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A new measure of math shame and a synthesized theory of math anxiety

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A NEW MEASURE OF MATH SHAME AND A SYNTHESIZED THEORY OF MATH ANXIETY

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Abstract

Research on math anxiety has historically explored cognitive and emotional factors independently. This study attempted to connect these areas of research through the lens of math shame. While discussing a more integrated approach to understanding mathematics anxiety, this research explored math anxiety through a formal validation of the newly developed Math Shame Scale (MSS). Data were collected from 489 volunteers at a regional university in the inland northwestern United States. Online questionnaires completed by the participants were used to assess the validity and reliability of the MSS. The results supported the reliability and validity of two separate scales of the MSS, one measuring affective and cognitive experiences of math shame (MSS-ACES) and the other measuring situational experiences of math shame (MSS-SE). The MSS scales demonstrated high internal consistency. Additionally, the MSS-ACES and the MSS-SE correlated with multiple established questionnaires providing evidence of construct validity. Furthermore, principal components analysis largely followed the proposed sections of the MSS assessing affective and cognitive experiences of shame and situational experiences of shame. The validation of the MSS provides support for the concept of math shame, yielding additional avenues for research designed at examining the role of math-specific shame in math anxiety.

Keywords: math anxiety, math shame

Table of Contents

List of Tables

List of Figures

A Synthesized Theory of Math Anxiety and a New Measure of Math Shame

Research demonstrates cultural differences in attitudes about mathematics as compared to other human endeavors. Unlike most shortcomings, which are typically hidden due to embarrassment, struggles with math can appear to be accepted, if not openly flaunted: “I’m a people person, not a numbers person,” “I’ve always hated math,” or, “I don’t need to learn math. That’s what computers were invented for” (Paulos, 1988). This can be problematic both personally and culturally. The social acceptance of math skill deficits are directly incompatible with the direction our economy will be taking in the near future and the skills required to be a part of that movement. By the year 2018, STEM (Science, Technology, Engineering, and Mathematics) jobs are projected to increase by 17% compared to a growth of 9.8% for non-STEM jobs (Langdon, McKittrick, Beede, Khan, & Doms, 2011). The study and refinement of math skills provide an important portal for knowledge and innovation within STEM fields, allowing for advances in medicine, engineering, and technology.

However, experiences of math anxiety, a persistent negative reaction to math, can result in a variety of behavioral, cognitive, and emotional experiences that range from mild discomfort to extreme avoidance (Hembree, 1990; Rubinsten, Bialik, & Solar, 2012). Furthermore, Ashcraft, Krause, and Hopko (2007) estimate that approximately 50% of college students experience mild levels and 17% experience high levels of math anxiety. Consequently, the future career choices of emerging generations are being affected negatively by the debilitating and pervasive effects of math anxiety (Eshaq, 2008; King, 1996). King (1996) showed that a low level of math self-efficacy, which is related to high levels of math anxiety, predicts a student’s avoidance of math-related careers.

Considering the potential consequences and prevalence of math anxiety, it is surprising to find that theories typically only focus on discrete mechanisms that perpetuate it, rather than the factors that cause it. Research has explored shame (Bibby, 2002), negative events related to math (Bekdemir, 2010), cognitive disruptions (Hunsley, 1987), and math performance (Ashcraft, 2002) in relation to math anxiety, but the discussion surrounding math anxiety has yet to be synthesized into an integrated understanding of the phenomenon. The current study proposes a synthesized theory of math anxiety reflected in the validation of a recently developed measure of math shame (Parker, Lewallen, Walsdorf, Cervantes, & Kolts, 2014).

Extant theories often take a purely cognitive approach to understanding math learning and anxiety (Paechter, 2001), even though math is often experienced as a highly emotional subject. Emotions are so entwined in math-related experiences that one study showed emotions to account for 37% of the variance in students' math achievement (Kim, Park, & Cozart, 2014). Another study found that 25% of an individual's accuracy (i.e., the number of math problems they answered correctly) was accounted for by an interaction between an individual's working memory capacity and their affective response to math problems (Mattarella-Micke, Mateo, Kozak, Foster, & Beilock, 2011). Largely qualitative research has investigated the variety of emotions experienced during learning -- specifically mathematics learning (e.g., see Eynde, Corte, & Verschaffel, 2006; Hannula, 2002; William-Johnson et al., 2008). This research has suggested the presence of shame as a particularly strong emotion that surfaces during math-related experiences (Bibby, 2002) and during educational learning in general (Holodynski & Kronast, 2009; Johnson, 2012; Turner & Waugh, 2007).

The Concept of Math Shame

In considering math shame, it is important to be clear what is meant by the term "shame." In a broad sense, shame arises from a negative evaluation of the *self*. In contrast, guilt focuses on "the *thing* done or undone" (i.e., the situation or event), which is negatively evaluated in connection with the self, but not representative of the self (Lewis, 1971). Experiences of shame extend beyond feeling poorly about a transgression or objectionable behavior and reflect a core understanding of the self as "defective and objectionable" (Tangney, Miller, Flicker, & Barlow, 1996).

Utilizing this distinction between guilt and shame, the concept of math shame refers to a negative evaluation of the self resulting from negative experiences with math. Unlike generally struggling with math, individuals who experience math shame connect beliefs about math incompetence with their self-worth. An individual simply struggling in a math class might believe, "I'm performing poorly in math and I feel badly about that." This experience is centered on guilty feelings about the situation of not doing well in math. However, given the above mentioned distinction between guilt and shame, an individual experiencing math shame is likely to center the negative evaluation on the self as in, "I am bad at math and that makes me a mathematically incompetent and incapable person".

Exploratory research has shown a preliminary measure of math-specific shame to be a powerful predictor of mathematics anxiety, over and above general anxious tendencies and general levels of test anxiety (Parker, Lewallen, Walsdorf, Cervantes, & Kolts, 2014). Shame experiences have been shown to be more painful, less controllable, and more likely to lead to the desire to escape or avoid when compared to guilt experiences (Tangney, 1993). Consequently, it seems that math anxiety, though plausibly following either a guilt or shame-induced thought pattern, is likely to be more intense, more intractable, and lead to more avoidance behaviors when tied to shame-fueled beliefs. This suggests that math-specific shame could play a crucial role in the creation and perpetuation of math anxiety.

Math-Related Shaming Experiences

Past negative (i.e., potentially shaming) experiences have garnered considerable support in explaining the source of math anxiety for many individuals (e.g., see Bekdemir, 2010; Harper & Daane, 1998; Jackson & Leffingwell, 1999), and such experiences can be seen as a crucial element in the etiology of math anxiety. It is likely that exposure to math-related negative emotional experiences, such as feeling worthless after receiving a graded math test or experiencing hostility or humiliation from peers or math instructors when not understanding a concept, produces feelings of shame regarding a person's ability and relationship with mathematics.

It is easy to see how these negative/shaming events could deeply affect an individual's immediate experiences with math. However, beyond the initial effects of the individual's experience of math-related shame, I'd like to suggest that such experiences can prompt the formation of a psychological context or schema that can continue to affect a person and his or her future experiences with math. For example, a single negative experience with an algebra equation that elicited feelings of shame could potentially affect an individual's future choice to engage with other algebra courses in an attempt to avoid additional feelings of shame or anxiety. Furthermore, feelings of shame and avoidance could expand to other math-related experiences, including completing one's taxes or engaging with a statistics course.

