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MATH PERFORMANCE AS A FUNCTION OF MATH ANXIETY AND AROUSAL PERFORMANCE THEORY

By

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A Dissertation

Submitted to the Graduate Faculty

of the

University Of North Dakota

in partial fulfillment of the requirements

for the degree of

Doctor of Philosophy

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ABSTRACT

While research continues to link increased math anxiety with reduced working memory, the exact nature of the relationship remains elusive. In addition, research regarding the extent of the impact math anxiety has on working memory is contradictory. This research clarifies the directional nature of math anxiety as it pertains to working memory, and the extent of impact it has in non-math tasks. Forty low, moderate, and high math anxious participants completed both a math and non-math working memory intensive task, several personality measures, and a series of progressively more taxing memory/attention tasks. There was no relationship between math anxiety and performance on a non-math task, but an inverse relationship between math anxiety and performance on the math portion of a working memory intensive math task. Math Anxiety was directly related to perfectionism and fear of negative evaluation. There was no relationship between math anxiety and processing speed, memory span, or selective attention. There was a significant effect of math anxiety on working memory, but this effect was limited to a math intensive task wherein the low math anxious group outperformed the moderate or high math anxious groups. Finally, scores on the Avoidant, Compulsive, and PTSD scales of the MCMI-III did not vary as a function of math anxiety, but the high anxiety group scored higher on the Anxiety scale of the MCMI-III than both the moderately and low math anxious groups. Exploratory analysis revealed an effect of math anxiety on SAT total score and SAT English, Math, and Science scores. Low

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math anxious individuals had higher SAT total and Math scores than both moderately and highly math anxious individuals, higher English scores than the high math anxious individuals, and both the low and moderately math anxious group had higher SAT Science scores than the high anxious groups. In a laboratory, the working memory deficit associated with math anxiety is limited to working memory intensive math tasks, but the real world impact appears more far reaching. Future research should clarify this relationship while controlling for the impact of other related constructs such as perfectionism and fear of negative evaluation.

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CHAPTER I

INTRODUCTION

Math anxiety can be defined as "feelings of tension, apprehension, or even dread that interferes with the ordinary manipulation of numbers and the solving of mathematical problems" (Ashcraft & Faust, 1994, Pg. 98). Although often overlooked in the psychological literature (Ashcraft, 2002), it is a debilitating illness that affects many people both academically and non-academically (Betz, 1978). Adams and Holcomb (1986) established that fully 1/3rd of the people seeking anxiety consultation at a major university were in some way affected by math anxiety. The impact math anxiety has is global, affecting everything from school performance, choice of educational major, occupational choices, career advancement, and finally to overall psychological well-being (Ashcraft, 2002).

Math anxiety, similar to other anxieties, results in a behavioral pattern of avoidance, thereby severely limiting the number of educational and occupational options available for a person (Ashcraft, 2002). Importantly, this avoidant behavior is not limited specifically to educational setting, but is a lifelong pattern of avoidance of anything requiring math. Compounding this is a deficit in the literature on math anxiety, its course, its etiology, and probably most importantly, its treatment. That said, a legitimate need exists for immediate research into the intricacies of math anxiety.

Math Anxiety

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Math anxiety, as defined above, is tension resulting from the manipulation of numbers (Ashcraft & Faust, 1994). This distinction is an important one, the tension that a person experiences is not the result of simply being confronted with numbers, but is the product of active manipulation of the aforementioned numbers. Math anxiety is a distinct form of anxiety. Only 37 % of the variance in math anxiety can be accounted for by test anxiety (Hembree, 1990), the most closely related form of anxiety. Further, according to Hembree (1990) and Hopko (2003) math anxiety is only minimally related to state anxiety ($r = .30$), trait anxiety ($r = .36$), fear of negative evaluation ($r = .39$), Anxiety Sensitivity Index ($r = .36$; Peterson & Reiss, 1993), and computer anxiety ($r = .37$) illustrating the interdependent nature of all anxieties, but also supporting the independence of math anxiety as a separate construct (Hopko, 2003).

While Adams and Holcomb (1986) work to distinguish math anxiety from generalized anxiety disorder, others have proposed math anxiety as a distinct Diagnostic and Statistical Manual of Mental Disorders (DSM IV TR; APA, 2002) specific phobia diagnosis (Faust, 1992 as cited in Ashcraft, 2002). People with math anxiety experience excessive and persistent fear that is unreasonable given the nature of the task (criterion A). This fear is accompanied immediately by physiological reactivity such as increased skin conductivity and increased heart rate (criterion B). Many people with math anxiety realize this fear is excessive (criterion C), and when confronted with the situation, either avoid or endure with great discomfort (criterion D). Most importantly, the math anxiety significantly impairs daily academic, social, and occupational functioning, often resulting in marked distress (criterion E). As such, math anxiety may cause significant enough impairment to warrant a diagnosis, and formal treatment.

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Ashcraft established an inverse relationship between math anxiety and performance on standardized tests ($r = -.31$). However, when looking at the individual components of the standardized test, this relationship only existed on the math portion, indicating that the score of math anxious people was artificially deflated as a result of decreased performance on the math component of the test. Further, math anxious persons scored lower ($r = -.17$) on standardized IQ measures (Ashcraft, 2002), but when the individual components are analyzed, math anxious people perform the same as non-anxious persons on the verbal components ($r = -.06$) indicating, again, artificial deflation of the math anxious person's score as a function of their performance on the math component of the task. Many other studies have established a relationship between math anxiety and general math functioning (Adams & Holcomb, 1998; Ashcraft, 2002; Ashcraft & Faust, 1994; Ashcraft & Kirk, 2001; Betz, 1978; Hembree, 1990; Hopko, Ashcraft, Gute, Ruggiero, & Lewis, 1998). Interestingly, Ashcraft (2002) established an increase in math performance following a cognitive behavioral treatment (CBT) of math anxiety, implicating math anxiety as the source of the performance decrements as opposed to the inverse.

Also of interest, this deficit in math performance only appears to exist when there are time constraints in assessment (Hopko, McNeil, Lejuez, Ashcraft, Eifert, & Riel, 2003). A paper and pencil format with no time constraints yields no difference in performance between the math anxious and non-math anxious group (Hopko et. al., 2003; Kellogg, Hopko, & Ashcraft, 1999). In exploration of this, many math anxiety researchers have concentrated on working memory impairment as central to the decreases in performance of the math anxious group. As will be explained in more detail later,

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working memory is responsible for the transient storage and active manipulation of information. The Processing Efficiency Theory (PET; Eysenck & Calvo, 1992) provides a model through which we might view the working memory deficit in math anxious people.

Math Anxiety and Working Memory

In pursuit of an explanation of the performance deficits central to anxiety, Eysenck and Calvo (1992) proposed the PET model. Although originally designed to account for the performance decrements in state anxiety, this is a viable model through which to view the performance decrements in a math anxious population. In their research, Eysenck and Calvo established that high trait and or test anxious persons performed more poorly on working memory intensive measures than did low anxious persons, especially under stressful conditions. Furthermore, this deficit is exaggerated as task difficulty increases. In a meta-analysis of 24 studies, Eysenck (1985) found this predicted difficulty by anxiety performance interaction in 22 different studies. However, although a contributing factor, Eysenck determined that task difficulty alone did not completely predict performance; there is not a perfect linear relationship between anxiety and performance in regards to task difficulty. In an attempt to more elaborately and comprehensively explain the variability in performance associated with anxiety, Eysenck and Calvo developed PET.

Before exploring the model of PET, it is necessary to analyze the underlying concept of worry and attentional interference proposed by Humphreys and Revelle (1984). Their theory proposes that anxiety exerts its influence on working memory in regards to task performance via worry. Briefly, in this model, worrisome thoughts

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interfere with attention to task relevant material thereby decreasing the resources available to manipulate the task at hand resulting in performance deterioration. According to this model, performance decrements should only be seen when the task requires significant short-term (working) memory resources.

However, this basic model is insufficient and overly simplistic in predicting anxiety related performance decrements. First, this model of worry and attentional interference overestimates the negative motivational influence of anxiety. If worry functioned as proposed above, we should see performance decrements immediately as task difficulty increases. However, the performance of high and low anxious people remains similar until difficulty reaches a certain level, at which point the high anxious group's performance deteriorates faster than the low anxious group.

Secondly, the role of arousal in this model may be overly emphasized. Although there is support for increased physiological arousal in anxious participants during working memory intensive tasks, this finding is not consistent. In fact, Holroyd, Westbrook, Wolf, and Badhorn (1978) found no difference in skin conductivity in anxious and non-anxious participants even though high-anxious participants self-reported higher levels of anxiety. Further, Calvo and Ramos (1989) found that increased verbal report of anxiety was not related to performance on either cognitive or fine motor tasks. It seems that physiological and verbal report indicators of arousal contribute only minimally in our understanding of anxiety's impact on performance.

Thirdly, this model does not take into account the variability in compenACTory behaviors of individuals in anxiety provoking tasks, instead assuming all humans respond similarly in stressful situations. Within the model of PET, individual compenACTory

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behaviors are viewed as directly and uniquely impacting a person's performance within a stressful situation.

Processing Efficiency Theory

It is the goal of PET to build on the model provided above, making it more comprehensive and more pragmatic. Central to PET is the proposal that state anxiety (and by extension, math anxiety) is determined interactively by trait anxiety and situational threats. Further, it is the level of state anxiety more than trait anxiety that impacts current cognitive performance. In this theory, worry is the cognitive component of anxiety. Worry has its effect on working memory, which is responsible for the active processing and transient storage of information. The most well accepted model of the working memory system has been proposed by Baddeley (1986), and consists of three components; the central executive, the articulatory loop, and the visuospatial sketchpad. Although we will not concern ourselves with math anxiety's influence on each of these subsystems, it is helpful to have a basic understanding of the model.

The PET most specifically implicates the central executive in performance decrements associated with anxiety, as the central executive is responsible for processing and storage of information, although the articulatory loop may also play a role. Within this model, we can see how state anxiety (math anxiety) impacts performance. Where a person who is not math anxious utilizes all available resources on problem solving, high-anxious persons expend a portion of working memory on worry thereby leaving fewer resources for problem solving. As such, as tasks become more difficult, the high anxious group is more likely to realize performance decrements.

Unique to this model, however, worry may also be beneficial in that it increases

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motivation, which results in increased attentional resources and improved problem solving (coping strategies). This helps account for the imperfect relationship between anxiety and performance, and helps explain some of the variability in the math anxiety research. For some, anxiety is beneficial in that it leads to attempts at allocation of additional attentional resources. If these attempts are successful, it results in improved performance. However, if these attempts are unsuccessful, performance is further impaired. As such, people who report high levels of anxiety, but are skilled at allocating additional resources may perform better on the same task as someone who reports the same anxiety, but is unskilled at allocating additional resources. Eysenck and Calvo (1992) do not specify from where these additional resources are acquired.

Central to this theory, PET proposes a self-regulatory mechanism which mediates the impact of anxiety on working memory, and therefore on performance. The regulatory mechanism copes with performance decrements in two possible ways; coping directly with the threat/worry or applying additional resources. This concept is sometimes referred to as metacognition, or thinking about thinking. People have some idea what their cognitive resources are, and can actively manipulate them to increase the level of resources available. The second form of coping, the application of additional resources, is thought to be the foundation of the performance decrements in some anxious persons. In this case, the high anxious person applies additional resources to task irrelevant stimuli (e.g. worrisome thoughts). Focusing on task irrelevant information utilizes working memory resources thereby decreasing performance. This decreased performance leads to increased self-awareness of impending failure and, therefore, increased worry and decreased availability of working memory resources for task-relevant information. In

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essence, they have established a circular pattern of increased working memory resources being expended on task-irrelevant stimuli, thereby decreasing performance and increasing metacognition of impending failure, which decreases available working memory resources, and completes the self-defeating loop.

Although this theory was originally proposed to account for performance decrements in state/trait anxiety, it works with math anxiety as well. Ashcraft (2002) has postulated math anxiety as a situation specific personality characteristic. In other words, he has made the argument that math anxiety is a form of state anxiety; it is merely specific to math situations. As such, we should be able to generalize the above model to account for performance decrements in math anxious persons in math situations.

Deficient Inhibition Mechanism

Although the PET model of working memory adjusts nicely to account for the decrements in math performance as a function of math anxiety, Hopko, Ashcraft, Gute, Ruggiero, and Lewis (1998) have proposed another, possibly complimentary, model through which we might view the performance decrements of math anxiety. Hasher and Zacks (1988) originally proposed the inhibition theory, which said that people without attentional suppression ability would be unable to ignore distracting stimuli, resulting in decrements in performance. Building on this theory, Hopko et al. attempted to establish the existence of a deficient inhibition mechanism (or an attentional suppression deficit) in math anxious participants.

