An Exploration of Preference for Numerical Information in Relation to Math Self-Concept and Statistics Anxiety in a Graduate Statistics Course

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Abstract

The purpose of the current research was to investigate the relationship between preference for numerical information (PNI), math self-concept, and six types of statistics anxiety in an attempt to establish support for the nomological validity of the PNI. Correlations indicate that four types of statistics anxiety were strongly related to PNI, and two were not related. Math self-concept was also strongly related to PNI. Results suggest that higher PNI is associated with higher math self-concept and lower statistics anxiety in graduate students, and indicate support for the nomological validity of the PNI within the context of graduate statistics classes.

1. Introduction

Statistics anxiety is a problem for many students, with the majority experiencing it to some degree and many avoiding statistics courses until late in their degree programs (Onwuegbuzie and Wilson 2003; Rajecki, Appleby, Williams, Johnson, and Jeschke 2005; Freng, Webber, Blatter, Wing, and Scott 2011). Several researchers have shown that this anxiety interferes with students' ability to comprehend (Onwuegbuzie 1997) and significantly impacts course grades (Zeidner 1991; Lalonde and Gardner 1993; Onwuegbuzie and Seaman 1995; Fitzgerald, Jurs, and Hudson 1996; Zanakis and Valenza 1997; Freng, Webber, Blatter, Wing, and Scott 2011).

Statistics anxiety has often been linked to math self-concept (Roberts and Saxe 1982; Benson and Bandalos 1989; Perney and Ravid 1990; Zeidner 1991; Bandalos, Yates, and Thorndike-Christ 1995; Wilson 1997; Onwuegbuzie 2000; Macher, Paechter, Papousek, and Ruggeri 2012), indicating that students with poorer math self-concept tend to have higher levels of statistics anxiety. Even though math self-concept and math anxiety have recently been shown to have a reciprocal relationship (Ahmed, Minnaert, Kuyper, and van der Werf 2012), wherein each one contributes to the other, students reporting high math anxiety don't necessarily report high statistics anxiety (Onwuegbuzie, DaRos, and Ryan 1997), and therefore may not possess lower levels of math self-efficacy. The reason for this apparent discrepancy is that math anxiety and statistics anxiety are viewed as two different constructs (Cruise, Cash, and Bolton 1985; Benson 1989; Benson and Bandalos 1989; Onwuegbuzie et al. 1997; Zeidner 1991; Baloglu 1999). Students often are not concerned about their math abilities, but still experience high levels of statistics anxiety. For example, one student in Onwuegbuzie et al.'s (1997, pg. 17) study stated, "I've never been frightened of math. In fact, I received an A in my last math class. Yet I am terrified of statistics." As Zerbolio (1999) explains, this comfort with math while experiencing a fear of statistics could be because logical and verbal reasoning skills are used more in statistics than are math skills when solving statistical problems. In recognizing the multifaceted nature of statistics anxiety, Cruise et al. (1985) developed an instrument that measures six aspects of statistics anxiety, known as the Statistics Anxiety Rating Scale (STARS). One subscale of the instrument taps the aspect of math self-concept (labeled "computation self-concept"), and another assesses attitude toward statistics ("worth of statistics"). The other four subscales measure test anxiety, interpretation anxiety, and social fears associated with statistics class.

Although Cruise et al.'s (1985) statistics anxiety instrument is recognized as a comprehensive evaluation of different aspects of students' statistics experiences (Onwuegbuzie and Wilson 2003); Viswanathan (1993) offers an additional construct that he believes has been overlooked. Preference for Numerical Information (PNI) is described as a basic attitude toward numerical information in general that may influence students' willingness to learn, and subsequently use, both math and statistics (Viswanathan 1993). The author contends that although it has been common in the literature to find measurements of both ability to use math and attitude toward the domains of math and statistics, the basic penchant for numerical information in everyday life has been neglected. If this is the case, and PNI is involved in students' math and/or statistics experiences, then we can expect to find some relationship between these constructs and PNI. For this reason, it is the purpose of this study to explore the relationship between these constructs as a means of corroborating the nomological validity of the PNI and lending credence to its usefulness in understanding students' experiences in statistics education.