While shaming events have been implicated in the development of math anxiety, the lingering effects of shame can potentially contribute to the maintenance of various aspects of math anxiety. Whether a single or multiple math-related shaming events occur to an individual who later develops math anxiety, the way that shame affects the self is documented by multiple studies examining shame's association with the development and maintenance of various mental health problems, such as depression (for a review see Kim, Thibodeau, & Jorgensen, 2011) and anxiety (Irons & Gilbert, 2005; Tangney, Wagner, & Gramzow, 1992). These shame memories can become "a reference point for everyday inferences, a turning point in an individual's life story, and a central component of one's identity" (Pinto-Gouveia & Matos, 2011).

Pinto-Gouveia and Matos (2011) modified the Centrality of Event Scale (CES) to measure the extent to which a memory of a shameful event can create a reference point for an individual's identity and attribute meaning to other experiences in that individual's life. They found that shameful events can become central to the organization of individuals' autobiographical narratives, and that such individuals also experienced higher levels of depression, anxiety, and stress. This research supports the idea that shaming events, and more specifically math-related shaming events, can become central to an individual's identity and potentially provide the foundation from which mental health issues arise, math anxiety being one such mental health issue.

Threat Arousal and Stereotype Threat

One way in which shame perpetuates and feeds the cycle of math anxiety can be found in the activation of threat responses. In characterizing evolved emotional responses, Gilbert (2014) discusses the threat system -- an emotional regulation system that facilitates detection and reaction to external and internal threats. Correlational data support the concept that shame can potentially create and maintain ongoing experiences of threat, specifically for those diagnosed with PTSD (Harmon & Lee, 2010). Harmon and Lee (2010) suggest that shame "attacks an individual's psychological integrity" which leads individuals to experience an increase in perceived, continuous, immediate threat. Applying this reasoning to the development of math anxiety, an individual who experiences math-related shame could experience hyper-arousal and an increased sense of fear when attending a math-based course or when creating a spending budget for a vacation. In essence, an individual's sense of shame related to their ability to engage with math could heighten anxious or fearful reactions to any activity perceived as relating to their ability, or rather feared inability, to engage with math. This could potentially create an ongoing sense of threat that maintains future perceptions of math as a threatening and feared subject that should be avoided.

The ways in which shame activates an individual's threat system works as a primary mechanism in the current integrated theory of math anxiety. The idea is that as feelings of shame and accompanying shaming cognitions create a psychological context that maintains the ongoing experience of threat around mathematics, threat-related arousal disrupts important cognitive functions, interfering with the individual's ability to perform mathematical tasks.

There is empirical evidence to support this hypothesized dynamic. Stereotype threat, a specific type of threat arousal, occurs when an individual, faced with a negative stereotype about a social group of which they are a part, is concerned that he or she will be evaluated based on this negative stereotype (Steele, 1997). Stereotype threat has been shown to affect certain minorities that are stereotypically mathematically disadvantaged, including women and racial minorities (Steele, 1997). Research has shown that women significantly underperform compared to equally qualified men when given a difficult math test. However, when participants are told the math test does not produce gender differences, women perform equally as well as men (Spencer, Steele, & Quinn, 1999).

The more stigmatized categories an individual falls within, the more intense his or her threat response, the higher his or her threat arousal, and the more his or her working memory suffers (Tine & Gotlieb, 2013). Additionally, the effect that stereotype threat has on arousal seems to be dependent on the social environment. Women, who are often affected by math-related stereotype threat, seem to benefit from the camaraderie of other women. Women who were in the presence of other women performed better on a math test under stereotype threat than did women who were taking it alone (Beaton, Tougas, Rinfret, Huard, & Delisle, 2007). This suggests that the presence of others from a similarly stigmatized social group may mollify the effects of stereotype threat. This provides some evidence for the social nature of threat activation and the role of social support in mathematics anxiety.

Research has also shown that placing individuals in certain social categories can impact math performance. Similar to the stereotype threat findings described above, when people are labeled as falling within a category that suggests they will do poorly (e.g., females performing math tasks), they tend to perform poorly. Conversely, when people are associated with a group that society suggests will do better than an out-group, they perform better (Johnson, Barnard-Brak, Saxon, & Johnson, 2012). For individuals who find themselves stuck in their threat system, subjected to threatening stereotypes, a perceived lack of social support can contribute to maintaining the ill effects of math anxiety. It has been shown that those with higher perceived levels of social support have more positive attitudes towards math and a higher sense of their own competence in the subject (Rice, Barth, Guadagno, Smith, & McCallum, 2013). Stereotype threat, and the accompanying drop in performance, shows the quantifiable effects threat arousal has on an individual's math performance.

Threat arousal in response to math is also reflected in an individual's brain activity. At the neurological level, math anxiety corresponds to increased activity in brain areas related to pain perception and threat detection, such as the dorso-posterior insula (Lyons & Beilock, 2012). As math anxiety increases, the brain demonstrates increased threat activation in response to math-related material. As discussed previously, there is potential for this threat activation to interfere with an individual's performance on math-related tasks. In other words, math anxiety can lead to higher levels of threat perception, which diminish an individual's ability to actively engage with and focus on the math task they have been presented with.

Cognitive Disruptions

Following these concepts of shame and threat activation, cognitive disruptions -- which have been well-supported and theorized as a mechanism behind math anxiety (e.g., Beilock, 2008; Young, Wu, & Menon, 2012) -- form the next piece of the proposed theory of math anxiety. One such cognitive disruption specific to math anxiety involves the reduction of activity in the posterior parietal and dorsolateral prefrontal cortex regions, which are involved in mathematical reasoning (Young, Wu, & Menon, 2012). Young, Wu, and Menon (2012), in an examination of the neural correlates of math anxiety, found that those who experience higher levels of math anxiety also experience a reduction in brain activity in areas implicated in mathematical reasoning and an increase in the activity of brain areas related to the experiences of negative emotions. Furthermore, these neural effects were specific to experiences of math anxiety and unrelated to general anxiety, intelligence, working memory, and reading ability. This suggests that the higher an individual's math anxiety, the less available their brain is for reasoning through the same math problem that is making them anxious.

Alongside the reduction in math reasoning ability, working memory capacity – which has been heavily implicated in math ability (Stevenson, Bergwerff, Heiser, & Resing, 2014) – declines when experiencing math anxiety. Studies show an unavoidable competition for available working memory space when individuals are faced with threat, specifically math-related threat (Beilock, 2008; Ganley & Vasiyeva, 2013; Tine & Gotlieb, 2013). Ganley and Vasiyeva (2013), in an examination of the role of anxiety and working memory in gender differences in math, found there to be a mediating pathway from gender to math performance created by the worry component of anxiety and working memory. The effect of worry on an individual's working memory is summarized in the theory of processing efficiency, which can be easily applied to math anxiety. The processing efficiency theory postulates that intrusive thoughts and worries due to anxiety disrupt working memory (Eysenck & Calvo, 1992) regardless of mathematical competence (Ashcraft, 2002; Ashcraft, Kirk, & Hopko, 1998; Faust, Ashcraft & Fleck, 1996).