In this study, Hopko et. al. (1998) presented reading material to math anxious and non-math anxious participants. Embedded within the reading material were task irrelevant stimuli. Half of the readings were math related, and half were not. The

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participants were instructed to read the paragraph, studying the material, and ignoring the irrelevant stimuli. In two readings (control condition), the distracters were non-meaningful consonant letter strings (e.g. X X X X X X), in four of the readings, the distracters were related to the reading but did not contribute to the content (math related), and in the other four, the distracters were entirely unrelated to the material (non-math related). In this study, the math anxious participants were less able to ignore the task irrelevant stimuli than were the non-math anxious participants, lending credence to what Hopko et al. term a deficient inhibition mechanism. Further, the inability to inhibit irrelevant stimuli was not limited to math situations. Much to the contrary, math anxious participants were less able to inhibit distracters in all conditions including the letter string control condition.

The deficient inhibition mechanism model proposed by Hopko et. al. was intended to supplement the PET model of Eysenck and Calvo (1992), making their model more comprehensive and more specific. Within the framework of PET, a deficient inhibition mechanism would be the specific component responsible for performance decrements in math anxious persons. Specifically, the inhibition mechanism, nested within the central executive, in math anxious persons would be what was responsible for the allocation of additional resources to task irrelevant stimuli, and therefore the decrease in performance (see figure 1 below). In non-anxious persons, the inhibition mechanism would inhibit competing irrelevant stimuli, thereby allocating additional resources to task relevant information and improving performance.

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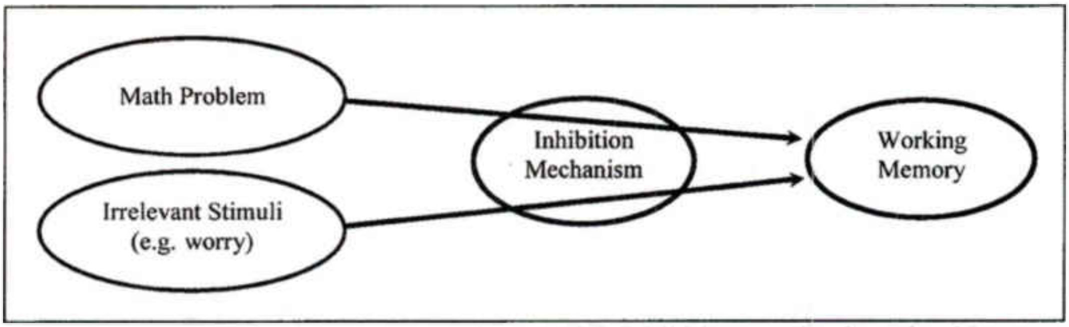

Figure 1. Deficient inhibition mechanism model. Inhibition mechanism should inhibit irrelevant stimuli, such as worry, from entering working memory.

Arousal Performance Function

The synthesis of these two theories provides a relatively comprehensive model through which to assess the impact of math anxiety on performance. However, contradictory research into Arousal Performance Function (APF; Sorg and Whitney, 1992) has begun to surface mediating our interpretation of the influence of math anxiety on math performance. APF is an extension of the original Yerkes-Dodson (1908) inverted U law, which states that as arousal increases, so does performance. However, at some intermediate level of anxiety, the maximum ability of a person is reached whereby any additional anxiety results in performance decrements. APF may complement Eysenck and Calvo's PET (1992) in that it accounts for the influence of allocating additional resources to improve performance. Further, when the task becomes too difficult, we realize performance decrements. As such, APF should fit nicely with PET. However, Miller and Bischel (2004), while assessing for this curvilinear relationship in math anxious participants, established a direct negative relationship whereby low math anxiety participants performed better than moderately math anxious participants, who in turn performed better than high math anxiety participants on a working memory intensive math task (Figure 2). This is partially contradictory to PET, as well as the previous

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research of Farnsworth and Hook (2002) who established a trend toward APF in a math task as a function of math anxiety (Figure 3 below). However, the small sample size jeopardizes interpretation and generalization of these findings beyond the actual study. As there exists a discrepancy in the impact of APF in math anxiety and math performance, future research could benefit from inclusion of APF in the research design.

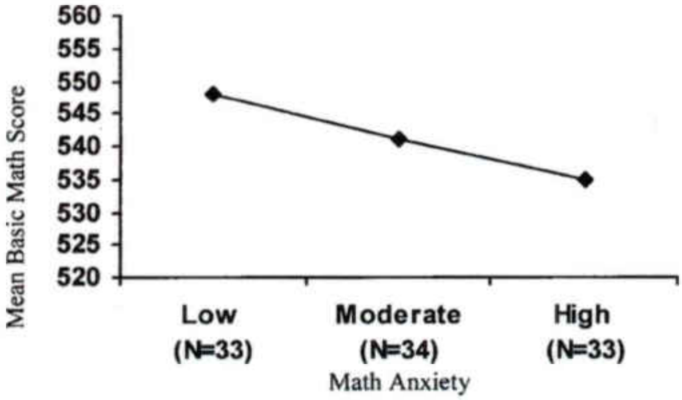

Figure 2. Basic math performance (as assessed by the Woodcock Johnson Calculation subtest) as a function of math anxiety (as assessed by the MARS; Miller & Bischell, 2004).

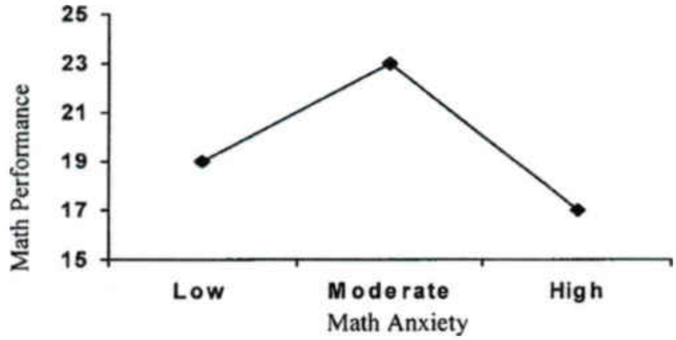

Figure 3. Math performance (as assessed by a working memory intensive math task) as a function of math anxiety (as assed by the sMARS; Farnsworth & Hook, 2002).

Complicating the math anxiety literature is the uncertainty about the boundaries of math anxiety's impact. In establishing the deficient inhibition mechanism Hopko et al. (2003) revealed an apparent global working memory deficit whereby math anxious

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participants performed more poorly on all tasks (math and non-math) involving task-irrelevant stimuli. This would indicate a global working memory deficit whereby math anxious persons should perform more poorly in all tasks, math related and non-math related, that tax working memory. However, Ashcraft (2002), somewhat contradictory to some of his other research, implies the performance decrements in math anxious persons that are the product of a working memory deficit may be math specific, more like a phobic reaction. He sights the non-significant difference between math and non-math anxious persons on non-mathematical IQ assessments and standardized tests. However, the argument can be made that, while the non-mathematical tasks are cognitively demanding, they are not as working memory taxing as the math components of the IQ assessment and standardized tests which do demonstrate significant differences between math anxious groups. Further, neither of these studies specifically assessed the influence of math anxiety on performance in a working memory intensive math and non-math task.

To assess these questions more specifically, Farnsworth (2005) proposed an APF relationship between math anxiety and performance in both a math and a non-math task. In this study, 1358 students in undergraduate psychology classes were screened, and120 undergraduate students were selected based on their responses to the Short Mathematics Anxiety Rating Scale (sMARS: Alexander & Martray, 1989), 40 high, moderate, and low math anxious participants. These participants completed both a math related (Addition Memory Task; AMT) and non-math related (Learning Efficiency Task; LET) working memory intensive task. In the non-math tasks, a curvilinear relationship existed whereby the moderate group outperformed the high anxious group and nearly outperformed the low anxious groups ($p = .055$). However, in the math task, a direct negative linear

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relationship existed whereby the low anxious group nearly performed better than the moderately anxious group ($p = .06$) and performed significantly better than the high anxious group. The Moderately anxious group also nearly performed better than the high anxious group ($p = .06$; see figure 4 below).

This distribution discrepancy across tasks calls the validity of a global working memory deficit into question, as the moderately anxious group's performance was substantially different (albeit not quite significant) from one task to the next. However, the performance of the high anxious group appears stable across tasks possibly indicating uniform performance deterioration given extreme anxiety, but unstable anxiety effects when anxiety is only moderate. Questioning the globality of the working memory deficit even more is the significant performance decrements in the low math anxious group from one task to the next. If a global and stable anxiety effect exists, there should be a consistent performance in this group across tasks. Instead there is a significant difference from one task to the other supporting the independence of working memory and anxiety, and possibly lending support to the phobic nature of math anxiety at its extreme.

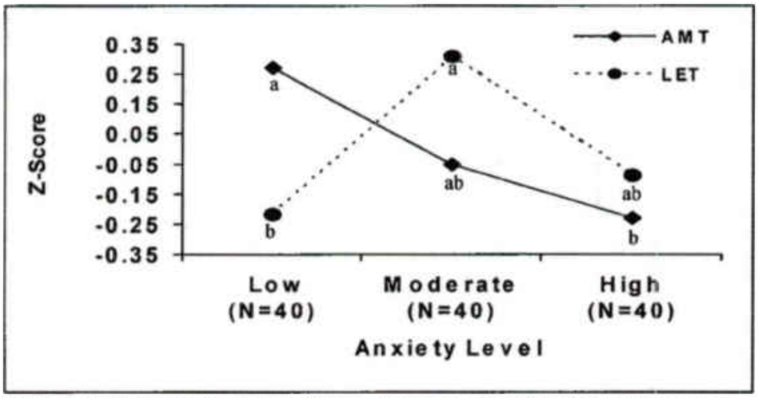

Figure 4. Learning Efficiency Test (LET; non-math) z-score and Addition Memory Task (AMT; math) z-score as a function of math anxiety level. Means that do not share a common subscript are significantly different, $p < .05$.

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The divided attention task of Hopko et. al. (2003) supported an overall working memory (attention) deficiency in math anxious persons. However, little research exists to understand which components of working memory (attention) are impacted directly by math anxiety, and therefore contribute to the performance decrements. In personal correspondences with Ashcraft (September 2005), he indicated the most sensible direction in the math anxiety research to be in locating where in the brain math anxiety has its impact. We do not have access to technology to allow us this approach to the research, but an investigation of the areas of working memory (attention) which are affected could offer insight into specific brain locations implicated in performance decrements, and further our understanding of the specific cognitive processes that are impacted by math anxiety. Clinically, a more in-depth understanding of the cognitive intricacies of math anxiety could allow for better assessment and treatment. Further, a clinician is not likely to refer for a fMRI for math anxiety evaluation, but is more likely to rely on traditional psychometric assessment techniques similar to those utilized here.

Current Research

This research is intended to replicate the previous research of Farnsworth (2005) and further clarify the relationship between APF and math anxiety by looking specifically at performance at individual attentional levels: processing speed, memory span, selective attention, and working memory. It will, again, explore this function in a math and non-math working memory intensive task. The hypotheses of this study are as follows.

Hypothesis 1

Similar to the previous research of Farnsworth (2005), APF will be supported in a non-math task.

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Hypothesis 2

APF will not be supported in a working memory intensive math task, instead, a direct negative linear relationship will be supported whereby the performance of the low math anxious group will be better than that of the moderately math anxious group, which will in turn be better than the performance of the high math anxious group.

Hypothesis 3

Perfectionism, as measured by the Frost Multi-Dimensional Perfectionism Scale, will be directly related to math anxiety as measured by the sMARS.

Hypothesis 4

Fear of negative evaluation, as measured by the Brief Fear of Negative Evaluation Scale, will be directly related to math anxiety as measured by the sMARS.

Hypothesis 5

As processing speed is too automatic a process, there will be no difference in performance on processing speed tasks as a function of math anxiety level.

Hypothesis 6

Hopko et. al. have proposed an overall cognitive deficit, in the form of a deficient inhibition mechanism, which manifests itself fairly quickly in math anxious persons both in math and non-math tasks. If this is the case, these people should perform more poorly on all tasks that require more than basic automatic processing including tests ranging in difficulty from memory span, to selective attention, to working memory. However, the research of Farnsworth seems to indicate a working memory deficit localized to math situations. If this is the case, we would expect to see no difference between math and non math anxious persons on memory span, selective attention, and working memory tasks

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that do not require the active manipulation of numbers. Support for Hopko's global working memory deficit theory would tend to support a trait model of math anxiety that is more global in it's influence, whereas support of Farnsworth's previous research would seem to indicate more state specific working memory deficits, and therefore a model more in line with a phobic response to a specific threatening stimulus.