2. Review of Literature

2.1 Statistics Anxiety

Cruise et al. (1985) describe statistics anxiety as "a feeling of anxiety when taking a statistics course or doing statistical analysis; that is gathering, processing, and interpreting data," (p. 92) while Zeidner (1991) characterizes this anxiety as involving excessive worry, tension, mental disorganization, and physiological symptoms that present any time a student is in a situation where statistics instruction and evaluation occurs. Zeidner (1991) also surmises that statistics anxiety stems from previous mathematical experiences and is influenced by various cognitive, emotional, and social factors. In a qualitative study exploring a similar idea, Onwuegbuzie et al. (1997) explain that statistics anxiety is rooted in dispositional, situational, and environmental influences. Dispositional influences are individual traits that determine how a student will react in a stressful situation, and included math self-concept, perfectionism, the need for approval, and negative attitudes toward statistics. Students who had stronger doubts in their abilities, who were worried about "ruining their GPA," and who were afraid of losing the approval of their instructors experienced more statistics anxiety than those who weren't as concerned in these areas. Also, students who came into the statistics course already fearful and expecting a negative experience reported more statistics anxiety. Situational factors, those that occur while the student is taking the statistics course, included positive feedback, instructional pace, rigidity and formality of the course, and the introduction of Greek symbols. When students received positive feedback, their anxiety was lessened, but when the pace of instruction was perceived as too fast, or when presented with Greek symbols during instruction, their anxiety increased. Environmental factors, as well as those experiences the students had prior to taking the statistics class, also affected students' anxiety. For example, students who were older and whose previous statistics or math classes were many years ago had higher levels of anxiety, as did students who were less successful in prior statistics or math classes.

From the exploration of these antecedents, Onwuegbuzie et al. (1997) conclude that statistics anxiety is a multi-dimensional construct that involves instrument anxiety (computational self-concept and anxiety), content anxiety (e.g. fear of statistical language, perceived usefulness of statistics), interpersonal anxiety (fear of asking for help and of instructors), and failure anxiety (study, test, and grade anxieties).

These dimensions are quite similar to those proposed by Cruise et al. (1985). In developing their Statistics Anxiety Rating Scale (STARS), these authors include six dimensions. Worth of Statistics refers to students' views of whether statistics is useful to them, both now and in their future careers, and addresses their attitudes toward statistics. Interpretation Anxiety and Computation Self-Concept refer to students' anxiety when deciding which analysis to use or interpreting results of an analysis, as well as their math self-concept. Fear of Asking for Help and Fear of Statistics Teachers are both social in nature, and reflect students' anxiety when seeking help from either professors or classmates. The last dimension, Test and Class Anxiety, reflects students' anxiety during statistics classes and while taking statistics exams. These six dimensions appear to be in agreement with both of the later researchers (Zeidner 1991; Onwuegbuzie et al. 1997) whose work delineated the same concepts in slightly different form.

All three of these researchers acknowledge the component of math self-concept, though it appears to be intertwined with other components that make up statistics anxiety. Zeidner (1991) alluded to the involvement of math self-concept when he wrote "statistics anxiety is likely to develop from a developmental history of success and failure experiences involving mathematics…" (p. 319). Onwuegbuzie et al. (1997) also acknowledge that students' self-concept is involved "when a student is attempting to solve a statistics problem which requires calculation" (p. 17). Similarly, Cruise et al. (1985) indicate that self-concept is an important component of statistics anxiety with their scale designed to measure "anxiety experienced when doing mathematical problems as well as the student's self-perception of his/her ability to understand and calculate…" (p. 93). Clearly, math self-concept is involved in statistics anxiety and several studies have shown the relationship between them. In fact, several math-related variables have been studied in relation to statistics anxiety (see Onwuegbuzie and Wilson 2003), with math self-concept being the most common attitudinal variable.