It has been speculated that the cognitive disruptions present in math anxiety are similar to those found in individuals experiencing test anxiety (Dew, Galassi, & Galassi, 1983; Dew, Galassi, & Galassi, 1984), which is the experience of tension, over arousal, worry, and dread that occurs before or during a testing situation (Zeidner, 1998). However, students' subjective ratings of exam importance, post-exam performance estimations, and ratings of performance satisfaction related to a psychology statistics test were related to math anxiety, but not to test anxiety (Hunsley, 1987). In this study, Hunsley (1987) compared and contrasted the cognitive processes involved in math and test anxiety through questionnaires assessing undergraduate students' anxiety, appraisals, internal dialogues, and performance attributions before and after five statistics exams across the duration of a required psychology statistics course. Hunsley's findings on the appraisals and internal dialogues present during statistics exams suggest that the cognitive processes present in math anxiety are qualitatively different from those present in test anxiety, and therefore, math anxiety is not simply a math-specific form of test anxiety. Furthermore, unlike for those experiencing test anxiety, this research shows that students experiencing math anxiety placed a higher importance on math-related performances, but doubted their competence and ability to adequately prepare for a math test. This suggests that, beyond general worries about their ability to perform on a test, individuals experiencing math anxiety encounter cognitive disruptions related to the ability of the self to comprehend, prepare, and perform specifically in math.

In addition to showing cognitive disruptions distinct to mathematics anxiety, Hunsley (1987) observed significant differences between the cognitive processes found in math and test anxiety. Although math anxiety and test anxiety are often positively correlated and both lead to cognitive disruptions, they seem to be qualitatively different, with mathematical abilities seen as more important and anchored more closely to the competence of the self than are testing skills (Hunsley, 1987). Research has yet to further explore the cognitive differences between math and test anxiety. The importance of math to the self could relate to a number of social, cultural, and personal factors. A discussion exploring the possible reasons for math's perceived level of importance would be largely anecdotal in nature. In reference to this study, this concept is most important to the concept of math-shame as it provides support that math ability appears to be related to the self in ways that other academic experiences and endeavors, specifically test anxiety, do not appear to be.

In addition to the competition and disruptions at the neurological level, research has suggested that individuals with high math anxiety struggle with negative internal attributions and self-critical dialogues that are seen as more important and anchored more closely to the self (Hunsley, 1987). This creates additional cognitive interference when individuals attempt to engage with math problems, providing individuals with consistently incongruent performances when considering his or her true ability and typical grades.

Math anxiety, in and of itself, produces poorer performance (Hembree, 1990; Ma, 1999), but it is unrelated to a person's genuine ability or competency in mathematics (Ashcraft, 2002; Ashcraft, Kirk, & Hopko, 1998; Faust, Ashcraft & Fleck, 1996). This gives much hope to interventions that target the patterns that maintain math anxiety. However, before interventions can be effectively designed, a fuller understanding of the etiology and maintenance of math anxiety is necessary.

An Integrated Theory of Math Anxiety

To summarize, in this proposed theory, math anxiety is thought to stem from an experience or a series of experiences that allow for situational, emotional, and cognitive events to create and maintain contexts in which math anxiety is created and perpetuated. As discussed earlier, negative experiences, which can be thought of as math-related shaming events, act as the source or etiology of math anxiety. These shaming events create a context for the development and maintenance of threat arousal activation during times of mathematical stress. Additionally, these math-shaming events can lead to shame-related cognitions (e.g., “I’m not good at math”), which can be continually activated, reinforced, and elaborated upon in response to future frustrating exposures to math.

Threat arousal activation can also then lead to cognitive disruptions – notably increased threat detection, reduction in mathematical reasoning ability, reduction in working memory, and negative internal dialogues – that affect immediate math performance, but not overall math competency. Math anxiety, likely to be encountered in response to the experience and effects of the cognitive disruptions, creates another context that can produce math-related shame, as the individual then observes herself or himself struggling at mathematical tasks. All of these components affect one another and allow math anxiety to shape an individual’s emotional, cognitive, and situational experiences with math.

Further, I propose that these elements that maintain an individual's experience of math and math anxiety can sustain themselves in a self-perpetuating fashion. As the individual experiences a series of negative experiences with math that include feelings of shame, anxiousness towards math, and poor mathematics performances, each aspect of the model can reinforce and strengthen the others. This creates a self-sustaining environment, in which shame, anxiety, and poor performance each contributes to the maintenance of the others (See Figure 1). This theory of math anxiety attempts to synthesize the existing research into a unifying framework that focuses on the development of math anxiety through experiences of math-related shame. In order to better understand the integrated theory that is being proposed, more information needs to be gathered regarding math-related shame.

The persistent memories surrounding past negative experiences with math (Bekdemir, 2010; Jackson & Leffingwell, 1999; Miller & Mitchell, 1994) and the feelings of shame that accompany them (Bibby, 2002) suggest that a measure of mathematics shame might serve useful in understanding the dynamics of math anxiety, especially in reference to the proposed theory of math anxiety. There is currently no known valid measure that attempts to measure the construct of math shame.

Hypotheses

Evidence from an initial attempt to measure math-related shame, called the Math Shame Scale (MSS), suggests that math shame is a construct that is correlated with, but separate from mathematics anxiety. In an initial examination by Parker et al., general anxious tendencies predicted 39.8% of variability in mathematics anxiety. However, the MSS contributed an additional 19.1% to the predictive value of math anxiety over and above that accounted for by general anxious tendencies (Parker, Lewallen, Walsdorf, Cervantes, & Kolts, 2014). Preliminary research showed the MSS to be an internally consistent, unitary scale with a Cronbach's Alpha of .95 and a principal components analysis supporting a single-component measure (Parker, Lewallen, Walsdorf, Cervantes, & Kolts, 2014).