Hypothesis 7

If support is found for Hopko's model of math anxiety, we would expect to see elevation on the Millon Multiaxial Clinical Inventory, 3rd Edition (MCMI-III) reflecting more trait specific personality characteristics as indicated by possible elevations on the scales 2 (avoidance) and 7 (compulsive). These scales are more indicative of core behavioral anxiety patterns likely to influence a wide range of functioning, including both the math and the non-math tasks. However, if the research supports Farnsworth's previous findings, and therefore a state specific model, we would expect to see elevations on the A (anxiety) and R (PTSD) scales of the MCMI III. These scales are more state specific conditions, and are therefore more likely to fluctuate from task to task. As such, a person endorsing symptoms of math anxiety and having an influx on the A and R scales of the MCMI III should manifest this anxiety only in decreased performance in the math task.

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CHAPTER II

METHOD

Participants

One hundred and twenty undergraduate students were recruited to participate in the study. The participants included both males ($n = 60$) and females ($n = 60$) enrolled in Introduction to Psychology and other lower level courses at the University of North Dakota. Participants were treated in accordance with APA ethical guidelines. As an incentive, participants received research/extra credit in their enrolled class. Participants were offered confidentiality, but could not be offered anonymity, given the design of the experiment.

Measures

Short Mathematics Anxiety Rating Scale

Math anxiety was screened using the short version of the Mathematics Anxiety Rating Scale (sMARS; Alexander, & Martray, 1989). The instrument assessed students' apprehension about taking or receiving the results of a mathematics test, executing numerical operations, and taking mathematics courses. Participants were asked to rate how anxious they would feel in the different situations by responding to 25 items using a five-point Likert-type scale ranging from "not at all" to "very much" (see appendix A).

The sMARS has demonstrated effectiveness in assessing math anxiety (Ashcraft & Kirk, 2001; Hopko et. al, 1998). Further, the parent measure of the

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sMARS, the Mathematics Anxiety Rating Scale (MARS; Richardson & Suinn, 1972), has also demonstrated effectiveness in assessing math anxiety (Ashcraft & Faust, 1994; Adams & Holcomb, 1986). As these two measures are correlated as high as .96 (Hopko et. al., 1998), this adds validity to the use of the sMARS as a screening tool for assessing math anxiety. Further, the sMARS has test/retest reliability of .75 (Hopko et. al.) indicating that the sMARS is efficiently measuring a relatively stable construct.

Participant Information Sheet

Each participant completed a brief questionnaire (Appendix B) to collect demographic information, including gender, age, class status, and college major. As well, it collected information about the highest-level math course they had completed in high school and college and the grade in that course, and whether they had ever received a diagnosis or services from a mental health practitioner for an attention deficit disorder, learning disability, or anxiety disorder.

Learning Efficiency Test

The Learning Efficiency Test (LET; Webster, 1998) was administered to measure working memory in a non-math context. It measured immediate, short term, and long-term recall. It has demonstrated reliability with Webster's test-retest reliability of .80, indicating that it is measuring a stable construct as opposed to a state.

The LET was adapted for use with the Super Lap Pro (SLP; Abboud, H., & Suger, D. 1997) experimental computer program. In this experiment, participants saw a letter on the screen for 2 seconds. This letter was then replaced by another letter. After the series of letters, the screen advanced, and the participant was instructed to recall the letters they

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saw (immediate recall). After 5 seconds, the screen advanced and they were instructed to count aloud from one number to another (e.g. from 5 to 15). After 5 seconds, the screen advanced again where the participants were instructed to recall the letters they saw (short-term recall). After this, the screen advanced and they were told to read aloud a short sentence (e.g. the horse ate a large bag of grass). Following this, the screen advanced and they again recalled the letters they saw (long-term recall). The first 2 series consisted of 2 letters, the 3rd series consisted of 3 letters, the 4th of 4, and so on until they reached 9 letters (see appendix C). Scores were recorded for how many letters were recalled in order, how many were recalled regardless of order, and the total letters recalled (sum of the ordered and unordered scores). Although not an original scoring component of the LET, this also provided a measure of cognitive organization by examining the letters recalled out of order (unordered score minus ordered score).

Addition-Memory Task

To assess working memory in a math context, the addition memory task (AMT; Farnsworth & Hook, 2002) was administered. The AMT was designed by Hook and Farnsworth (2002), and modeled after the research of Ashcraft and Kirk (2001). It was designed as a working-memory intensive measure of math performance, and was modified slightly for use in this research. As the original AMT was believed to have a restriction of range in the total score, which made interpretation and statistical manipulation difficult, this version of the AMT includes both easier and more difficult problems.

As per the finding of Ashcraft and Kirk (2001), the AMT was designed to be maximally taxing on working memory requiring both information storage and active

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information processing. Ashcraft and Kirk established this type of task to be powerful in distinguishing math and non-math anxious persons. Ashcraft and Kirk assert that in order for a task to reveal the working memory deficit in math anxious persons, the task must require more than simple arithmetic. In an attempt to establish the point at which the working memory deficit begins to exert its influence on math performance, this task has been designed to begin very easily and to become progressively more difficult.

In this task, via SLP, a set of 6 different consonant letters appeared on the screen for 6 seconds. Each letter set was unique, and was evaluated for meaningful acronymic combinations. After 6 seconds, the screen automatically advanced to an arithmetic problem. The participants were instructed to retain the letters from the previous screen in memory while completing the math problem. They orally solved the addition problem, and, after 5 seconds had elapsed, the screen advanced. They were then given 5 seconds to recall the letters they saw on the original screen before the screen advanced and the trial ended.

The first set (3 trials) was composed of single digit numbers, and required no regrouping operation. The second set contained single digit numbers that did require a regrouping operation. The third set contained 1 single digit number and 1 double-digit number that did not require a regrouping operation. The fourth set contained a single digit number and a double-digit number that required a regrouping operation. The fifth set contains 2 double-digit numbers that did not require a regrouping operation. The sixth set contained 2 double-digit numbers that required a regrouping operation in the tens column. The seventh set contained 2 double-digit numbers that required a regrouping operation in both the tens and hundreds column. The eighth set contained 3 double-digit

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numbers that required no regrouping operation. The ninth set contained 3 double-digit numbers that required a regrouping operation in the tens column. The tenth set contained 3 double-digit numbers that required a regrouping operation in both the tens and in the hundreds column. As such, this task consisted of 30 total trials (see Appendix D).

The original scoring for the AMT awarded the participant 1-point for correctly answering the addition problem, and one point for every letter recalled regardless of order. As such, each trial had a maximum possible score of 7, and the overall task had a maximum score of 210. Following several administrations of the AMT, it was noted that many participants would forgo the addition component of this task, instead focusing cognitive energy on the letter recall component. This resulted in an exaggerated influence of letter scores on the total AMT score, which did not accurately represent the divided attention nature of this task. As such, a new scoring system was developed whereby participants received a score of 1 on the addition component for saying any number, and an additional point for having a correct number in the correct right justified location. For example, if the correct answer was 122, and the person said 4, they would receive a score of 1. If they said 92, their score would be 2. If they said 102, their score would be 3. If they said 122, their score would be 4. On the letter task, they received a score of 1 for recalling 1 or 2 letters in the correct left justified position, 2 points for recalling 3 or 4, and 3 points for recalling 5 or 6. This resulted in a total possible addition score of 93, letter score of 90, and total score of 183, which was much more balanced and more accurately reflected the divided attention nature of this task. The new scoring method was used for all analysis in this study.

Task Evaluation Sheet

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Following both the LET and the AMT, participants filled out a task evaluation sheet soliciting task difficulty, task anxiety, and task effort. A separate identical questionnaire was given immediately following the LET and the AMT. Participants were asked to record their answers on a 7-point Likert-type scale ranging from 1 (not at all) to 7 (very much; see Appendix E).

Processing Speed

Digit Symbol Coding

To assess processing speed, participants were given the Digit Symbol Coding subtest of the Wechsler Adult Intelligence Scale, 3rd Edition (WAIS III). In this task, the participant was given a key, which had the numbers 1-9. Corresponding to each number was a unique relatively simplistic symbol. Directly beneath the key was a grid, which contained 133 randomly presented numbers from 1 to 9. In this task, the participant was instructed to utilize the key to identify the appropriate symbol for each letter, after which they transcribed that symbol into a box directly beneath the number. This test had a time limit of 120 seconds, after which time, the number of correct transcriptions was recorded. If the participant finished before the allotted time, the amount of time to completion (in seconds) was recorded.

Symbol Search

To assess processing speed in a slightly different format, each participant also completed the Symbol Search subtest of the WAIS III. In this task, participants were given a sheet of paper with 3 columns. In the left most column were 2 target symbols, in the center were 4 match symbols, and in the right most column were blocks with the words "yes" and "no". In this task, the participant was instructed to scan the match

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symbols for the presence of either of the target symbols. If the target symbol was present in the match symbols, the participant marked the "yes". If neither of the target symbols were present in the match column, the participant marked the "no" box. The participant had 120 seconds to match as many of the 60 trials as possible. The amount of time to completion (if less than 120 seconds), number of correct responses, number of incorrect responses, and total raw score (correct minus incorrect) were recorded.

Rapid Picture Naming

To assess processing speed in a domain that did not require motor coordination, the Rapid Picture Naming subtest of the Woodcock Johnson Test of Cognitive Abilities 3rd Edition (WJ-COG III) was administered. In this task, participants were shown 4 cards sequentially. On each card was printed 30 pictures. The participant had 120 seconds to name as many of the 120 picture stimuli as possible. Completion time (if less than 120 seconds) and total number of correctly identified pictures was recorded.

Memory Span

Digits forward

To assess simple attention, the Digits Forward of the Digit Span subtest from the WAIS III was administered. In this task, participants were presented auditorily with a sequence of numbers. They were told to remember these numbers, and, when instructed, to recall them. The task levels became progressively more difficult ranging from 2 numbers to 9 numbers. Each level contained 2 trials. The task was discontinued when the participant was unsuccessful at both trials in the same level.

Letter Span Forward

To assess simple attention in a non-numerical domain, each participant completed

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the alphabetical equivalent of the Digits Forward task. In this task, the participant was presented auditorily with randomly selected consonant letters varying in length from 2 to 9 letters. These letter sets were different than the letter sets used in the AMT. As with the Digits Forward, the Letter Span task had 2 trials of 8 difficulty levels resulting in a possibility of 16 trials. The cutoff was the same as the Digits Forward task, incorrect responses to both trials in a level.

Alphabet Forward

In this task, the participant was asked to recite the letters of the alphabet in order as quickly as possible without making any mistakes. Both their time and the number of errors were recorded. This allowed both a measure of simple attention and an assessment of knowledge of the alphabet, which was important in both letter span tasks.

Selective Attention

Stroop Test

To assess selective attention (inhibition at its most basic level, each participant completed the Stroop test. In this task, the client was given a piece of paper with the names of colors printed on it. However, they were printed in a different color than the name of the printed word. For example, the word green might have been printed in blue ink or the work red might have been printed in yellow ink. Each participant was instructed to say the color the word was printed in, ignoring what the word said. So, in our example above, the person would say blue and yellow. This required the person to forgo the written information in favor of the color information. In this task, to identify reading ability and color vision, the person first read the same list of color words that they saw in the actual task, but printed in black ink. Then they saw the colors, but no

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words. The person was simply to say the color. Then the person completed the actual task as outlined above. In each portion of the task, the person had 45 seconds, after which time the person was told to stop and the number of correctly completed items was recorded.

Number Stroop Test

The Number Stroop Test was designed for this experiment (following the advice of a committee member) to assess for a Stroop effect in the traditional condition and in a condition that involved interaction with numbers. This task had two components. In the control component, participants looked at a page which had 117 boxes. In each box were between 1 and 9 "X"s. There was no identifiable pattern to the sequence of numbers in boxes. The participants were instructed to count the number of "X"s, starting on the left and working down, then moving to the next column. They were given 45 seconds to count the "X"s in as many boxes as possible. The experimental part of the task was identical to the first except the "X"s were replaced with numbers. However, the number of digits in the box was different that the actual numeral. For example, there may have been 5 "9"s in a box, or 7 "2"s. The directions were identical. To ensure that any difference was not a relic of positioning of numerals in the box, the numerals were in the exact location in the box as the "X"s on the corresponding control condition (See appendices F and G). Based on their performance, a discrepancy score was computed from the control condition to the experimental condition.

d2

The d2 test is a measure of sustained attention requiring an individual to focus attention on a specific task for an extended period of time. This task is composed of 14

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lines of 47 letters. The letters are either "d" or "p", and contain 1, 2, 3,or 4 hash marks either above, below, or in some combination. In this task, the individual was given instructions to cross out only the "d's" that had 2 hash marks. They could be on the top, on the bottom, or both, so long as the sum of the hash marks was 2. Although the person was not told it was a timed task, they were given 20 seconds to complete each line before they were told to discontinue that line and move on to the next. This measure provided assessments of quantity completed, accuracy, errors, percent accuracy, percent errors, errors of omission, errors of commission, response stability across lines, and a general index of concentration performance. While the selective attention component of this task was of immediate interest here, other data (e.g. inattention and inhibition) may be interesting for post-hoc analysis.