2.2 Math Self-Concept

Bandura (1986) describes self-concept as a view of the self that is developed through experience. Therefore, experiences with math will form the math self-concept, as well as other attitudinal aspects, through evaluations of those experiences in terms of success or failure (Bandura 1986). When students approach any type of mathematical situation, such as a math or statistics class, their math self-concept will naturally be involved (Bandura 1986). Math self-concept is an aspect of one's attitude toward math that may also include evidence of preferences for math, a tendency to avoid or be attracted to math, and a belief that math is either useful or useless (Ma and Kishor 1997).

Researchers have found several variables related to math self-concept (Pajares and Miller 1994; Sax 1994; Githua and Mwangi 2003; Skaalvik and Skaalvik 2005; Lee 2009; Nagy, Watt, Eccles, Trautwein, Ludtke, and Baumert 2010; Ahmed et al. 2012). For example, Pajares and Miller (1994), in their sample of 350 undergraduate students, found that math self-concept was related to math self-efficacy ($r = .61$, $p < .0001$), which acted as a mediator between math self-concept and math performance. More recently, Ahmed et al. (2012) studied the relationship between math self-concept and math anxiety in 522 adolescents and found that those with lower math self-concept experienced higher math anxiety ($r = -.43$, $p <.01$). Additionally, the authors showed through structural equation modeling that as math anxiety increases, math self-concept is further affected, indicating a reciprocal relationship between the two.

Several researchers have supported the relationship between math self-concept and statistics variables (Benson 1989; Benson and Bandalos 1989; Perney and Ravid 1990; Zeidner 1991; Bandalos et al. 1995; Wilson 1997; Onwuegbuzie 2000; Macher et al. 2012). For example, based on the contention that students view statistics classes as higher-level math, Perney and Ravid (1990) explored math self-concept, attitude toward tests, and attitude toward statistics in a sample of 68 largely female (93%) graduate students. Results indicated that attitude toward statistics was positively related to math self-concept ($r = .54$, $p < .001$), as well as to attitude toward tests ($r = .35$, $p < .01$). These findings seem to suggest that students may actually view statistics as a math class, and consequently their math self-concept is involved. In a similar endeavor, Wilson (1997) explored several variables in relation to math and statistics anxiety. In her sample of 178 graduate students, the variables of math preparation, number of years since previous math course, perceived math ability, perceived calculator proficiency, computer anxiety, expected grade, department, major, age, and gender together accounted for 37% of the variation in anxiety ($R^2 = .37$). A significant independent relationship was found for the four predictors of math preparation (R^2 change = .05, $p < .001$), perceived math ability (R^2 change = .03, $p < .05$), calculator proficiency (R^2 change = .02, $p < .05$), and gender (R^2 change = .02, $p < .05$). This finding regarding perceived math ability reinforces Perney and Ravid's (1990) suggestion that students view statistics classes as higher-level math classes, and further supports the influence of math self-concept on statistic anxiety.

In a later study, Onwuegbuzie (2000) explored the canonical relationship between students' self-perceptions and statistics anxiety variables in a sample of 146 statistics students. Among several significant relationships, those reporting higher levels of statistics interpretation anxiety also reported lower levels of perceived intellectual abilities ($r = -.47$, $p < .001$) and perceived academic competence ($r = -.39$, $p < .001$). Similarly, those reporting higher anxieties about computational self-concept also had lower perceived intellectual abilities ($r = -.39$, $p < .001$) and lower perceived academic competence ($r = -.35$, $p < .001$). His findings suggest that students with greater statistics anxieties and poorer math self-concepts also have poorer self-concepts concerning their academic abilities in general.

There is little doubt that math self-concept and statistics anxiety are related constructs, or that they are related to other variables such as attitudes toward statistics. But Viswanathan (1993) argues that it is important to also recognize a largely unexplored variable that he believes is related to numerically oriented domains: that of preference for numerical information.