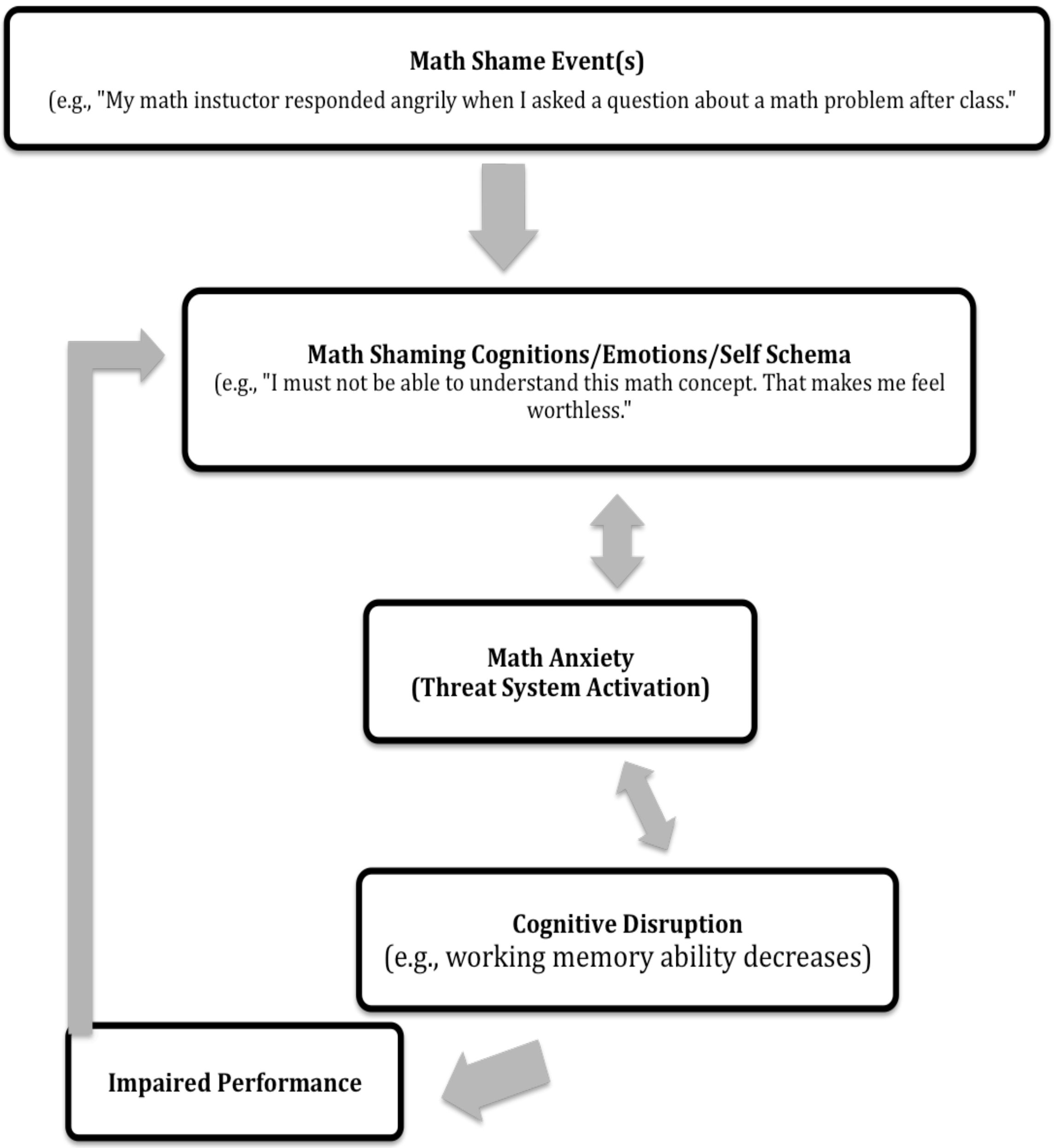

Figure 1. Proposed theory of math anxiety.

The current study sought to formally examine the reliability and validity of the MSS. Consequently, I investigated the validity of the MSS by comparing it with a number of measures that would be expected to bear relationships to math shame. I reasoned that individuals who commonly experiences shame in other aspects of their life would also be more likely to experience shame in relation to math. Therefore, positive correlations were hypothesized between the MSS and the Experiences of Shame Scale (ESS; Andrews, Qian, & Valentine, 2002). The ESS measures an individual's level of shame in two general categories, characterological and behavioral shame.

Considering the previously discussed research that suggests the likelihood of a relationship between math shame and math anxiety, a positive correlation was also hypothesized between the MSS and the Mathematics Anxiety Rating Scale-Revised (MARS-R; Plake & Parker, 1982). The MARS-R measures math anxiety in two categories, including anxiety towards learning math and anxiety related to math-performance evaluations.

Additionally, previously discussed research suggests a relationship between an individual's sense of competency in math and his or her feelings of math-related anxiety and, further, his or her feelings of math-related shame. The Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ; May, 2009) assesses an individual's level of math self-efficacy and provides another measure of math anxiety. Positive Correlations were hypothesized between the MSS and the anxiety portions of the MSEAQ, while negative correlations were hypothesized between the MSS and the self-efficacy portion of the MSEAQ.

Due to the likelihood of a relationship between math anxiety and math shame, it is also probable that individuals who experience math shame will experience worries related to evaluations unrelated to math, such as test anxiety, and increased levels of general anxiety. Positive relationships were also hypothesized between the MSS and the Cognitive Test Anxiety Scale (CTAS; Cassady & Johnson, 2002), which measures cognitive components of test anxiety, and the Beck Anxiety Inventory (BAI; Beck, Epstein, Brown, & Steer, 1988), which is a measurement of an individual's general level of anxiety.

Previous exploratory investigations have already supported a positive relationship between the MSS and the MARS-R, r (267) = .74, $p < .01$; the MSS and the CTAS, r (267) = .60, $p < .01$, and the MSS and the BAI, r (267) = .52, $p < .01$ (Parker, Lewallen, Walsdorf, Cervantes, & Kolts, 2014). I am, again, exploring these relationships in this formalized validation of the MSS due to structural changes in the MSS that occurred after the initial validity investigation. The hypotheses and the reasoning are consistent with the original version of the MSS despite the structural changes.

Research has already suggested that an individuals' level of self-criticism is a key component in their experience of shame (Gilbert & Procter, 2006). Gilbert and Procter (2003) also suggest that those who engage in self-soothing (i.e., self-reassurance such as "I am gentle and supportive with myself.") have decreased feelings of shame. The Forms of Self-Criticizing/Attacking and Self-Reassuring Scale (FSCRS; Gilbert et al., 2004) assesses the typical form and style of an individual's evaluation of the self in response to a setback or a disappointment. Positive correlations were hypothesized between the MSS and the self-criticizing portions of the FSCRS, while negative correlations were hypothesized between the MSS and the self-reassuring portion of the FSCRS.

Following the same logic as above, individuals who experience self-compassion are more likely to be able to work with their shame in compassionate and self-soothing ways, which suggests an individual who experiences higher levels of self-compassion will experience lower levels of shame. Consequently, a negative correlation was hypothesized between the MSS and the Self-Compassion Scale (SCS; Neff, 2003). The SCS measures self-compassion through six subscales that address contrasting components of self-compassion.

Finally, in order to gather criterion validity, I investigated the correlations between the MSS and an individual's self-reported average and most recent math course grades. Considering the proposed theory of math anxiety, specifically the relationship between math shaming experiences, cognitive disruptions, math anxiety, and math performance, it was hypothesized that those who experience high levels of math shame would perform poorer in math classes. Consequently, it was hypothesized that math course grades (both average and most recent) were negatively correlated with the MSS.

Method

Participants

Participants were gathered from a regional university in the inland northwestern United States. All participants were enrolled in undergraduate courses at the university. Participants enrolled in eligible courses received extra credit towards their respective course grade. Forty-seven participants' data were excluded due to incomplete survey forms. Of the final pool of participants, 353 (72.2%) were female and 136 (27.8%) were male, equaling a total of 489 participants. Their ages ranged from 18 to 60 with a mean of 23.50 years (*SD* = 6.69). In regards to racial and ethnic demographics, 385 (78.7%) participants described themselves as White/Caucasian, 38 (7.7%) as Hispanic/Latino, 21 (4.3%) as Asian, 21 (4.3%) as Black/African American, 16 (3.3%) as American Indian/Alaska Native, 13 (2.7%) as other, and 4 (0.8%) as Hawaiian/other Pacific Islander. Sixty-nine (14.1%) participants indicated their class standing as freshman, 88 (17.9%) as sophomore, 135 (27.6%) as junior, 146 (29.9%) as senior, 40 (8.2%) as post-baccalaureate, and 11 (2.3%) as other. Participants reported a range of 0 to 40 years since they were last enrolled in a math course (*M* = 1.69; *SD* = 3.38). Ranging from the completion of no college level math courses to the completion of calculus and finite math courses, participants indicated a variety of math courses when asked about the most recent math course they were enrolled in. Statistics was the most commonly reported recent math course (25.8%; *n* = 137). On average, when reporting the grade in their most recent math course, participants reported receiving a numeric grade of 3.03 (*SD* = 0.87) on a 4.0 scale. On average, participants reported receiving a numeric grade of 3.03 (*SD* = 0.76) on a 4.0 scale in a combined look at all of their past mathematics courses.

Materials

A questionnaire detailing the participants' demographics was included. The personal information sheet contained 9 items, assessing various demographic questions. The questions ranged from multiple-choice to numerical entry, including items gathering gender, age, and average mathematics course grade information. Examples of these questions: "What was the last mathematics course you completed?" and "How many years has it been since you last participated in a math course? (provide a numerical value)." Participants were also asked about their most recent and average grades in mathematics courses. These questions were not limited to college courses. Instead, they reflected a general sense of one's typical grade within math-related courses.