Connor's Continuous Performance Test (CPT)

The Connor's Continuous Performance Test is a robust assessment of sustained attention (Spreen & Strauss, 1998). This task required participants to depress a key on the computer any time a letter was presented on the screen *except* the letter "X". There were 6 blocks each with three 20-trial sub-blocks. Within each interval was different inter stimulus intervals ranging in length from 2 to 4 seconds. The stimuli were presented for 250 milliseconds each. The CPT provided data regarding omissions, commissions, response latency, and response variability across the task. Again, the selective attention information was of immediate interest here, but the other data (inattention, response variability, inhibition, …) may prove interesting for post-hoc analysis.

Auditory Attention

To assess selective attention in a non-visual domain, the Auditory Attention

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subtest of the Woodcock Johnson Test of Achievement 3rd Edition (WJ-ACH III) was utilized. In this task, via an auditory track presented on audio equipment, the person was presented with words. These words were presented in the context of background noise that continually increased making discrimination of the auditory stimuli more difficult. The words were presented sequentially until the person failed to recognize 6 consecutive words. In this task, the number of words correctly recognized was recorded providing a non-visual assessment of selective attention.

Working Memory

Letter-Number Sequencing

To assess working memory, the Letter-Number Sequencing subtest of the WAIS III was administered. In this task, the participant was read a sequence of random intermixed numbers and letters. The participant was instructed to recall the numbers first in numerical order followed by the letters in alphabetical order. For example the stimulus 7-J-4-C would be recalled as 4-7-C-J. There were 7 blocks of 3 trials each ranging in difficulty from 2 to 8 letter/number items. The participant's response was scored as correct if they recalled the correct sequence of both numbers and letters. They were scored as incorrect if any of the letters or numbers were recalled incorrectly. The task was continued until the participant failed to correctly recall any of the three trials in a specific block.

Auditory Working Memory

Similar to the task above, the Auditory Working Memory subtest of the WJ-COG III was administered to each participant. In this task, the participant heard, via audio CD, a sequence of intermixed numbers and words. They were instructed, after presentation of

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the stimuli, to recall the words first followed by the numbers, both in the order they were presented. There were 21 total trials ranging in difficulty from 1 number and 1 word to 4 numbers and 4 words. The participant was awarded 1 point for recalling all of the words in the presented order, and 1 point for recalling all of the numbers in the presented order.

Paced Auditory Serial Addition Test

The Paced Auditory Serial Addition Test (PASAT; Gronwall, 1977) assessed working memory through an auditory addition task. In the PASAT, participants added consecutive numbers as they were presented auditorily, and responded orally with the sum. As each digit was presented, the participants had to sum that number with the digit that was presented prior to it. There were 4 trials with 61 single digit presentations in each. The first presentation had an inter-stimulus interval of 2.4 seconds, with a .4 second decrease in interval width with each succeeding trial. Amount of time to respond, total number correct in both the trial and the task, and the number of incorrect or omitted responses was recorded for each participant.

Personality

Frost Multi-dimensional Perfectionism Scale

To identify perfectionistic personality characteristics, each participant also completed the Frost Multi-dimensional Perfectionism Scale (F-mps; Frost, Marten, Lahart, & Rosenblate,1990). Zettle and Raines (2000) suggested a possible link between math anxiety and perfectionistic tendencies based on their previous work, but had no conclusive data to support it. Ugumba-Agwunobi (2002) found a modest correlation between anxiety about statistics and perfectionism, but did not directly assess math anxiety. As there appears to be a connection between perfectionism and math anxiety,

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this study sought to clarify this relationship. On the F-mps, participants responded to 35 items indicating how much that item was like them (see Appendix H). They responded on a 1-5 Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). Based upon their original research, Frost et. al. established 6 factors underlying the Fmps; concern over making mistakes (CM), personal expectations (PE), parental expectations (PX), parental criticism (PC), doubt (D), and organization (O).

Brief Fear of Negative Evaluation

To assess social phobia symptoms, specifically fear of negative evaluation, the Brief Fear of Negative Evaluation (BFNE; Leary, 1983) scale was used. In a meta-analysis compiling data from 4 studies, Hembree (1990) found a modest correlation of .44 between fear of negative evaluation and math anxiety. Hopko (2003) also found a modest .39 correlation between math anxiety and fear of negative evaluation. As there is a great deal of overlap between most anxiety measures, this correlation is not unexpected. However, as there appears to be a recurring theme involving math anxiety and fear of negative evaluation, and as both of these studies utilized the Fear of Negative Evaluation (FNE; Watson &Friend, 1969) scale, a derivative of this scale will be employed here as well to assess the impact of negative evaluative ideations. The original FNE, an assessment of the amount of apprehension a person has in possibly negative evaluative situations, is composed of 30 items that are endorsed either true or false. It has high internal consistency (.94-.96), and adequate test-retest reliability at between .78 and .94 (Watson & Friend). However, those completing it often experienced it as long and arduous.

In an attempt to develop a more parsimonious assessment of fear of negative

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evaluation, Leary (1983) developed the BFNE as a derivative of the original FNE. It contains only 12 of the original 30 items from the FNE, and the response format was changed to a 5-point Likert-Type scale with the anchors from 1, "Not at all characteristic or me" to 5 "Extremely characteristic of me" (see Appendix I). The BFNE correlates highly with the original FNE (.96), and shows good internal consistency with a Cronbach's alpha of .90. Further, it has 4-week test-retest of .75, even higher than the 4-week test-retest of the original FNE (.68) demonstrating measurement of a fairly reliable and temporally consistent construct.

Millon Clinical Multiaxial Inventory-3rd Edition

The Millon Clinical Multiaxial Inventory 3rd Edition (MCMI-III; Millon, 1983) was used to assess for the interplay of other psychopathological influences. The MCMI III is an objective personality assessment consisting of 175 items endorsed either true or false. This assessment has demonstrated effectiveness in discriminating the personality disorders outlined by Theodore Millon, and has also demonstrated utility as a companion to the Diagnostic and Statistical Manual of Mental Disorders 4th edition (DSM IV TR; APA, 2002) personality disorders section. Further, multiple items assessing each psychopathological domain increase validity of the assessment instrument (Lumsden, 1988). The personality dimensions assessed with this instrument include:

Scale 1. Schizoid Personality Disorder. This disorder is marked by a pattern of social detachment and avoidance without the expected accompanying distress. These individuals are generally indifferent to the needs of other, and, as such, often lack sufficient social support.

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Scale 2A. Avoidant Personality Disorder. This disorder is marked by a strong tendency to avoid others, but unlike the schizoid personality, this person does so with great distress as they genuinely desire the personal interaction of others. However, these people are generally socially inhibited in response to expected fear of negative evaluation and rejection.

Scale 2B. Depressive Personality Disorder. These individuals generally approach life with an overwhelming sense of pessimism, unhappiness, and gloom.

Scale 3. Dependent Personality Disorder. These individuals generally abandon their own autonomy in favor of close association with usually one person, but sometimes more. They demonstrate very clingy and attached behavior, and are often submissive to the needs of others at the expense of their own desires and needs.

Scale 4. Histrionic Personality Disorder. Similar to the Dependent personality in the desire to be close to people, the Histrionic is generally more manipulative in their attempts, and generally only attaches to an individual for a short time before detaching and moving to the next person. These people are generally attention seeking through gregariousness and socially engaging behavior, including often sexually provocative behavior.

Scale 5. Narcissistic Personality Disorder. This individual is generally self-centered and egocentric. They have an overvalued and inflated sense of self worth, and produce an arrogant and assuming demeanor. They generally have a high need for admiration, and will often become angry, even violent, if they do not receive it.

Scale 6A. Antisocial Personality Disorder. This person has near complete disregard for the rules and laws of society, and is indifferent to the needs of others. This

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person will often participate in illegal activities will little or no remorse to gain desired goods.

Scale 6B. Sadistic Personality Disorder. Otherwise known as the aggressive personality disorder, this person is marked by hostility in most social situations. These individuals are highly combative and confrontational in interpersonal relationships.

Scale 7. Compulsive Personality Disorder. This person generally experiences tremendous anxiety in ambivalent situations, and structures life so there is as little ambivalence as possible. This rigidity and structure generalizes in all areas of life from daily living skills to interpersonal relationships. These persons are likely to stick very closely to schedules, to be perfectionistic, and to deviate only minimally from daily patterns.

Scale 8A. Negativistic Personality Disorder. Otherwise known as passive aggressive disorder, people with this personality type often display behavior that subsumes an underlying resentfulness. However, they are unable to express this resentment directly, and so resort to passive "back door" approaches at being hostile.

Scale 8B. Masochistic Personality Disorder. A sacrificial demeanor marks this personality, and this person is often content to serve the needs of others, even at the expense of their own needs and desires.

This personality assessment is also valuable in that it yields scores for the severe personality pathology scales of:

Scale S. Schizotypal Personality Disorder. This person exhibits much of the behavior of the schizoid personality, but also has cognitive confusion and perceptual distortion. This disorder is sometimes considered a mild form of schizophrenia.

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Scale C. Borderline Personality Disorder. An individual with elevated scores on this dimension would likely exhibit unstable interpersonal relationships and labile emotions. It is possible that one or both of two underlying conditions may be at the foundation of the often erratic behavior, an overwhelming fear of abandonment and/or a confused self image.

Scale P. Paranoid Personality Disorder. Individuals with score elevations here likely are suspicious of others and have a fear of loosing independence or being controlled by others.

Of interest in assessment/screening, the MCMI 3 also yields clinical diagnostic information in the form of clinical syndrome scales and severe clinical syndrome scales which include:

Scale A. Anxiety Disorder. Persons scoring high on this scale are likely to have increased anxiety, tension, and apprehension as well as possibly higher somatic complaints resulting from phobic reactions.

Scale H. Somatoform Disorder. This scale measures the existence of health complaints with no known physical basis. The DSM IV distinguishes among 7 different somatoform disorders, a distinction not made on the MCMI 3.

Scale N. Bipolar: Manic Disorder. An individual scoring high on this dimension is likely to display persistent, elevated, and expansive mood similar to a hypomanic episode.

Scale D. Dysthymic Disorder. This scale is characterized by at least a two-year period of depressed mood including insomnia, loss of appetite, low self-esteem, apathy, fatigue, and poor concentration.

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Scale B. Alcohol Dependence. An individual consuming excessive amount of alcohol is likely to have elevations on this scale. In Millon's theory, this is likely a person experiencing distress at work or at home.

Scale T. Drug Dependence. Similar to the Alcohol Dependence scale above, persons using excessive amounts of drugs are likely to have elevations on this scale, especially if the drug use is having and adverse impact on the person's life.

Scale R. Post Traumatic Stress Disorder. An assessment of physiological arousal following a traumatic event that is outside the range of natural events. This arousal need be present for at least one month following the traumatic event.

The Severe Clinical Syndrome Scales consist of:

Scale SS. Thought Disorder. Fragmented thinking, blunted affect, disorganized behavior, and withdrawn seclusion are the most characteristics of this scale. The symptoms on this scale are often indicative of schizophrenia type disorders.

Scale CC. Major Depression. This disorder is marked by depressed mood most of the day, suicidal ideation, and a severe sense of helplessness. This disorder often indicates an inability to function in daily activities.

Scale PP. Delusional Disorder. An individual with this disorder is likely extremely paranoid and has disturbed thinking, but does not endorse the non-bizarre type thinking of the Thought Disordered person.

Procedure

Participants were solicited from lower level psychology courses at the University of North Dakota. After verbal informed consent was explained (Appendix F), the sMARS, F-mps, and BFNE were distributed to all students in lower level Psychology

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courses as a screening measure. Although only the sMARS was be used to screen and select participants, collecting perfectionism and fear of negative evaluation data during the screening process minimized contamination during the experiment. Attached to the front of the sMARS was an ID sheet, which had the participant ID number, a space for the name, and a space for the phone number. While completing the screening measure, a separate sheet of paper circulated on which students wrote their name so as to receive extra/research credit for the screening portion. Students were informed to fill out the sheet of paper attached to the front of the screening packet if they wanted to be called back for the second half of the study. They were informed that if they were called back, they would receive an additional 2 hours of either research or extra credit.

Based on their responses on the sMARS, 40 people from the bottom, middle, and top 15% were called back (20 males and 20 females in each group) resulting in a total sample of 120 participants.

The experiment was conducted individually. Each session began with the presentation of the Informed Consent Agreement (Appendix J) explaining the rights and responsibilities of the participants. After having the informed consent explained to them and after signing it, they filled out the participant information sheet. Following completion of the participant information sheet, participants completed the remainder of the experiment. The presentation of the replication assessment measures was counter balanced across participants to control for order effects. Half of the participants completed the AMT, the AMT task evaluation sheet, the LET, and the LET task evaluation sheet in that order, and half of the participants completed the LET, the LET task evaluation sheet, the AMT, and the AMT task evaluation sheet in that order.