2.3 Preference for Numerical Information

Preference for numerical information (PNI) is defined as "a preference or proclivity toward using numerical information and engaging in thinking involving numerical information" (Viswanathan 1993, p. 742). The author developed a scale to measure this construct through a series of studies in an attempt to address what he believes to be an overlooked aspect of students' and consumers' basic attitude toward numerical information. As Viswanathan (1993) explains, attitude toward numerical information is likely to influence whether people are willing to engage in activities or situations where numbers are involved. If this is true, then students with a poorer attitude toward numerical information may be more likely to avoid statistics and research classes, or at least put them off until late in their degree programs. Onwueguzie and Wilson (2003) are among the researchers who point out that this is a typical problem for graduate students that often impedes their progression toward obtaining their degrees.

Although variables such as students' math ability, math self-concept, and attitude toward statistics have already been well documented as contributors to students' statistics anxiety and consequent avoidance of statistics classes, Viswanathan (1993) maintains that ability and attitude are different from preference for numerical information. Attitudes toward math, such as that measured by Aiken (1974) or described by Ma and Kishor (1997), are evaluated in terms of liking for math, value for math, or belief in one's math ability, while attitude toward statistics (e.g. Wise 1985) is measured as an attitude toward both statistics courses and the field in general. These, according to Viswanathan (1993), measure attitude toward domains where numerical information is used, but fail to measure attitude toward numerical information in general. The author also explains that the construct of numeracy, which is intended to capture both ability and attitude, is measured largely as the ability to use numerical information in a variety of everyday settings. This, he argues, still misses the aspect of PNI in that people may possess the ability, but if they have a low PNI they will likely choose not to use that ability. This could be an important determinant of not only the timing of students' enrollment in statistics and research courses, but also whether they will choose involvement in research after graduation.

Another worthy consideration is how attitude toward numbers may influence students' learning in statistics courses. In citing Payne (1992), who claims that attitude and ability can influence each other, thereby influencing learning, Viswanathan (1993) argues that attitude toward numerical information may influence learning in situations where numbers are used. Based on this idea, the author reasons that students who have low PNI may be less likely to acquire the ability needed for success in math or statistics classes, as well as less likely to apply their ability in situations requiring statistical analyses. This contention translates into students with low PNI not only avoiding statistics classes as long as possible, but possibly attaining only the ability needed to earn a passing grade as well as declining to join research groups or projects with their professors. Decisions such as these may harm students' success later in their programs, as statistics and research classes are important for the development of scientific reasoning (Tomcho et al. 2009). Freng et al. (2011) found as much in a sample of 129 undergraduate psychology majors. Using hierarchical multiple regression to control for previous scientific reasoning ability and achievement, previous math ability, and previous GPA, the authors found that average course grades from statistics/research classes and timing of enrollment in statistics and research courses predicted later success in their programs ($R^2 = .38$, $F(6, 22) = 12.20$, $p < .001$). This indicates that students who take their statistics and research courses earlier in their programs, and do well, are more likely to flourish later in their studies.

Viswanathan (1993) makes a reasonable argument. Even so, very few researchers have utilized his measurement of PNI with a total of only five research studies located at the time of this writing. Alkhateeb and Abed (2000) first translated the PNI instrument into Arabic, then used it to survey a group of 157 high school students. They report that preference for numerical information is positive for Arabic students, scoring higher (though not significantly) than the American students in Viswanathan's (1993) study. Two years later, Alkhateeb and Abed (2002) reported on the factor structure for the translated PNI, concluding that the instrument measures a single dimension as reported by Viswanathan (1993).