Beck Anxiety Inventory (BAI). The BAI was used to measure the participants' general levels of anxiety. The 21-item scale assesses an individual's severity of anxiety through endorsement of common physical (e.g., 'Hands Trembling') and cognitive (e.g., 'Fear of Worst Happening') symptoms of anxiety. Using self-report, the BAI utilizes a 4-point Likert-type scale ranging from *'Not at all'* to *'Severely, it bothers me a lot.'* This yielded a total score reflecting an individual's level of anxiety over the past week. The BAI has an internal consistency of .92 and a test-retest reliability of .75 (Beck, Epstein, Brown, & Steer, 1988).

Cognitive Test Anxiety Scale (CTAS). The CTAS was used to assess the participants' level of test anxiety. The 27-item self-report scale measures cognitive components of test anxiety, such as the "tendency to engage in task-irrelevant thinking, to draw comparisons to others, and to have intruding thoughts or relevant cues escape the learners' attention during an exam" (Cassady & Johnson, 2002). The CTAS uses a 4-point Likert-type scale ranging from '*Not at all typical of me'* to '*Very typical of me.'* The CTAS has an internal consistency of .91, and generates test-retest reliability coefficients ranging from .88 to .94 (Faleye, 2010).

Experiences of Shame Scale (ESS). The ESS was used to assess the participants' level of shame in various categories. This self-report measure consists of 25 items that assess two major categories of shame (characterological shame and behavioral shame) and eight subcategories within those broader classifications of shame (shame of personal habits, manner with others, sort of person you are, personal ability, shame about doing something wrong, saying something stupid, failure in competitive situations, and body shame). For each of the eight shame areas covered, the measure addresses the experiential component of shame as assessed through direct questions about feelings of shame (e.g., "have you felt ashamed of your personal habits?"), through cognitive components as measured by questions about concerns over others' opinions (e.g., "have you worried about what other people think of your personal habits?"), and through a behavioral component as assessed by questions about concealment or avoidance (e.g., "have you tried to cover up or conceal any of your personal habits?"). A 4-point Likert-type scale is used to measure the amount of shame experienced by individuals in the past year (1 = '*Not at all'* to 4 = '*Very much'*). For scoring, the scale can be separated into three subscales (characterological shame, behavioral shame, and body shame) and it can be summed to provide a total measure of shame. For this study, the total shame score and the characterological and behavioral subscales were used. The total ESS scale obtained a Cronbach's alpha of .92 and a test-retest reliability of .83 suggesting adequate reliability of the measure (Andrews, Qian, & Valentine, 2002).

Forms of Self-Criticizing/Attacking and Self-Reassuring Scale (FSCRS). The FSCRS was used to measure the typical form and style of the participants' evaluation of the self in response to a setback or a disappointment. The 22-item self-report scale assesses levels of self-criticism and levels of self-reassurance. These are considered separate constructs rather than polar ends of a unitary construct (Gilbert, Clarke, Hempel, Miles, & Irons, 2004). The FSCRS uses a 5-point Likert -type scale ranging from '*Not at all like me'* to '*Extremely like me'*. Questions are grouped to produce a score for

"Inadequate Self" (e.g., 'I think I deserve my self-criticism'), "Reassure self" (e.g., 'I find it easy to like myself.'), and "Hated Self" (e.g., 'I have a sense of disgust with myself.'). The FSCRS demonstrated good internal consistency, ranging from .90 to .86 (Gilbert et al., 2004).

Math Shame Scale (MSS). ***Scale/item development.*** The MSS was designed to assess participants' level of math-related shame. This self-report measure consists of 30 items and was created by drawing from research done by Bekdemir (2010) and Bibby (2002). The MSS is divided into two sections, including one assessing an individual's affective and cognitive experiences of math shame and one measuring specific potentially math-shaming events. Questions regarding affective and cognitive experiences of shame during math were formed from the themes found in both Bibby's interviews and through my observations drawn from personal and professional experiences as a math and statistics tutor.

Questions regarding negative experiences, or potentially shaming events, related to math were formed from themes gathered in Bekdemir's study using Jackson and Leffingwell's (1999) qualitative measure of the Worst Experience and Most Troublesome Mathematics Classroom Experience Reflection Test (WMTMCERT). These themes ranged from experiences where instructors displayed hostile behaviors to experiences where math instructors displayed inadequate math abilities. The relevance of inadequate math abilities to an individual's experience of shame was understood as a potentially indirect shaming event where, for example, a math instructor struggles to solve a math problem and the student believes, "If they can't solve this problem and they have a degree in this, how can I ever understand it." These potential shaming events were expanded to include parents/caregivers, peers, and siblings/similarly aged relatives.

Previously discussed as the defining feature of shame, items were developed with a focus on anchoring negative evaluations to the self and an individual's sense of worth, specifically in relationship to math, in order to distinguish math shame from math self-efficacy and math anxiety. These items are rated on a Likert-type scale from 0 to 4 with descriptions ranging from '*Not at all true'* to '*Almost always true'*. These items are indicated in Table 1. Preliminary research showed the MSS to be an internally consistent, unitary scale with a Cronbach's Alpha of .95 and a principal components analysis supporting a single-component measure (Parker, Lewallen, Walsdorf, Cervantes, & Kolts, 2014).

Table 1

Math Shame Scale (MSS) Items

Affective and Cognitive Experiences of Math Shame -- Section I

1. I have felt like I could not keep up with my math class.
2. I have felt worthless after getting back a math test.
3. I have been the last person to understand a mathematical concept.
4. I have fears of looking incompetent in front of peers in my math classes.
5. I have often told others that I am inherently not good at math.
6. I often feel incompetent when doing my math homework.
7. I have avoided a career based on the number of mathematics classes required.
8. I will never understand math, no matter how hard I work.
9. I have felt like I'm the only one who doesn't understand a mathematical concept.
10. I prefer that others not know I struggle with math.
11. I have felt worthless when compared to others in my math class.
12. I've felt ashamed at my math ability.
13. Others look down on my struggles with math.

14. My struggles with math make me feel stupid.

Situational Experiences of Math Shame -- Section II

1. In the past, my **math instructors** have

    made me feel incompetent.

    displayed hostile behavior.

    displayed inadequate math abilities.

    made me feel poor at math.

2. In the past, my **peers** have

    made me feel incompetent.

    displayed hostile behavior.

    displayed inadequate math abilities.

    made me feel poor at math.

3. In the past, my **parents/caregivers** have

    made me feel incompetent.

    displayed hostile behavior.

    displayed inadequate math abilities.

    made me feel poor at math.

4. In the past, my **siblings/similarly aged relatives** (indicate N/A if no one matches that description) have

    made me feel incompetent.

    displayed hostile behavior.

    displayed inadequate math abilities.

    made me feel poor at math.

Mathematics Anxiety Rating Scale-Revised (MARS-R). The MARS-R was used to assess the participants' level of math anxiety. This self-report measure consists of 24 items. These items are rated on a Likert-type scale from 0 to 4 with descriptions ranging from '*I experience no anxiety*' to '*I experience extreme anxiety*'. Questions fall within two subscales (learning mathematics anxiety and mathematics evaluation anxiety).

