at item that costs more than $1.00</td>
<td>1 2 3 4 5</td>
</tr>
<tr>
<td>3. Seeing such numbers as 45 1/8 or -2 3/8 in the newspaper report on Wall Street**</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>
"A SURVEY ON YOUR FEELINGS ABOUT MATHEMATICS (Continued)"

4. Deciding on how many hours are needed and which courses to take so that you can get your degree*
   
5. Having a salesman explain to you how his higher priced item is better for you as he illustrates how it will reduce long term expenses*

6. Being asked to explain what odds of 5 to 2 mean on a horse race*

7. Reading your W-2 form showing your annual earnings and taxes

8. Listening to a person explain how he figured your share of expenses on a trip including meals, transportation, etc.

9. Applying math to your life, such as finding out how much money you have for recreation after paying the bills.*

10. Figuring a monthly budget

11. Signing up for a math course

12. Walking into a math class

13. Raising your hand in a math class to ask a question
"A SURVEY ON YOUR FEELINGS ABOUT MATHEMATICS (Continued)"

14. Thinking about a final exam in a math class

15. Thinking about a math test a day before the test

16. Thinking about a math test an hour before the test

17. Waiting to have a math test returned

18. Realizing that you have a certain number of math classes to take in order to fulfill the requirements of your major

19. Receiving your final math grade in the mail

20. Being given a "pop" quiz in a math class*

21. Having to work a math problem that has x's & y's instead of 2's & 3's

22. Being told that everyone is familiar with the Pythagorean Theorem

23. Realizing that my psychology professor has just written some algebraic formulas on the chalk board
"A SURVEY ON YOUR FEELINGS ABOUT MATHEMATICS (Continued)"

24. Being asked to solve
   \[ x^2 - x - 3 = 0 \] *  
   
25. Being asked to discuss the mathematical justification (the theory) involved in a word problem *  
   
26. Trying to read a sentence full of symbols, such as:
   \[ \{ Q = x : |x - 2| = 3, x > 1 \} \]  
   
27. Listening to a friend explain something they have just learned in calculus  
   
28. Opening up a math book and not seeing any numbers, only letters, on an entire page  
   
29. Reading a description from the college catalog of the topics to be covered in the next math course that you have to take *  
   
30. Having someone lend you a calculator and not being able to tell which buttons to push to get the answer
"A SURVEY ON YOUR FEELINGS ABOUT MATHEMATICS (Continued)"

31. Trying to keep track of the amount of money you have spent in a grocery store without the aid of a calculator **

32. Trying to do subtraction problems such as 1,000 - 876 without the aid of a calculator **

33. Trying to do division problems such as 39672 ÷ 87 without the aid of a calculator **

34. Computing \((8 \frac{1}{4}) \times (1 \frac{3}{4})\) as fractions, rather than as \((8.25) \times (1.75)\) on a calculator **

35. Evaluating \(2x^2 - 3x + 6\) when \(x = -2\) without the aid of a calculator **

* Revised from PHOBOS

** Additional questions, not on PHOBOS
<table>
<thead>
<tr>
<th>MBTI TYPE</th>
<th>PERCENT*</th>
<th>MBTI TYPE</th>
<th>PERCENT*</th>
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<td>1.0</td>
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* Percents from Myers (1987)
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<tr>
<th>SUBSCALES</th>
<th>PREAX</th>
<th>p</th>
<th>POSTAX</th>
<th>p</th>
<th>AXDIFF</th>
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<tbody>
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"Table 16 (continued)"

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<tr>
<th>SUBSCALES</th>
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<th>p</th>
<th>AXDIFF</th>
<th>p</th>
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<tbody>
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<td>-0.03</td>
<td>0.358</td>
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</table>

*p < 0.05
LIST OF REFERENCES


Brown, R. L. (1979). A determination of attitudes toward mathematics and an analysis of factors which are associated with negative attitudes toward mathematics of students at an urban community college. Doctor of Education Practicum, Heed University.