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Following completion of the replication portion of the experiment, half of the participants completed the attention tasks in a hierarchical order (HO); Digit Symbol Coding, Symbol Search, Rapid Picture Naming, Digits Forward, Letters Span Forward, Alphabet Forward, d2, Stroop Test, Number Stroop Test, Letter-Number Sequencing, Auditory Working Memory, PASAT, Connor's Continuous Performance Test, and finally the MCMI-III. The other half of the participants completed the experiment in reverse hierarchical order (RHO); PASAT, Auditory Working Memory, Letter-Number Sequencing, Number Stroop Test, Stroop Test, d2, Alphabet Forward, Letter Span Forward, Digits Forward, Rapid Picture Naming, Symbol Search, Digit Symbol Coding, Connors Continuous Performance Test, and the MCMI-III. As such, there were four possible orders to provide counterbalance control with 5 males and 5 females in each anxiety category completing each; LET – AMT – HO – RHO, AMT – LET – HO – RHO, LET – AMT – HO – RHO, and AMT – LET – RHO – HO. Regardless of order, the Connor's Continuous Performance Test and the MCMI were always administered as the last 2 tests to minimize fatigue. Following completion of the MCMI-III, each participant was debriefed, and extra credit awarded based on the amount of time they participated.

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CHAPTER III

RESULTS

Screening Data

Overall Screening

Of the 2212 student participating in screening, 1458 (65.9%) were females, 737 (33.3%) were males, and 17 (.8%) did not report gender.

sMARS Screening Data

2212 individuals completed the sMARS, 1458 females, 737 males, and 17 did not report gender. The minimum score was 25, the maximum was 125, and the mean and standard deviation was 56.92 and 18.38, respectively. Fall semester students (M= 57.62) did not differ significantly from the spring semester students [(M = 56.09); t (2210) = 1.95, p = .051]. Female students (M = 58.31) reported significantly more math anxiety than male students (M = 54.22), t (2193) = 4.95, p < .001.

BFNE Screening Data

2171 individuals completed the BFNE, 1439 females, 715 males, and 17 did not report gender. The minimum score was 2, the maximum was 62, and the mean and standard deviation was 34.90 and 7.71, respectively. Fall semester students (M = 34.76) reported more fear of negative evaluation than spring semester students [(M = 33.66); t (2169) = 2.74, p < .01]. Female students (M = 35.01) reported significantly more fear of negative evaluation than male students [(M = 32.77); t (2152) = 5.27, p < .01]

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Fmps

Refer to tables 1 and 2 below for descriptive statistics and for a gender comparison of score distributions for the Fmps.

Table 1. Demographic Data for Fmps Screening Data.

Subscale	Total N	Females	Males	Gender Not Reported	Mean	SD
CM	2136	1417	702	17	22.19	6.69
PE	2139	1422	700	17	23.40	4.94
PX	2160	1427	716	17	14.69	4.06
PC	2147	1424	706	17	8.28	3.20
D	2160	1427	717	16	10.14	3.13
O	2133	1414	703	16	22.55	4.85

Note: Fmps = Frost Multidimensional Perfectionism Scale, CM = Concern over making mistakes, PE = Parental expectations, PX = Personal expectations, PC = Parental criticism, D = Doubt, O = Organization.

Table 2. Fmps Gender Comparisons

Subscale	Female Mean	Male Mean	*t*	*df*	*p*
CM	22.01	22.60	1.92	2117	.055
PE	23.33	23.54	0.91	2120	.364
PX	14.57	14.92	1.91	2141	.056
PC	8.17	8.51	2.25	2128	.025
D	10.01	10.40	2.70	2142	.007*
O	23.27	21.10	9.94	2115	<.001*

Note: * = Significant at .008. Fmps = Frost Multidimensional Perfectionism Scale, CM = Concern over making mistakes, PE = Parental Expectations, PX = Personal expectations, PC = parental criticism, D = Doubt, O = Organization.

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Final Sample

Demographics

The mean age of the final sample was 20.01 with a range of 17 to 30 and a standard deviation of 2.25. For ethnic origin, 92.5 percent reported euro American, 4.2 percent reported American Indian, 1.7 percent reported Latin American, and 1.7 percent reported other. With regards to highest level of education, 87.5% had high school diplomas, 8.3% had 2 years of college, 2.5% had 4 years of college, and 1.7% reported "other". Of this sample, 43.3% were freshmen, 27.5% were sophomores, 17.5% were juniors, and 10.8% were seniors. Algebra was reported as the highest level of high school math for 19.2% of participants, 17.5% reported geometry, 39.2% reported trigonometry/pre-calculus, 11.7% reported calculus, 7.5% reported advanced calculus, 0.8% were uncertain of their highest level of high school math, and 4.2% reported "other". As for college math, .8% failed to answer this item, 45% reported none, .8% reported beginning algebra, 4.2% reported intermediate algebra, 26.7% reported college algebra, 3.3% reported pre-calculus, 12.5% reported calculus, 4.2% reported advanced calculus, .8 reported something higher than advanced calculus, and 1.7 reported "other". In the final sample, females ($M = 59.33$) reported similar math anxiety as males ($M = 56.90$), $t\,(118) = 0.51$, $p = .58$. This lack of significance is to be expected given the restrictive sampling techniques utilized in selecting the final sample.

Attrition

One individual discontinued participation prior to completion of the experiment. He was a member of the High Male category, and discontinued midway through the AMT. This was the first test administered to him. He noted that this task was going to be

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too difficult for him to complete, and he did not wish to continue. Although he agreed to allow analysis of his data, there was too little from which to draw conclusions.

Hypothesis 1: Arousal Performance Function will be Supported in a Non-Math Task

A between subjects ANOVA revealed a non-significant effect of anxiety group on LET total score, $F(2,117) = 2.25$, $p = .11$ (see figure 5 Below). Although non-significant, the trend in this data is opposite that of Farnsworth's (2005) previous research and inconsistent with the theory of APF in a non-math task. A one-way (anxiety group) between subjects MANOVA revealed a non significant effect of recall latency, $F(6,230) = 1.32$, $p = .248$. A one-way (anxiety group) MANOVA revealed a non-significant effect of letter recall organization (ordered recall vs. unordered recall), $F(4,232) = 2.10$, $p = .082$.

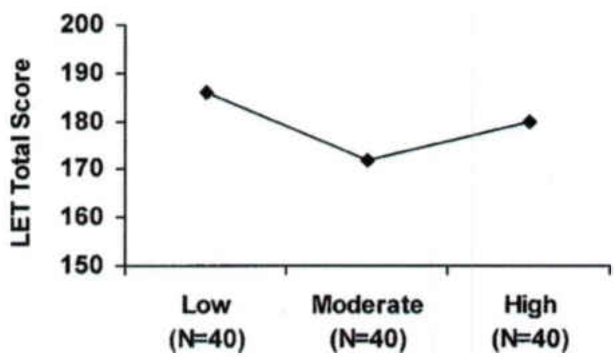

Figure 5. Learning Efficiency Test (LET) total score as a function of math anxiety group.

Hypothesis 2: Arousal Performance Function will not be Supported in a Math Task

A between subjects ANOVA revealed a non-significant effect of math anxiety on AMT total score, $F(2,117) = 1.95$, $p = .147$. A MANOVA examining the two test levels (Addition and Letter recall) showed a significant multivariate effect of anxiety group, $F(4,232) = 2.77$, $p < .05$. Follow-up ANOVAs revealed a non-significant effect of anxiety group on letter recall score [$F(2, 117) = .299$, $p = .742$] and a significant effect of anxiety

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group by addition score [$F(2,117) = 5.01, p < .01$; see figure 6 below]. Post hoc Tukey's HSD tests revealed that the low anxiety group ($M = 80.8$) correctly answered more addition problems than the high anxiety group ($M = 73.7$), $p < .01$. The moderately anxious group's addition scores ($M = 76.2$) was not significantly different than either the high or low anxious group. To assess the interaction of addition score by letter recall, z scores were computed based on this sample. An ANOVA based on these transformed scores revealed a non-significant interaction, $F(2,117) = 3.05, p = .051$, indicating consistent (but nearly significantly different) performance across the components of this task. This is also inconsistent with Farnsworth's 2005 results.

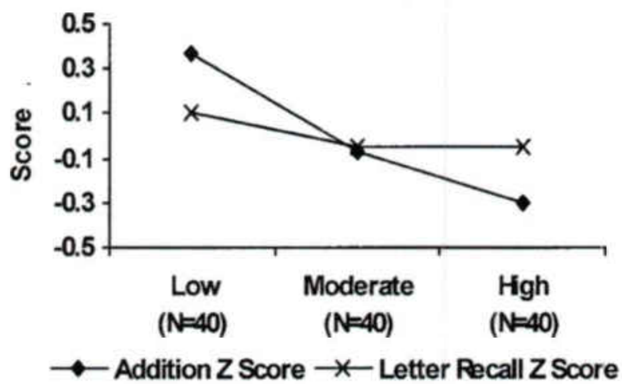

Figure 6. Addition Memory Task addition z-score and letter recall z-score as a function of anxiety group.

Hypothesis 3: Perfectionism will be Directly Related to Math Anxiety

Analysis of this hypothesis was conducted in two different ways, one looking at the entire screening sample, and one looking at the differences between the math anxiety groups in the final sample. A Pearson correlation comparing sMARS total score to Fmps total score established a modest positive correlation between math anxiety and self-reported perfectionism, $r(2240) = .181, p < .001$. When looking at the component scales

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of the Fmps (with an alpha correction of .05/6 = .008 to control for inflated type 1 error), self-reported math anxiety was most directly related to doubt [r (2204) = .318, $p < .001$], followed by concern over making mistakes [r (2179) = .237, $p < .001$], parental criticism [r (2190) = .166, $p < .001$] parental expectations [r (2180) = .072, $p = .001$], and organization [r (2177) = .065, $p = .002$]. Self reported anxiety was not significantly related to personal expectations, r (2180) = -.003, $p = .903$.

A between subjects ANOVA comparing anxiety groups in the final sample on Fmps total score yielded a non-significant effect of perfectionism, F (2,114) = .813, p = .446. A between subjects MANOVA looking at the subscales that comprise the Fmps revealed a non-significant effect of anxiety group, F (12,210) = 1.74, $p = .061$. Given this non-significant effect, no further analyses were conducted on the subscales of the Fmps as they relate to math anxiety group membership.

Hypothesis 4: Fear of Negative Evaluation will be Directly Related to Math Anxiety

Again, to test this hypothesis, analysis was conducted utilizing both the entire screening sample and the final sample. A Pearson correlation comparing self-reported math anxiety to self-reported fear of negative evaluation established a significant direct relationship, r (2215) = .282, $p < .001$. A one way ANOVA with the final sample revealed a significant effect of anxiety group on self-reported fear of negative evaluation, F (2,115) = 4.86, $p < .01$. A Tukey's post hoc test indicated that the moderate group (M = 31.25) had less fear of negative evaluation than the high anxious group (M = 37.38). The low anxiety group (M = 33.58) was not significantly different than either the moderate or the high anxious group (See figure 7 below).

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Figure 7. BFNE score as a function of math anxiety group.

Hypothesis 5: Processing Speed will not Vary as a Function of Math Anxiety Group

A one-way (anxiety group) MANOVA showed a non-significant multivariate effect for the 3 processing speed tests (symbol search, digit symbol coding, and rapid picture naming), $F(6,230) = 1.48$, $p = .19$. (Note: For this comparison, correct items per second was used as the DV for the Digit Symbol Coding test. This was done to take into account not only the number of correctly completed items, but also the amount of time it took the person to complete each item.)

Hypothesis 6: There will be no Difference Between Math Anxious and Non-Anxious Individuals on Tasks of Memory Span, Selective Attention, and Working Memory

To assess for difference at each of these levels of memory, individuals MANOVAs were conducted on the group of subtests that comprise each category. A one-way (anxiety group) MANOVA revealed a non-significant effect for the tests that comprise memory span (digit span, letter span, and alphabet forward), $F(6,230) = .958$, $p = .454$. To ensure that variance associated with alphabet forward was not washing out significant results from the other two tests in this category (and as alphabet forward was really a screen to ensure that all individuals knew the alphabet well enough to have valid results in the remainder of the study), an additional one-way (anxiety group) MANOVA

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was conducted with alphabet forward removed from the analysis. This analysis also produced non-significant results, $F(4,232) = 1.18, p = .321$.

For the tests that comprise selective attention (Stroop Test, Number Stroop Test, Connor's Continuous Performance Test, d2 Test of Attention, and Auditory Attention), a one-way (math anxiety group) MANOVA revealed a non-significant effect of selective attention test, $F(10,222) = .497, p = .891$. (Note: For this comparison, given that selective attention was being assessed, the interference score from the Stroop Test and the Number Stroop Test, the Detectibility score from the Connor's CPT, and the Concentration Performance score from the d2 were used as DVs in this comparison.)