An example item would be to indicate your level of anxiety when "working on an abstract mathematical problem." The MARS-R has a coefficient alpha reliability estimate of .98, and was correlated .97 with the 98-item full scale Mathematics Anxiety Rating Scale (MARS; Plake & Parker, 1982).

Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ). The MSEAQ was used to assess the participants' perceptions of his or her self-efficacy in math and his or her feelings of anxiety towards math as it relates to various aspects of math-related learning in college. This self-report measure consists of 28 items. These items are rated on a Likert-type scale from 1 (*'never'*) to 5 (*'usually'*). Questions are grouped into five categories of an individual's level of anxiety and self-efficacy in math, including general self-efficacy, grade anxiety, future anxiety, in-class anxiety, and assignment anxiety. Example items for each category are as follows: general factor (e.g., 'I believe I can understand the content in a mathematics course.'), grade factor (e.g., 'I worry that I will not be able to get a good grade in my mathematics course.'), future factor (e.g., 'I worry that I will not be able to use mathematics in my future career when needed.') in-class factor (e.g., 'I feel confident enough to ask questions in my mathematics class.'), and assignment factor (e.g., 'I believe that I can complete all of the assignments in a mathematics course.'). The MSEAQ obtained a Cronbach's coefficient alpha of .96, and showed significant correlations with other measures of math self-efficacy and math anxiety (including the MARS-R) without being considered a redundant measure of either construct (May, 2009).

Self-Compassion Scale (SCS). The SCS was used to assess the participants' level of self-compassion. The 26-item scale assesses self-compassion through six subscales that address contrasting components: self-kindness versus self-judgment, common humanity versus isolation, and mindfulness versus over-identification. The SCS uses a 5-point Likert-type scale ranging from '*Almost never*' to '*Almost always,*' yielding a total score reflecting a global measurement of self-compassion. The SCS has an internal consistency of .92 and it demonstrates good construct validity and test-retest reliability (Neff, 2003). Research has already supported the negative relationship between self-compassion and shame measures (see Woods & Proeve, 2014).

Procedure

Students were recruited from the on-campus tutoring center, math lab, and undergraduate courses at the university. Participants were asked to complete the series of questionnaires through an online survey system. Individuals logged into and signed up for the study through a university run website (ewu.sona-systems.com). Once a participant signed up for the study, they were redirected to an external website where the survey was located (Qualtrics.com). This system allowed all participants' data to be anonymous to the researchers while still allowing the granting of extra credit to individuals who completed the survey. For each participant, the order of the questionnaires was randomized through the survey program. All procedures were reviewed and approved by the sponsoring university's Institutional Review Board.

Results

Preliminary Analysis

In order to determine the final item pool for the measure, I conducted corrected item-to-total correlations. No items were correlated at less than .30. Therefore, as recommended by Field (2009), no items were eliminated from the measure. This resulted in the retention of all 30 original items shown in Table 2. Mean corrected item-to-total correlation was .59 (*SD* = .15). Subsequent analyses, within the preliminary analysis, were conducted using the original 30 items of the MSS.

Table 2

Corrected Item-to-Total Correlations of 30-item MSS

Item	Item-to-Total Correlation
I have felt like I could not keep up with my math class.	.67
I have felt worthless after getting back a math test.	.73
I have been the last person to understand a mathematical concept.	.75
I have fears of looking incompetent in front of peers in my math classes.	.67
I have often told others that I am inherently not good at math.	.65
I often feel incompetent when doing my math homework.	.76
I have avoided a career based on the number of mathematics classes required.	.59
I will never understand math, no matter how hard I work.	.67
I have felt like I'm the only one who doesn't understand a mathematical concept.	.73
I prefer that others not know I struggle with math.	.58
I have felt worthless when compared to others in my math class.	.77
I've felt ashamed at my math ability.	.80
Others look down on my struggles with math.	.66
My struggles with math make me feel stupid.	.79
In the past, my **math instructors** have	
made me feel incompetent.	.67
displayed hostile behavior.	.45
displayed inadequate math abilities.	.34
made me feel poor at math.	.62
In the past, my **peers** have	
made me feel incompetent.	.64
displayed hostile behavior.	.50

Item	Item-to-Total Correlation
In the past, my **peers** have	
displayed inadequate math abilities.	.36
made me feel poor at math.	.68
In the past, my **parents/caregivers** have	
made me feel incompetent.	.52
displayed hostile behavior.	.47
displayed inadequate math abilities.	.37
made me feel poor at math.	.55
In the past, my **siblings/similarly aged relatives** have	
made me feel incompetent.	.48
displayed hostile behavior.	.40
displayed inadequate math abilities.	.30
made me feel poor at math.	.51

In order to evaluate the structure of the two MSS subscales (Affective and Cognitive Experiences and Situational Experiences), I conducted a principal components analysis (PCA) with oblique rotation (oblimin). As recommended by Field (2009) and Costello and Osborne (2005), an oblique rotation was used due to the anticipation that the components would be correlated. The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis, KMO = .93, and all KMO values for individual items were > .79, which is above the accepted minimum of .5. Barlett's test of sphericity indicated that inter-item correlations were sufficient for PCA, χ^2 (435) = 9865.17, $p < .001$.

An initial PCA analysis was preformed to obtain eigenvalues for each component of the measure. Six components had eigenvalues above Kaiser's criterion of 1.00. In combination, these six components explained 71.58% of the variance in the item set. The scree plot was slightly ambiguous, showing inflections justifying retaining either 2 or 6 components. Given the relatively large sample size, the average communalities after extraction exceeding .70, and the convergence of Kaiser's criterion and the scree plot on six components, six components were retained. Pattern Matrix component loading for the items after rotation are shown in Table 3.

Table 3

Pattern Matrix Component Loadings for Exploratory Principal Components Analysis with Oblimin Rotation of 30-item Math Shame Scale

Item	ACES	PCE	MIE	PE	SSE	IMA
I have felt like I could not keep up with my math class.	**.83**	-.07	.14	-.15	.02	.05
I have felt worthless after getting back a math test.	**.82**	.02	.11	-.04	.03	-.02
I have been the last person to understand a mathematical concept.	**.84**	-.03	.07	-.04	-.04	.01
I have fears of looking incompetent in front of peers in my math classes.	**.78**	-.09	-.06	.08	-.00	.16
I have often told others that I am inherently not good at math.	**.76**	.01	-.11	.13	.04	-.03
I often feel incompetent when doing my math homework.	**.85**	-.04	.02	.02	-.04	.01
I have avoided a career based on the number of mathematics classes required.	**.70**	.15	-.06	-.03	.01	-.06
I will never understand math, no matter how hard I work.	**.72**	.05	.03	.00	-.06	-.12
I have felt like I'm the only one who doesn't understand a mathematical concept.	**.82**	.01	.05	-.01	-.03	-.08
I prefer that others not know I struggle with math.	**.67**	-.08	-.04	-.04	-.14	.14
I have felt worthless when compared to others in my math class.	**.79**	.01	.03	.12	-.01	-.02
I've felt ashamed at my math ability.	**.86**	.10	-.01	.05	.03	-.01
Others look down on my struggles with math.	**.49**	.17	.11	.27	.06	-.07
My struggles with math make me feel stupid.	**.82**	.05	.04	.06	.02	.03