In a 2004 study exploring the influence of different types of testimony on jurors' verdicts, Bornstein used a sample of 141 college undergraduates as mock jurors. The author found that the students were influenced differently by the entry of experimental data as evidence depending on their level of PNI. Those having high PNI were more likely to consider the argument convincing, while low PNI students were more likely to agree with the opposing side. This finding supports Viswanathan's (1993) assertion that preference for numerical information may be especially relevant in situations where only a minimal level of ability is needed to interpret numerical information. In these situations, the author states, usage of numerical information is likely to be influenced more by preference than by ability. That same year, Smith and Drumming (2004) explored the PNI of 236 African American students. They found a significant positive relationship between PNI and achievement on questions requiring computations ($r = .27$, $p < .001$), but no significant relationship between PNI and achievement on questions requiring no computations ($r = .13$, $p < .05$). As reported by these authors, these results are similar to those obtained by Viswanathan (1993) in the seventh of his series of studies wherein students' PNI scores were significantly related to grades in their most recent statistics course ($r = .43$, $p < .01$). The final study located in the literature was published in 2011 (De' Armond and Durband 2011) and investigated, among other things, the relationship between PNI and several personal and demographic variables including gender, perceived success, education, and annual compensation. Although women showed a higher level of PNI than men, the relationships are not reported to be significant.

The common element that is lacking in previous studies that make use of the PNI is that no studies were found which attempted to directly validate the assertion that PNI is a measure of general attitude toward numbers that adds to the nomological network of attitudinal measures toward math or toward domains involving math such as statistics. This is important because such an exercise would augment what Cronbach and Meehl (1955) referred to as the "nomological net," wherein a set of qualitatively different constructs that overlap are found to relate to other constructs, thereby helping to define each other. This validation is necessary in order to establish its utility in a variety of realms, especially the academic realm. Therefore, construct validity of the nomological type should be attempted. Additionally, because of the paucity of researchers making use of the PNI, it would be easy to misinterpret this lack as an indication of the insignificance of the construct of preference for numerical information. Given Viswanathan's (1993) arguments, however, that attitude toward numerical information may influence the acquisition and usage of numerical information, the construct bears further investigation. Given the implications for graduate students, who tend to avoid statistics and research courses, and who frequently display a poor math self-concept, this construct should be studied within the context of statistics class and the experiences of statistics students. Therefore, the current study will explore the relationship between PNI, math self-concept, and statistics anxiety in a sample of graduate students as a means of nomological construct validation.

2.4 Summary

Cruise et al. (1985) laid out six dimensions of statistics anxiety. Four dimensions are more content-oriented, and two are more socially-oriented. The first of these dimensions (Worth of Statistics) taps into attitude toward the domain of statistics. Another dimension (Computation Self-Concept) addresses attitude toward using math in statistics. Two other dimensions measure anxiety associated with interpreting and using statistics (Interpretation Anxiety and Test/Class Anxiety), and the final two dimensions are social in nature (Fear of Asking for Help and Fear of Statistics Teachers). If preference for numerical information is part of the nomological system involved in attitudes toward math and math-dependent fields, then PNI is expected to have a moderate to strong relationship with the four content dimensions of the STARS, and weaker relationships between PNI and the two social dimensions (fear of asking for help and fear of statistics teachers) of the STARS as delineated by Cruise et al. (1985). Additionally, the PNI should have a moderate to strong relationship with math self-concept that is similar to the relationship found between PNI and the STARS dimension of computation self-concept. It is agreed that since it is the extent of validity that is to be investigated, rather than absolute validity (Cronbach and Meehl 1955), terms such as "moderate," "weak," and "strong" are relative, but as a reference point these terms shall be used in accordance with Cohen's (1992) effect size index wherein a small effect size would indicate a weak relationship between variables with an of r = .10, a moderate effect size would have an r = .30, and a strong effect size would have an r = .50. For multiple correlations, Cohen (1992) deems a small effect size as being $f^2 = .02$, with moderate and strong effect sizes as being $f^2 = .15$ or $f^2 = .35$ respectively. Accordingly, the following hypotheses will be addressed:

1) PNI will show a moderate-to-strong relationship with the combined STARS factors of worth of statistics, computation self-concept, interpretation anxiety, and test/class anxiety.
2) PNI will show a weak relationship with the combined STARS factors of fear of asking for help and fear of statistics teachers.
3) PNI will show a moderate-to-strong relationship with the STARS factor of computation self-concept.
4) PNI will show a moderate-to-strong relationship with math self-concept.