For the tests that comprise working memory (Letter-Number Sequencing, Auditory Working Memory, and PASAT), a one-way (math anxiety group) MANOVA revealed a significant multivariate effect of anxiety group on working memory task, $F(6,230) = 3.87, p =.001$. Follow-up ANOVAs revealed a non-significant effect of anxiety group on both Letter-Number Sequencing [$F(2,117) = 1.88, p = .156$] and Auditory Working Memory [$F(2,117) = 2.651, p = .075$]. However, follow-up analysis on the PASAT revealed a significant effect of math anxiety, $F(2,117) = 11.618, p < .001$. A Tukey's follow-up of the PASAT results indicated that the low anxious group ($M = 93.7$) outperformed the moderately anxious ($M = 82.7$, p = .014) and high anxious ($M = 75.25$, $p < .01$) groups. The moderate and high anxious groups' scores were not significantly different ($p = .134$).

Hypothesis 7: Math Anxious Individuals will not Score Differently from Non-Anxious Individuals on the Avoidant and Compulsive Scales from the MCMI-III, but will Score Higher on the Scales of Anxiety and PTSD

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In testing the hypothesis consistent with Hopko's research, a one-way (anxiety group) MANOVA revealed a non-significant effect of the Avoidant and Compulsive scales from the MCMI-III, $F(4,232) = 1.226, p = .301$. In testing Farnsworth's hypothesis, a one-way (anxiety group) MANOVA revealed a significant multivariate effect of the Anxiety and PTSD scales of the MCMI-III, $F(4,232) = 2.82, p = .026$. Follow-up ANOVAs indicated that there were no differences between anxiety groups on PTSD scores [$F(2,117) = 1.877, p = .158$], but that there were significant differences between the math anxiety groups on MCMI-III Anxiety scores [$F(2,117) = 5.020, p = .008$]. A follow-up Tukey's post-hoc analysis indicated that the high anxiety group ($M = 41.55$) had significantly higher scores than either the low anxiety group ($M = 25.075, p = .047$) or the moderate anxiety group ($M = 21.025, p = .009$). The moderately and low anxious groups were not significantly different ($p = .826$).

Exploratory Analysis

ACT Results

At the recommendation of a committee member, ACT data was also collected for participants completing the second portion of the study. A one way between subjects ANOVA revealed a significant effect of math anxiety on ACT Total score, $F(2,90) = 9.70, p < .001$. A follow-up Tukey's post-hoc test indicated that the low anxious group ($M = 24.3$) scored significantly better than either the Moderately ($M = 22.60$) or High anxious group ($M = 21.2$; see figure 8 below). The moderate and high anxious groups scores were not significantly different.

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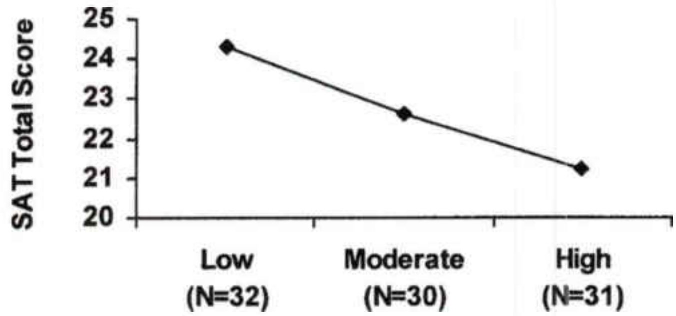

Figure 8. ACT total score as a function of math anxiety group.

Using the ACT Total score by anxiety group ANOVA in the previous paragraph to control against inflated alpha, follow-up ANOVAs were completed on the individual subtests of the ACT. A One-way ANOVA revealed a significant effect of math anxiety group on ACT English score, F (2,85) = 3.95, p =.023. Tukey's follow-up testing revealed that the low anxious group (M = 23.25) scored significantly higher than the high anxious group (M = 20.71). The moderately anxious group (M = 22.14) did not score differently than either the low or high anxious group (see figure 9 below). Another One-way ANOVA revealed a significant effect of math anxiety group on ACT Math score, F (2,85) = 21.42, p < .001. A follow-up Tukey's test revealed that the low anxious group (M = 26.04) scored significantly higher than both the moderate (M = 22.17) and high anxious (M = 20.13) groups (see figure 9 below). In addition, a One-Way ANOVA revealed a significant effect of anxiety group on ACT science score, F (2,85) = 11.066, p < .001. Follow-up Tukey's for this analysis revealed that the both the low (M = 24.86) and the moderate (M = 23.30) anxious groups scored higher than the high (M = 20.90) anxious group (see figure 9 below). The low and the moderately anxious groups were not significantly different. Other ANOVAs revealed non-significant effects of math anxiety group on English Writing [F (2,24) = 1.96, p = .163], Reading [F (2,85) = 1.20, p = .307],

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and the Writing Subtest [F (2,21) = 1.12, p = .345].

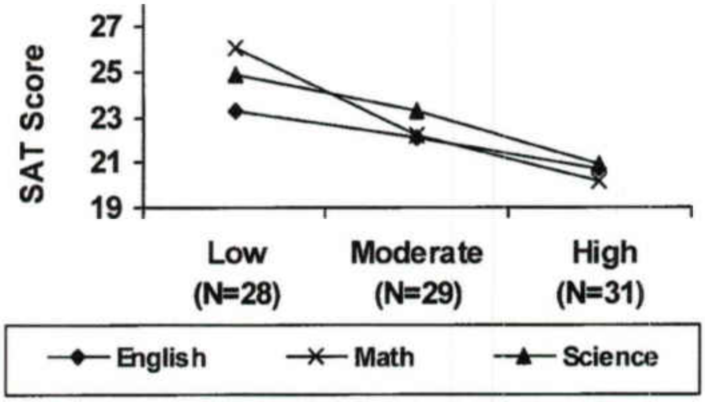

Figure 9. ACT English, Math, and Science scores as a function of math anxiety group.

Correlation Between the sMARS and Other Memory/Attention Measures

See appendix K to examine correlations between the sMARS and all memory/attention measures used in this study.

Correlation Between sMARS and ACT and MCMI-III Scales by Gender

See appendix L to examine correlations between the sMARS and both the ACT and MCMI-III scales separated by gender.

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CHAPTER IV

DISCUSSION

Hypothesis 1: APF in a Non-Math Task

Contrary to previous research, APF was not supported in a non-math task. Instead, there was a trend in this data in the opposite direction of APF (see figure 5 above). However, these results were also inconsistent with the findings of Hopko et. al. (1998), that math anxiety results in an overall working memory deficit obvious in both math and non-math contexts. It appears that the working memory deficit of math anxious individuals is not immediately obvious in non-math tasks.

Hypothesis 2: APF in a Math Task

Analysis of this hypothesis is somewhat more convoluted. Although there was no significant difference between anxiety groups on the AMT total score, there was a significant effect of anxiety group on performance on the math component of this dual process task. The hypothesis postulated a direct negative relationship "in a working memory intensive *math* task" (italics added for emphasis). As such, this research offers partial support for this hypothesis. However, this research does support the assertion that the negative effect of math anxiety is limited to math situations only, and does not generalize to non-math situations, even when the two tasks are interwoven.

Hypothesis 3: Perfectionism and Math Anxiety

This analysis was completed in two ways, one looking at the overall screening

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sample, and one looking at the final sample. When looking at the overall screening sample, there was a positive relationship between math anxiety and self-reported perfectionism. However, this correlation was essentially non-meaningful explaining only about 3.3% of the variance. The strongest relationship was between math anxiety and doubt, followed by concern over making mistakes, parental criticism, parental expectations, and organization, in that order. However, again, the relationships were generally weak at best with 10%, 5.6%, 2.8%, 0.5%, and 0.4% explained in each respective relationship. The weakness of these relationships are highlighted in analysis of the final sample which did not find a significant difference, using multi-variate statistics, between the anxiety groups on any of the perfectionism scales. As such, it appears the relationships established in the screening sample are a relic of increased power secondary to an extremely large sample size.

Hypothesis 4: Fear of Negative Evaluation and Math Anxiety

Again, analyses of these results were completed in two ways, first with the screening sample, and second with the final sample. In the screening sample, there was a direct relationship between self-reported math anxiety and fear of negative evaluation. But, as with the perfectionism data outlined above, the relationship was generally weak, explaining approximately 8% of the variance. The weakness of this relationship is only complicated by analysis of the final sample data which indicated that high math anxious group had more fear of negative evaluation than the moderately anxious group, and that the low anxious group had similar fear of negative evaluation as both the high and low math anxious groups. These results offer partial support for the hypothesis of increased fear of negative evaluation in high math anxious individuals, but this relationship is

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generally weak, and is convoluted when the extremes of the population are sampled.

Hypothesis 5: Processing Speed and Math Anxiety

As purported in hypothesis 5, there was not a significant difference between anxiety groups on measures of processing speed. This is consistent with the assertion that math anxiety does not exert it's influence until more attentional resources are demanded by a task.

Hypothesis 6: Math Anxiety and Memory Span, Selective Memory, and Working Memory

Hopko et. al. (1998) purported a global working memory deficit, wherein individuals that report more math anxiety perform more poorly in all working memory intensive tasks, both math and non-math related. However, the research of Farnsworth has generally supported a more state-like model of math anxiety with the effects of math anxiety limited to math situations. The results of this research support that latter assertion, in that there were no significant differences between the math anxiety groups in any of the Memory Span or Selective Attention subtests, and the only significant effect in the Working Memory subtests was on the PASAT, a working memory intensive task relying solely on math computation. As such, this research supports a state specific working memory deficit more in line with a phobic-like response wherein the person begins with equal working memory resources, but when confronted with the anxiety provoking stimulus, expends available working memory resources worrying about the presence of the phobic object. This research does not support the assertion of poverty of working memory resources in individuals with higher levels of math anxiety.

Hypothesis 7: Hopko vs. Farnsworth – Personality Characteristics of Math Anxiety

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As outlined above, Hopko postulated an overall working memory deficit more consistent with trait anxiety, while Farnsworth postulated specific working memory deficits more consistent with state anxiety. Research comparing personality characteristics partially supports Farnsworth's assertion in that there was a significant difference between math anxiety groups on the Anxiety scale of the MCMI-III. Specifically, the high anxious group had higher scores than either the moderate or low anxious group, with the latter two groups being statistically equivocal. However, the math anxiety groups did not differ on scores on the PTSD scale of the MCMI-III, as hypothesized. As such, this research partially supports this hypothesis, but also partially refutes it. Nonetheless, this research offers no support for Hopko's assertion of a more trait like anxiety in that there were no differences between the anxiety groups on either the Avoidant or Compulsive scales of the MCMI-III. As such, math anxiety appears more like a state anxiety than a trait anxiety.

Exploratory Analysis: ACT and Math Anxiety

Increased math anxiety continues to be related to decreased performance on standardized tests assessing math and science ability. In addition, in this research, high math anxious persons performed more poorly on the non-math ACT tests of English and English Writing. This is inconsistent with available literature (Ashcraft, 2002), and, to the knowledge of this author, unprecedented in the math anxiety field. While this could be an anomaly of this study, additional research is necessary to understand the existence and extent of this relationship.

Summary/Conclusions

This research generally supports the assertion of a deficient inhibition mechanism

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as central to math deficits in individuals with self-reported math anxiety. However, it breaks with some recent literature postulating an overall working memory deficit which results in increase error rates in both math and non-math intensive working memory tasks. This research demonstrates that the working memory impairments associated with math anxiety are limited to working memory intensive *math* situations, with differences in any other task largely attributable to variance.

In addition, this research does not support the utilization of an APF model in understanding math anxiety. First, self-reported math anxiety is indirectly related to performance in a working memory intensive math task. Secondly, and contrary to my previous research, self-reported math anxiety does not map onto an APF curve in a non-math working memory intensive task. It appears APF is of little utility in understanding the cognitive impact of math anxiety, and the more parsimonious deficient inhibition mechanism model is more appropriate.

Perfectionism and Social Anxiety (as measured by fear of negative evaluation) are only minimally related to math anxiety, and do little to further our understanding of this construct. This research does offer additional support for the independence of the math anxiety construct, consistent with previous research. This generally supports Faust's (as cited in Ashcraft, 1992) assertion of math anxiety as a possible separate DSM-IV diagnosis.

Finally, math anxiety continues to be related to standardized measures of math and science performance. In addition, and new to this research domain, math anxiety may be adversely related to performance on the non-math standardized measures of English and English Writing. This finding requires additional research to understand if math

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anxiety has a more far reaching influence than currently recognized in the math anxiety literature.