Item	ACES	PCE	MIE	PE	SSE	IMA
In the past, my **math instructors** have						
made me feel incompetent.	.24	.04	**.74**	.03	-.05	-.06
displayed hostile behavior.	-.12	.09	**.83**	.11	-.03	-.11
displayed inadequate math abilities.	.04	-.08	**.77**	-.04	.03	.18
made me feel poor at math.	.19	.06	**.74**	.01	-.05	-.06
In the past, my **peers** have						
made me feel incompetent.	.15	.02	.02	**.77**	-.15	-.07
displayed hostile behavior.	-.06	.16	.06	**.78**	-.02	.00
displayed inadequate math abilities.	-.03	-.18	.12	**.60**	.02	**.46**
made me feel poor at math.	.20	.07	.04	**.71**	-.10	-.04
In the past, my **parents/caregivers** have						
made me feel incompetent.	.01	**.83**	.04	.05	-.14	-.01
displayed hostile behavior.	.01	**.86**	.03	-.00	-.02	.19
displayed inadequate math abilities.	.08	.38	.02	.00	.04	**.70**
made me feel poor at math.	.05	**.81**	.05	.09	-.09	-.00
In the past, my **siblings/similarly aged relatives** have						
made me feel incompetent.	.02	-.00	.01	.01	**-.92**	-.01
displayed hostile behavior.	-.08	.15	.04	-.03	**-.71**	.21
displayed inadequate math abilities.	.01	.04	.03	.05	-.17	**.80**
made me feel poor at math.	.06	-.01	.00	.10	**-.86**	-.11
Rotation Sums of Squared Loadings	10.72	4.68	5.23	5.33	4.74	2.13

Note. Component loadings >.40 are in boldface. ACES = Affective and Cognitive Experiences of Shame; PCE = Parents/Caregivers Experiences; MIE = Math Instructor Experiences; PE = Peer Experiences; SSE = Sibling/Similarly-aged Experiences; IMA = Inadequate Math Abilities.

Generally speaking, this component structure fit important aspects of the proposed elements of math shame. However, a few items clustered in an unexpected way. Items related to experiences associated with inadequate math abilities displayed by others, particularly family members, clustered into an unexpected component. Considering the clustering of items, I named component 1 “Affective and Cognitive Experiences of Shame” (ACES), component 2 “Parents/Caregivers Experiences” (PCE), component 3 “Math Instructor Experiences” (MIE), component 4 “Peer Experiences” (PE), component 5 “Sibling/Similarly-aged Experiences” (SSE), and component 6 “Inadequate Math Ability” (IMA). Table 4 indicates the components to which each item belongs ordered by loading size.

Table 4

Ordered Pattern Matrix Component Loadings for Exploratory Principal Components Analysis with Oblimin Rotation of 30-item Math Shame Scale

Item	ACES	PCE	MIE	PE	SSE	IMA
I’ve felt ashamed at my math ability.	**.86**					
I often feel incompetent when doing my math homework.	**.85**					
I have been the last person to understand a mathematical concept.	**.84**					
I have felt like I could not keep up with my math class.	**.83**					
My struggles with math make me feel stupid.	**.82**					
I have felt like I’m the only one who doesn’t understand a mathematical concept.	**.82**					
I have felt worthless after getting back a math test.	**.82**					
I have felt worthless when compared to others in my math class.	**.79**					
I have fears of looking incompetent in front of peers in my math classes.	**.78**					
I have often told others that I am inherently not good at math.	**.76**					
I will never understand math, no matter how hard I work.	**.72**					
I have avoided a career based on the number of mathematics classes required.	**.70**					
I prefer that others not know I struggle w/math.	**.67**					

Item	ACES	PCE	MIE	PE	SSE	IMA
Others look down on my struggles with math.	**.49**					
In the past, my **parents/caregivers** have						
displayed hostile behavior.		**.86**				
made me feel incompetent.		**.83**				
made me feel poor at math.		**.81**				
In the past, my **math instructors** have						
displayed hostile behavior.			**.83**			
displayed inadequate math abilities.			**.77**			
made me feel poor at math.			**.74**			
made me feel incompetent.			**.74**			
In the past, my **peers** have						
displayed hostile behavior.				**.78**		
made me feel incompetent.				**.77**		
made me feel poor at math.				**.71**		
displayed inadequate math abilities.				**.60**		
In the past, my **siblings/similarly aged relatives** have						
made me feel incompetent.					**-.92**	
made me feel poor at math.					**-.86**	
displayed hostile behavior.					**-.71**	
In the past, my **siblings/similarly aged relatives** have						
displayed inadequate math abilities.						**.80**
In the past, my **parents/caregivers** have						
displayed inadequate math abilities.						**.70**

Note. ACES = Affective and Cognitive Experiences of Shame; PCE = Parents/Caregivers Experiences; MIE = Math Instructor Experiences; PE = Peer Experiences; SSE = Sibling/Similarly-aged Experiences; IMA = Inadequate Math Abilities.

Table 5 features the 489 participants' mean scores, standard deviations, possible score ranges and Cronbach's alpha for the total MSS and each extracted component. To analyze the reliability of the MSS, the internal consistency of the entire 30-item measure was examined. The internal consistency for the MSS was considered to be excellent (α = .95). The internal consistency for the separate components of the MSS ranged from 'good' to 'excellent' (alpha coefficients between .74 and .96). Therefore, in terms of internal consistency, the MSS and its components are considered to be reliable measures.

Table 5

Mean, Standard Deviation, Score Range, and Cronbach's Alpha for Scale and Extracted Components

	# of Items	Mean	SD	Possible score range	α
MSS-ACES	14	21.66	15.62	0-56	.96
MSS-SE	16	12.08	10.81	0-64	.90
Parents/Caregivers	3	1.78	3.07	0-12	.91
Math Instructors	4	3.95	3.78	0-16	.86
Peers	4	3.58	3.41	0-16	.83
Siblings/Similarly-aged	3	1.72	2.73	0-12	.85
Inadequate Math Abilities	2	1.57	2.01	0-8	.74
MSS-Total	30	32.78	22.96	0-120	.95

Note. For the MSS: ACES = Affective and Cognitive Experiences of Shame, SE = Situational Experiences

After examination of the component structure of the MSS, it was decided to separate the two sections of the MSS (i.e., MSS-ACES and MSS-SE) into independent scales. The first 14 items of the MSS (i.e., the MSS-ACES) appear to measure affective and cognitive experiences of math shame, while the final 16 items of the MSS (i.e., the MSS-SE) assess potential math-related shaming situations or events that an individual has experienced. Further analysis including all six components is also provided. Correlations between each component are presented in Table 6.

The above analysis suggests that questions related to siblings/similarly-aged relatives are internally consistent (Sibling/Similarly-aged Experiences [SSE] α = .85 and

Inadequate Math Ability [IMA] α = .74) and explain a portion of variance in the item pool (SSE: 8.02% and IMA: 7.19%). However, it is important to note that of the 489 participants, 252 (65.6%) participants responded N/A (i.e., Not applicable) to questions regarding siblings/similarly-aged relatives.

Table 6

Correlation Between MSS Components

	ACES	PCE	MIE	PE	SSE	IMA
ACES	1	.38**	.51**	.49**	.35**	.20**
PCE		1	.40**	.44**	.53**	.44**
MIE			1	.54**	.37**	.29**
PE				1	.45**	.40**
SSE					1	.39**
IMA						1

Note. ** $p < .001$. For the MSS components: ACES = Affective and Cognitive Experiences of Shame, PCE = Parents/Caregivers Experiences, MIE = Math Instructor Experiences, PE = Peer Experiences, SSE = Sibling/Similarly-aged Experiences, IMA = Inadequate Math Abilities.