3. Methods

3.1 Participants

One hundred three (n = 103) graduate students in a large Southwestern university were invited to participate. Information on the demographic variables of major, gender, ethnicity, and degree of program completion were obtained. The sample represented several different majors (e.g. educational psychology, sports psychology, higher education, counseling, hospitality administration, nutritional science, mass communications, and family/consumer science) enrolled in four sections of a graduate introductory educational statistics course during the 2011-2012 academic year. The same instructor taught all sections, and though no incentive to participate was offered, none of the students declined to participate. The sample consisted of 41.7% (n = 43) male and 58.3% (n = 60) female students, with a mean age of 31.36 ($\bar{x}$ = 31.36, SD = 10.64). The majority of students reported their ethnicity as white/Anglo (62.1%), with the balance being 14.6% Asian, 12.6% Hispanic, 4.9% African American, and 5.8% non-specified. Most students (83.9%) were over halfway through their programs of study and 60.9% had 30 hours or less remaining.

3.2 Procedures and Instruments

On the first day of class, the students were informed of the nature of the study and asked if they would be willing to participate. The participants were assured of the confidentiality of the study, and the anonymity of their responses, and were then given a questionnaire consisting of a statistics anxiety instrument, a math self-concept instrument, and the preference for numerical information instrument. The questionnaire also asked for demographic information. In an effort to avoid influencing the students' attitudes, emotions, preferences, or opinions, the information about the study and the questionnaires were given before the syllabus and course description were presented as well as before any statistics instruction.

Statistics anxiety was measured with the Statistics Anxiety Rating Scale (STARS) (Cruise et al. 1985). The instrument consists of 51 items measured on a 5-point scale asking students about their level of agreement or asking them to rate their anxiety levels along the six dimensions of statistics anxiety proposed by the authors. Higher scores on the subscales indicate higher levels of anxiety in each area. For example, if a student chooses "strongly agree" for the statement "I'm too slow in my thinking to get through statistics" on the Computation Self-Concept subscale, the student is indicating the highest level of anxiety. The scale of Worth of statistics measures students' attitude toward the domain of statistics, which is believed to indirectly contribute to anxiety. On this subscale, if a student strongly agrees with the statement "Statistics is worthless to me since its empirical and my area of specialization is philosophical," the student is indicating a low value for statistics and a higher level of anxiety. Sample items from the six subscales include: "I'm never going to use statistics, so why do I have to take it?" (Worth of Statistics, 16 items), "Figuring out whether to reject or retain a null hypothesis" (Interpretation Anxiety, 11 items), "Going over a final examination in statistics after it has been graded" (Test and Class Anxiety, 8 items), "I can't even understand seventh- and eighth-grade math; how can I possibly do statistics?" (Computation Self-Concept, 7 items), "Going to ask my statistics teacher for individual help with material I am having difficulty understanding" (Fear of Asking for Help, 4 items), and "Statistics teachers talk in a different language" (Fear of Statistics Teachers, 5 items). The current study's Cronbach's reliability coefficients for the six subscales were .94 (Worth of Statistics), .88 (Interpretation Anxiety), .93 (Test and Class Anxiety), .90 (Computation Self-Concept), .89 (Fear of Asking for Help), and .82 (Fear of Statistics Teachers).

Math self-concept was measured using the Self Description Questionnaire III (SDQIII) math subscale (Marsh 1992). The instrument was developed for measuring various aspects of self-concept for college students and other adults, and was chosen due to its extensive validation for use with adult respondents. Only the math self-concept subscale was used in the current study. The scale consists of 10 items measured on a 9-point scale asking participants to rate the accuracy of each statement presented. Sample items include "I have hesitated to take courses that involve mathematics" and "I am quite good at mathematics." In the current study, Cronbach's alpha reliability coefficient was .88 for the math self-concept subscale.