Limitations/Future Research

The results of this research directly contradict my previous research with regards to APF in a non-math task, suggesting that one or both of the conclusions may have been incorrect. This establishes a significant limitation in this line of research which requires clarification before it can advance. It is possible there is some qualitative difference between the two schools at which the research was conducted (e.g: more stringent entrance criteria at UND vs. MSU or vice versa, geographic specific caveats, testing environments, …) which could have contributed to the differences. It is also possible that the results of one study were simply incorrect. Regardless, clarification is necessary before concrete conclusions can be drawn.

Although this research design employed a working memory intensive math task, it had a dual math/non-math format which may have contaminated the results. Future research may benefit from a purer research design with a working memory math task that requires only math. Or, the design could be varied across participants such that divided attention is directed toward different components (as proposed by Dr. Ferraro in consultation with regards to research design in 2005) such that some individuals would be instructed to focus on solving the problem, some on the letters, and some on both components. This would allow for greater understanding of the nature of math anxiety in interfering with a non-math working memory intensive task embedded within a larger task involving math.

In addition, assessing math anxiety at its extremes is of experimental value, but

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may be of little clinical value as most individuals will fall somewhere in between the polls. Future research could enlist a more representative sample and attempt to replicate to better understand the point at which math anxiety exerts its influence, as well as to improve understanding of any curvilinear relationships.

Also, while perfectionism and social anxiety were only minimally related to math anxiety, they were in fact related. This comorbidity of symptomology may have influenced the results. In addition, the stimuli in the replication component of this research were presented primarily using the computers. Computer anxiety is also mildly related to math anxiety, which may have contaminated the findings. As such, future research could screen for these and other potentially related constructs, and either exclude based on them, or design research to accommodate them such that their influence is mediated.

Finally, while this research has advanced the understanding of math anxiety as a unique construct with an impact generally limited to working memory intensive math tasks, the finding of possible differences in non-math standardized test performance as a function of math anxiety is puzzling. It is necessary to further explore this possible relationship to better understand its existence and extent.

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APPENDICES

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Appendix A

Short Mathematics Anxiety Rating Scale

ID # __________

Directions: Please indicate the level of anxiety that you would experience during each of the following math situations by circling the number on the scale of 1 to 5: 1 = not at all, 2 = a little, 3 = a fair amount, 4 = much, and 5 = very much.

	Not at All	A Little	A Fair Amount	Much	Very Much
1. Studying for a math test.	1	2	3	4	5
2. Taking math section of college entrance exam.	1	2	3	4	5
3. Taking exam (quiz) in a math course.	1	2	3	4	5
4. Taking an exam (final) in a math course.	1	2	3	4	5
5. Picking up a math textbook to begin working on a homework assignment	1	2	3	4	5
6. Being given homework assignments of many difficult problems that are due the next class meeting.	1	2	3	4	5
7. Thinking about an upcoming math test 1 week before.	1	2	3	4	5
8. Thinking about an upcoming math test 1 day before.	1	2	3	4	5
9. Thinking about an upcoming math test 1 hour before.	1	2	3	4	5
10. Realizing that you have to take a certain number of math classes to fulfill requirements.	1	2	3	4	5
11. Picking up a math textbook to begin a difficult reading assignment.	1	2	3	4	5
12. Receiving your final math grade in the mail.	1	2	3	4	5
13. Opening a math or stat book and seeing a page full of problems.	1	2	3	4	5
14. Getting ready to study for a math test.	1	2	3	4	5
15. Being given a "pop" quiz in a math class.	1	2	3	4	5
16. Reading a cash register receipt after your purchase.	1	2	3	4	5
17. Being given a set of numerical problems involving addition to solve on paper.	1	2	3	4	5
18. Being given a set of subtraction problems to solve.	1	2	3	4	5
19. Being given a set of multiplication problems to solve.	1	2	3	4	5
20. Being given a set of division problems to solve.	1	2	3	4	5
21. Buying a math textbook.	1	2	3	4	5
22. Watching a teacher work on an algebraic equation on the blackboard.	1	2	3	4	5
23. Signing up for a math class.	1	2	3	4	5
24. Listening to another student explain a math formula.	1	2	3	4	5
25. Walking into a math class.	1	2	3	4	5

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ID # __________

Appendix B

Participant Information Sheet

For each of the following questions, please circle the answer that is most correct. If the question does not pertain to you, or if you feel uncomfortable answering it, please do not answer it.

1. What is you sex?
    1. Female
    2. Male

2. What is your age?_______

3. Are you an international student?
    1. Yes
    2. No

4. What is your ethnic origin? (Please circle the one that most closely identifies you.)
    1. Euro American (white)
    2. African American (black)
    3. Native American
    4. Asian American
    5. Latin American
    6. Other

5. What is the highest level of education you have completed?
    1. Less than high school
    2. GED
    3. High school diploma
    4. 2 year college degree
    5. 4 year college
    6. Graduate degree
    7. Other

6. What is your current class standing?
    1. Advanced Placement (PSEO)
    2. Freshman
    3. Sophomore
    4. Junior
    5. Senior
    6. Graduate Student
    7. Other

7. What is your major area of study?
    1. General or Applied Psychology
    2. Sociology of other social science
    3. Education
    4. Business
    5. Biology or other natural science
    6. Math or computer science
    7. Humanities
    8. Undecided
    9. Other

OVER →

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8. What is the highest-level math class you completed in high school? Grade in that course ______________?

1. None
2. Algebra
3. Geometry
4. Trigonometry/Pre-calculus
5. Calculus
6. Advanced Calculus
7. Uncertain
8. Other

9. What is the highest-level math class you have completed in college? Grade in that course ____________?

1. None
2. Beginning algebra
3. Intermediate algebra
4. College algebra
5. Pre-calculus
6. Calculus
7. Advanced Calculus
8. Higher than Advanced Calc
9. Uncertain
10. Other

10. Have you ever been diagnosed or treated **by a mental health practitioner** for ADHD?

1. Yes
2. No

11. Have you even been diagnosed or treated **by a mental health practitioner** for a learning disorder?

1. Yes
2. No

12. Have you ever been diagnosed or treated **by a mental health practitioner** for an anxiety disorder?

1. Yes
2. No

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Appendix C
Learning Efficiency Test Score Sheet

ID # __________

Trial #	Letters	IM Recall	Ord score	Unord score	ST Recall	Ord Score	Unord score	LT Recall	Ord Score	Unord score	Total Ord Score	Total unord score
Example	PL											
prac 1	HR											
1	MS											
2	XP											
3	YJL											
4	RXHS											
5	FMJQP											
6	QYFRXL											
7	SLRHMJQ											
8	PXQSYHFR											
9	QRHLSMJPF											

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ID # __________

Appendix D
Addition Memory Task Score Sheet

Trial	Addition Problem	Addition Answer	Subject Answer	Addition Score	Correct Letters	Subjects recalled letters	letter recall score	Total Score
Example	23 + 18	41	N/A	N/A	XNLHZS	N/A	N/A	N/A
Practice 1	27 + 34	61	N/A	N/A	XBDNHL	N/A	N/A	N/A
Practice 2	28 + 13	41	N/A	N/A	JPLFRN	N/A	N/A	N/A
Practice 3	47+16	63	N/A	N/A	HKGZMR	N/A	N/A	N/A
1	3+6	9			ZLJMFK			
2	4+3	7			KWBNPX			
3	7+2	9			MWZTGH			
4	4+8	12			GNFXMW			
5	6+8	14			LZWDHG			
6	9+4	13			JSQLKF			
7	31+7	38			WCRKGQ			
8	66+3	69			JHZFMR			
9	4+73	77			DXZMPN			
10	27+6	33			JPZRGN			
11	44+8	52			XFPCBV			
12	9+74	83			JDQCMW			
13	42+16	58			FZBKRM			
14	33+24	57			DMJHQS			
15	71+13	84			HWCBLD			
16	13 + 38	51			HWSGDB			
17	77 + 17	94			PLKDVX			
18	78 + 12	90			PRWTBV			
19	68+57	125			XZHVJG			
20	56+77	133			YXBFHZ			
21	34+96	130			VCZJWH			
22	31+44+12	87			NJPVSG			
23	13+42+23	78			WJLSFZ			
24	46+21+32	99			PMZQWX			
25	43+27+14	84			BDKZCN			
26	26+37+12	75			XPFRLN			
27	63+18+13	94			CLWSZT			
28	47+26+51	124			DLBFRQ			
29	59+18+32	109			THZFJB			
30	37+49+62	148			RGQFVW			

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Appendix E

Task Evaluation Sheet

ID # __________

LET

How easy was this task for you?

1	2	3	4	5
Very easy	Somewhat easy	Neither easy nor difficult	Somewhat difficult	Very difficult

How much anxiety did you feel during this task?

1	2	3	4	5
None	Some	Moderate	Much	Very much

What was your level of effort on this task?

1	2	3	4	5
None	Some	Moderate	Much	Very much

AMT

How easy was this task for you?

1	2	3	4	5
Very easy	Somewhat easy	Neither easy nor difficult	Somewhat difficult	Very difficult

How much anxiety did you feel during this task?

1	2	3	4	5
None	Some	Moderate	Much	Very much

What was your level of effort on this task?

1	2	3	4	5
None	Some	Moderate	Much	Very much

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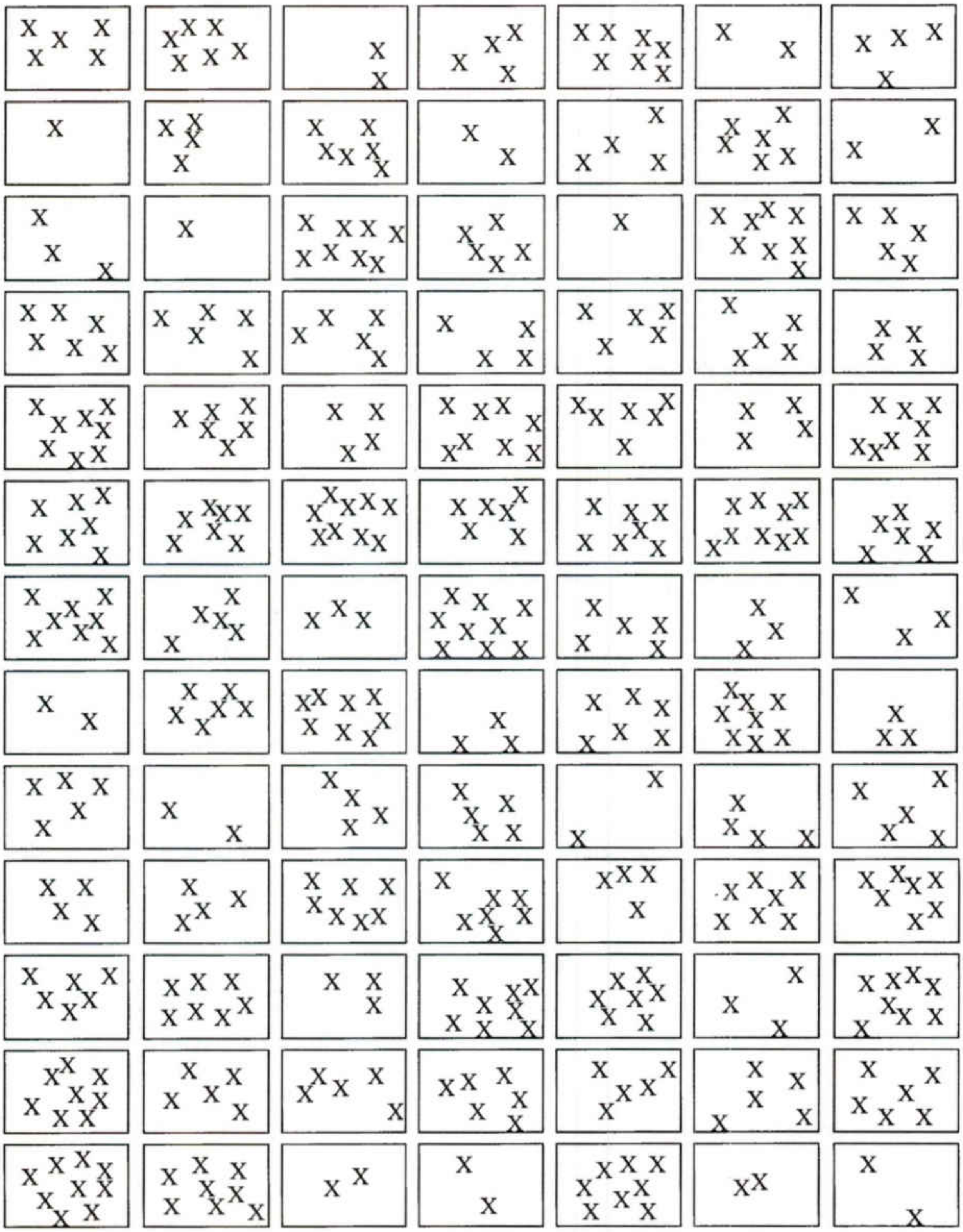
Appendix F
Number Stroop Control Condition



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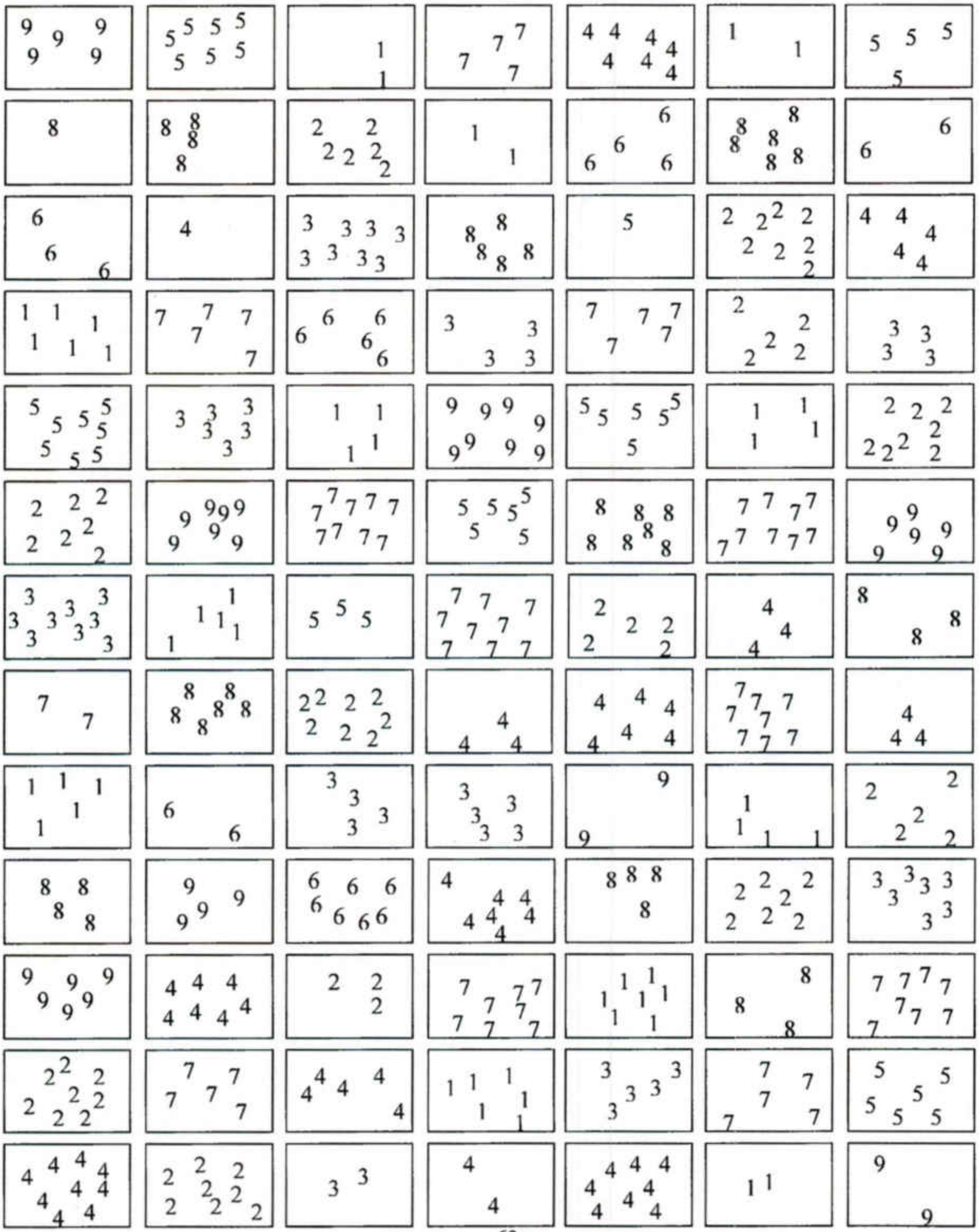
Appendix G

Number Stroop Experimental Condition



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Appendix H

ID # __________

Frost Multidimentional Perfectionism Scale

Directions: Indicate the degree to which you believe the following statements to be true by *circling* your answer on the corresponding scale. Answers range from **1-"Strongly Disagree"** to **5-"Strongly Agree."** Circle *only one response* per statement.	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1. My parents set very high standards for me.	1	2	3	4	5
2. Organization is very important to me.	1	2	3	4	5
3. As a child, I was punished for doing things less than perfect	1	2	3	4	5
4. If I do not set the highest standards for myself, I am likely to end up a second-rate person	1	2	3	4	5
5. My parents never tried to understand my mistakes.	1	2	3	4	5
6. It is important to me that I be thoroughly competent in everything I do.	1	2	3	4	5
7. I am a neat person.	1	2	3	4	5
8. I try to be an organized person.	1	2	3	4	5
9. If I fail at work/school, I am a failure as a person.	1	2	3	4	5
10. I should be upset if I make a mistake.	1	2	3	4	5
11. My parents wanted me to be the best at everything.	1	2	3	4	5
12. I set higher goals than most people.	1	2	3	4	5
13. If someone does a task at work/school better than I, then I feel like I failed the whole task.	1	2	3	4	5
14. If I fail partly, it is as bad as being a complete failure.	1	2	3	4	5
15. Only outstanding performance is good enough in my family.	1	2	3	4	5
16. I am very good at focusing my efforts on attaining a goal.	1	2	3	4	5
17. Even when I do something very carefully, I often feel that it is not quite right.	1	2	3	4	5
18. I hate being less than the best at things.	1	2	3	4	5
19. I have extremely high goals.	1	2	3	4	5
20. My parents have expected excellence from me.	1	2	3	4	5
21. People will probably think less of me if I make a mistake.	1	2	3	4	5
22. I never felt like I could meet my parents' expectations.	1	2	3	4	5
23. If I do not do as well as other people, it means I am an inferior human being.	1	2	3	4	5
24. Other people seem to accept lower standards from themselves than I do.	1	2	3	4	5
25. If I do not do well all the time, people will not respect me.	1	2	3	4	5
26. My parents have always had higher expectations for my future than I have.	1	2	3	4	5
27. I try to be a neat person.	1	2	3	4	5
28. I usually have doubts about the simple everyday things I do.	1	2	3	4	5
29. Neatness is very important to me.	1	2	3	4	5
30. I expect higher performance in my daily tasks than most people.	1	2	3	4	5
31. I am an organized person.	1	2	3	4	5
32. I tend to get behind in my work because I repeat things over and over.	1	2	3	4	5
33. It takes me a long time to do something "right."	1	2	3	4	5
34. The fewer mistakes I make, the more people will like me.	1	2	3	4	5
35. I never felt like I could meet my parent's standards.	1	2	3	4	5

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Appendix I

ID # __________

Brief Fear of Negative Evaluation

Directions: Read each of the following statements carefully, and indicate how characteristic it is of you according to the following scale: **1-"Not at all characteristic of me"** to **5-"extremely Characteristic of me"** Circle *only one response* per statement.

	Not at all characteristic of me	Slightly characteristic of me	Moderately characteristic of me	Very characteristic of me	Extremely Characteristic of me
1. I worry about what people think of me even when I know it doesn't make any difference.	1	2	3	4	5
2. I am unconcerned even when I know people are forming an unfavorable impression of me.	1	2	3	4	5
3. I am frequently afraid of other people noticing my shortcomings.	1	2	3	4	5
4. I rarely worry about what kind of impression I am making on someone.	1	2	3	4	5
5. I am afraid that others will not approve of me.	1	2	3	4	5
6. I am afraid that people will find fault with me.	1	2	3	4	5
7. Others people's opinions of me do not bother me.	1	2	3	4	5
8. When I am talking to someone, I worry about what they may be thinking of me.	1	2	3	4	5
9. I am usually worried about what kind of impression I make.	1	2	3	4	5
10. If I know someone is judging me, it has little effect on me.	1	2	3	4	5
11. Sometimes I think I am too concerned with what other people think of me.	1	2	3	4	5
12. I often worry that I will say or do the wrong things.	1	2	3	4	5

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ID # __________

Appendix J
CONSENT FORM

Math Performance as a Function of Math Anxiety and Arousal Performance Theory

You are invited to participate in a research study being done by Donald Farnsworth, under the supervision of Dr. Joseph Miller of the UND psychology department. This study is looking at how someone does at math when they are nervous, and how well people do in various memory situations.

This study will help provide information to the psychology community so they have a better idea how people do at math when they are nervous. It will take about 2 hours to complete the study, during which time you will complete some computer tasks, and some paper and pencil tasks that look at memory.

You may feel a little anxious during this study, but it is not likely. However, you will contribute to the knowledge that we have of math and being nervous. Further, you will learn how we conduct research in the social sciences.

If you choose to participate, we will record how much time you participate on a sheet of paper to take to your professor to ensure that you get your credit for participation. You will be given extra credit for the amount of time that you spend in this study at the discretion of you professor.

Any information from this study and that can be identified with you will remain confidential and will be disclosed only with your permission. All data and consent forms will be kept in separate locked cabinets for a minimum of 3 years after completion of the study. Only the researcher, the advisor and people who audit the IRB procedures will have access to the data. After 3 years, the data will be shredded. The only time this confidentiality would be broken is if I thought you were a threat to yourself or to someone else, at which time I am state mandated to report.

Participation is voluntary, and your decision whether or not to participate will not change your future relations with the psychology department of the university. If you decide to participate, you are free to leave the study at any time without penalty. There is no cost associated with participation, and you may find out the results at the end of the study if you would like by contacting either Donald Farnsworth or Dr. Joseph Miller at the numbers below.

If you have questions about the research, you may call Donald Farnsworth at (701)739-2324 or Dr. Joseph Miller at (701) 777-3691. If you have any questions or concerns, please call the Research Development and Compliance office at 777-4279.

You will be given a copy of this consent form for future reference.

All of my questions have been answered, and I am encouraged to ask any questions that I may have concerning this study in the future.

_______________________________________ ______________________

Participants Signature Date

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Appendix K
Correlation Between sMARS and Memory/Attention Measures

	Digit Symbol Coding	Symbol Search	Rapid Picture Naming	Digit Span	Letter Span	Alphabet Forward	d2 Concentration Performance	Auditory Attention	Color Stroop	Number Stroop	Letter-Number Sequencing	Auditory Working Memory	PASAT	Connors' Detectibility
sMARS	-.138	-.146	-.083	-.036	-.174	-.065	-.146	-.090	-.085	-.050	-.199*	-.237*	-.401*	-.018
Connors' Detectibility	-.113	-.059	-.010	-.076	-.152	.036	.059	.045	-.080	.058	-.007	-.082	-.186*	
PASAT	.389**	.494**	.127	.153	.278**	-.115	.382**	-.099	-.021	.174	.355**	.502**		
Auditory Working Memory	.311**	.264**	.115	.478**	.453**	-.126	.211*	.072	.070	.074	.449**			
Letter-Number Sequencing	.145	.198*	.026	.310**	.298	-.050	.238**	.209*	.142	.154				
Number Stroop	.233*	.278**	.076	.155	.066	-.073	.316**	.014	.059					
Color Stroop	.076	.140	-.029	.095	.089	-.063	.233*	.117						
Auditory Attention	-.095	-.041	.083	.295**	.214*	-.101	.053							
D2 Conc. Perf.	.491**	.580**	.011	-.034	-.110	-.017								
Alphabet Forward	-.112	-.142	-.040	-.127	-.143									
Letter Span	.052	.051	.124	.576**										
Digit Span	-.018	.056	.191*											
Rapid Picture Naming	.005	.040												
Symbol Search	.612**													

Note: * = p < .05, ** = p < .01

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Appendix L

Correlation Between sMARS and both ACT and MCMI-III by Gender

		Males	Females
ACT	Total	-.36*	-.47*
	English	-.19	-.39*
	English Writing	-.41	-.34
	Math	-.56**	-.55**
	Reading	-.16	-.12
	Science	-.40**	-.51**
	Writing Subtest	.04	-.12
MCMI - III	Schizoid	.14	.16
	Avoidant	.21	.15
	Depressive	.18	.13
	Dependent	.24	.00
	Histrionic	-.13	-.16
	Narcisstic	-.15	-.14
	Antisocial	.02	.05
	Sadistic	.26*	.16
	Compulsive	.05	-.23
	Negativistic	.25	.13
	Masochistic	.30*	.06
	Schizotypal	-.08	-.03
	Borderline	.21	.06
	Paranoid	.29*	.19
	Anxiety	.27*	.22
	Somatoform	.20	.26*
	Bipolar - Manic	.07	.17
	Depressive	.37**	.21
	Alcohol Abuse	.03	.05
	Drug Abuse	.10	.00
	PTSD	.23	.15
	Thought Disorder	.13	.17
	Major Depression	.16	.22
	Delusional Disorder	.26*	.06

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