Preference for numerical information was assessed with the Preference for Numerical Information Scale (PNI) (Viswanathan 1993). The instrument measures participants' liking for and enjoyment in using numerical information and engaging in thinking that involves numbers. The 20 questions were measured on a 5-point scale, and ask participants to rate their agreement with each statement. Sample items include "I enjoy work that requires the use of numbers" and "Thinking is enjoyable when it does not involve quantitative information." Viswanathan (1993) showed an internal consistency of .94, and test-retest reliability of .91, and Cronbach's alpha for the current study was a comparable .91.

4. Results

In order to address the hypotheses of the study, correlational analyses were conducted on the three research variables of preference for numerical information, math self-concept, and statistics anxiety. Means and standard deviations of the measures are given in Table 1, and correlations between the variables are given in Table 2. Due to the number of correlations conducted, the Bonferroni adjustment was applied, and the chosen alpha level of $\alpha = .05$ was divided by the number of correlations conducted. Therefore, any correlation significant at $p \leq .003$ will indicate significance at the .05 level.

Table 1. PNI, Math Self-Concept, and STARS factors Means and Standard Deviations

Variable	*mean*	SD
PNI	3.72	0.60
Math self-concept	34.40	9.46
Worth of statistics	30.98	10.0
Interpretation anxiety	28.05	8.77
Test and class anxiety	24.38	8.80
Computational self-concept	14.51	5.86
Fear of asking for help	8.35	4.01
Fear of statistics instructor	10.08	3.67

n = 103

Table 2. Pearson's *r* correlations among variables

	PNI	MSC	WS	IA	TCA	CSC	FAH	FST
PNI	-	.68**	-.59*	-.24	-.29*	-.49*	.01	-.09
MSC		-	-.32*	-.31*	-.42*	-.57*	.04	-.14

Note: PNI: Preference for Numerical Information; MSC: Math Self-Concept; WS: Worth of Statistics; IA: Interpretation Anxiety; TCA: Test and Class Anxiety; CSC: Computation Self-Concept; FAH: Fear of Asking for Help; FST: Fear of Statistics Teacher.
*$p \leq .05$; **$p \leq .001$

Hypothesis one stated that PNI would show a moderate-to-strong relationship with the combined STARS factors of worth of statistics, computation self-concept, interpretation anxiety, and test/class anxiety. Results of a multiple correlation indicate a strong relationship between the variables (R = .64, p < .001), with the combination of the four STARS factors explaining 37.9% of the variance in PNI (R^2_{adj} = .379), indicating a strong effect size of f^2 = .61. Bivariate correlations were also conducted between each of the four STARS factors and PNI, with results indicating a strong negative correlation between PNI and worth of statistics (r = -.59. p < .003, r^2 = .35), wherein PNI explains 35% of the variance in worth of statistics, and a strong negative relationship with computation self-concept (r = -.49, p <.003. r^2 = .24), with PNI explaining 24% of the variance in computation self-concept. Interpretation anxiety was also negatively related to PNI (r = -.24, p = .007, r^2 = .05), though with the Bonferroni adjustment it is non-significant, explaining just 5% of the variance. Test/class anxiety was significantly and negatively related to PNI (r = -.29, p < .003, r^2 = .08), explaining 8% of the variance. Therefore, the first hypothesis is supported.

Hypothesis two predicted that PNI would show a weak relationship with the combined STARS factors of fear of asking for help and fear of statistics teachers. Results of the multiple correlation indicate an extremely weak and non-significant relationship (R = .12, p = .52) with the combination of the two STARS factors explaining just 0.7% of the variance in PNI (R^2_{adj} =

.007), with an effect size of f^2 = .007. Bivariate correlations between each of the two STARS factors and PNI also indicate no significant relationship between fear of asking for help and PNI (r = .01. p = .91), as well as no significance for fear of statistics teachers and PNI (r = -.09. p = .338). Consequently, the second hypothesis is also supported.

Hypothesis three predicted that PNI would show a moderate-to-strong relationship with the STARS factor of computation self-concept. As indicated in the recounting of the first hypothesis, the PNI showed a strong negative relationship with computation self-concept (r = -.49, p <.003. r^2 = .24), with PNI explaining 24% of the variance. Therefore, the third hypothesis is supported.

Hypothesis four stated that PNI would show a moderate-to-strong relationship with math self-concept. Results indicate that PNI is significantly related to math self-concept (r = .68, p < .001, r^2 = .46), with PNI explaining 46% of the variance in math self-concept. Therefore, the fourth hypothesis is supported.

5. Discussion

The purpose of this study was to investigate the relationship between preference for numerical information, math self-concept, and statistics anxiety. This probe was undertaken as a means to validate Viswanathan's (1993) postulation that although instruments have been developed to assess attitude toward math and statistics, as well as attitudes toward these domains, the continuously neglected construct of attitude toward numerical information in general is an important part of the picture. According to Viswanathan (1993) the PNI measures this general attitude, and may be an important determinant in students' decisions to learn subjects requiring the use of numbers, to use the ability they already possess, and to become involved in situations where numerical information may be used. This suggests that PNI can be considered part of a nomological network of math-related constructs affecting students' experiences. If this is true, then PNI is an important addition to the already familiar constructs of statistics anxiety and math self-concept in the case of graduate students being fearful of statistics courses.

In the current sample of graduate statistics students, PNI was found to be significantly related to four types of statistics anxiety and math self-concept, with PNI explaining 37.9% of the variance in attitudinal variables related to statistics and 46% of the variance in a separate measure of math self-concept. PNI explained a much lesser degree (0.7%), though not significantly, of the variance in the social anxiety variables related to statistics anxiety. These results indicate considerable overlap between the PNI, four types of statistics anxiety, and math self-concept, suggesting that PNI does tap into the same areas. This is similar to that reported by Viswanathan (1993) who found PNI to be strongly related to a measure of attitude toward statistics (r = .61, p < .01) as well as a measure of attitude toward math (r = .74, p < .01), which led to his claim of nomoligical validity. The results of this study appear to support that claim.

Interestingly, the variance in PNI not explained by the other constructs provides some indication of Viswanathan's (1993) claims of PNI being a construct that measures a general numerical preference rather than the more narrowly focused attitudes toward math-oriented subjects. Though not the focus of this study, the remaining variance (62.1% for statistics attitudes and

54% for math self-concept) seems rather large to be due simply to random variability, so may be considered an indication of discriminant validity as well.

5.1 Limitations

As the current study is intended to provide evidence for the nomological validation of the PNI, some limitations should be noted. First, all of the measures used in this study are self-report and therefore subject to social bias. Graduate students who may feel under pressure to appear socially desirable may under-report their levels of statistics anxiety as well as over-report their levels of preference for numerical information. Therefore, future studies should be conducted to further supports the nomological validity of the PNI. Second, the sample of students was drawn from a limited population with little variation in terms of ethnicity and background, making generalization to other populations difficult. Future studies should obtain varied samples as a means of enhancing generalizability.

6. Conclusions

In the current study, increased levels of the graduate students' preference for numerical information were associated with a better math self-concept and decreased statistics anxiety. This is an important finding because not only do we see a fuller picture of graduate students' statistics class experience, meaning that there is more involved than just math self-concept and anxiety, but also because of the potential for increasing students' preference for activities that involve numbers. If attitudes develop along with ability, and attitudes also affect ability (Payne 1992), then preference for numerical information, as an attitude toward numerical information in general, may well influence students' outcomes in statistic courses. If this is true, a poor attitude toward numerical information could influence students' decisions to avoid any statistics/research courses or experiences beyond the minimum requirements for graduation. Future research should explore ways to influence the attitudes of students, both graduate and undergraduate, in an attempt to enhance learning and willingness to become involved with statistics and research.

In conclusion, the current study adds to the construct validity of a thus far little-utilized measure that is intended to provide information about students' general preference for working with numbers. This has the potential to increase educators' understanding of students who present with statistics anxiety and the often-accompanying problems with math self-concept.

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