Construct Validity: Correlations Between MSS Scales and Various Measures

Positive correlations with math-related measures. A summary of the correlations between the MSS and the math-related measures are presented in Table 7. The MSS-ACES and MSS-SE showed strong positive relationships with various math-related constructs, specifically a number of areas of math anxiety. Correlations between the MSS-ACES and the MARS-R were significant, r (487) = .79, $p < .001$. Correlations between the MSS-SE and the MARS-R were also significant, r (487) = .50, $p < .001$. Other measures of math anxiety showed similarly strong positive associations with both scales of the MSS. However, the MSS-ACES consistently showed stronger positive correlations on math-related measures than did the MSS-SE. Results were consistent with hypotheses regarding math-related measures, specifically the MARS-R and the anxiety portions of the MSEAQ. This suggests that those who experience high levels of math-related shame also experience high levels of math anxiety. Additional correlations between all six components are presented in Table 8.

Table 7

Positive Correlations of the MSS Scales with Math-Related Measures

	MSS-ACES	MSS-SE
MSS-ACES	1	
MSS-SE	.55**	1
MARS-R	.79**	.50**
MSEAQ-IC	.62**	.35**
MSEAQ-A	.60**	.38**
MSEAQ-GA	.79**	.41**
MSEAQ-F	.79**	.43**

Note. ** $p < .001$. For the MSS: ACES = Affective and Cognitive Experiences of Shame, SE = Situational Experiences; MARS-R = Math Anxiety Rating Scale - Revised; For the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ): MSEAQ-IC = In-Class, MSEAQ-A = Assignment Factor, MSEAQ-GA = Grade Anxiety, MSEAQ-F = Future.

Table 8

Correlations of the MSS Components with Math-Related Measures

	ACES	PCE	MIE	PE	SSE	IMA
MARS-R	.79**	.35**	.49**	.43**	.33**	.17**
MSEAQ-IC	.62**	.20**	.37**	.31**	.22**	.15**
MSEAQ-A	.60**	.25**	.40**	.31**	.25**	.11*
MSEAQ-GA	.79**	.29**	.42**	.33**	.25**	.13**
MSEAQ-F	.79**	.30**	.41**	.37**	.30**	.16**

Note. * $p < .05$. ** $p < .001$. For the MSS components: ACES = Affective and Cognitive Experiences of Shame, PCE = Parents/Caregivers Experiences, MIE = Math Instructor Experiences, PE = Peer Experiences, SSE = Sibling/Similarly-aged Experiences, IMA = Inadequate Math Abilities; MARS-R = Math Anxiety Rating Scale - Revised; For the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ): MSEAQ-IC = In-Class, MSEAQ-A = Assignment Factor, MSEAQ-GA = Grade Anxiety, MSEAQ-F = Future.

Positive correlations with measures of anxiety and self-evaluation. A summary of the correlations between the MSS and measures of anxiety and self-evaluation are presented in Table 9. The MSS scales showed significant positive relationships with various non-math-related constructs, specifically general anxiety, test anxiety, general shame, and self-evaluation styles. Results were consistent with hypotheses of positive correlations between an individual's experiences of math shame and his or her experiences of general and test anxiety. The MSS-ACES exhibited significant positive relationships with the BAI, r (487) = .48, $p < .001$, and the CTAS, r (487) = .61, $p < .001$. This suggests that individuals who experience high levels of math-related shame also tend to experience high levels of general anxiety and test anxiety.

Results also supported hypotheses regarding positive correlations between individuals' affective and cognitive experiences of math shame (MSS-ACES) and their experiences of general shame, r (487) = .51, $p < .001$, specifically characterological experiences of shame, r (487) = .48, $p < .001$, and behavioral experiences of shame, r (487) = .48, $p < .001$. This suggests that individuals who experience high levels of math-related shame also experience high levels of shame related to their personal characteristics and their behaviors.

Additionally, results were consistent with hypotheses of positive correlations between an individual's affective and cognitive experiences of math shame (MSS-ACES) and their typical self-evaluation styles when experiencing a setback or disappointment. The MSS-ACES showed a significant positive relationships with the inadequate-self portion of the FSCRS, r (487) = .47, $p < .001$, and the hated-self portion of the FSCRS, r (487) = .40, $p < .001$. This suggests that individuals who experience high levels of cognitive and affective math-related shame tend to relate to themselves with higher levels of self-criticism in the form of believing themselves to be inadequate or believing they should be hurt or persecuted for their shortcomings. The MSS-SE showed the same pattern of significant positive correlations with measures of anxiety and self-evaluation. Additional correlations between all six components are presented in Table 10.

Table 9

Positive Correlations of the MSS Scales with Measures of Anxiety and Self-Evaluation

	MSS-ACES	MSS-SE
BAI	.48**	.44**
CTAS	.61**	.31**
ESS-Total	.51**	.43**
ESS-Characterological	.48**	.42**
ESS-Behavioral	.48**	.40**
FSCRS-Inadequate	.47**	.41**
FSCRS-Hated	.40**	.44**

Note. ** $p < .001$. For the MSS: ACES = Affective and Cognitive Experiences of Shame, SE = Situational Experiences; BAI = Beck Anxiety Inventory; CTAS = Cognitive Test Anxiety Scale; For the Experiences of Shame scale (ESS): ESS-Characterological = Characterlogical Shame, ESS-Behavioral = Behavioral Shame; For the Forms of Self-Criticizing/Attacking and Self-Reassuring Scale (FSCRS): FSCRS-Inadequate = Inadequate Self; FSCRS-Hated = Hated Self.

Table 10

Correlations of the MSS Components with Measures of Anxiety and Self-Evaluation

	ACES	PCE	MIE	PE	SSE	IMA
BAI	.48**	.29**	.38**	.41**	.29**	.19**
CTAS	.61**	.23**	.32**	.25**	.21**	.10*
ESS-Total	.51**	.32**	.34**	.42**	.28**	.20**
ESS-Characterological	.48**	.31**	.32**	.39**	.32**	.20**
ESS-Behavioral	.48**	.30**	.32**	.39**	.21**	.18**
FSCRS-Inadequate	.47**	.27**	.31**	.40**	.29**	.26**

	ACES	PCE	MIE	PE	SSE	IMA
FSCRS-Hated	.40**	.32**	.31**	.43**	.35**	.21**

Note. * $p < .05$. ** $p < .001$. For the MSS: ACES = Affective and Cognitive Experiences of Shame, PCE = Parents/Caregivers Experiences, MIE = Math Instructor Experiences, PE = Peer Experiences, SSE = Sibling/Similarly-aged Experiences, IMA = Inadequate Math Abilities; BAI = Beck Anxiety Inventory; CTAS = Cognitive Test Anxiety Scale; For the Experiences of Shame scale (ESS): ESS-Characterological = Characterlogical Shame, ESS-Behavioral = Behavioral Shame; For the Forms of Self-Criticizing/Attacking and Self-Reassuring Scale (FSCRS): FSCRS-Inadequate = Inadequate Self; FSCRS-Hated = Hated Self.

Relationships with measures of efficacy and self-compassion. A summary of the correlations between the MSS and measures of self-efficacy and self-compassion are presented in Table 11. The MSS scales showed significant negative relationships with measures of math self-efficacy, tendency to self-reassure, and self-compassion. Results were consistent with the hypothesis of a negative correlation between individuals' experiences of math shame and their level of math-related self-efficacy. The correlation between the MSS-ACES and the self-efficacy portion of the MSEAQ was significant, r (487) = -.75, $p < .001$. This suggests that individuals who experience high levels of affective and cognitive math-related shame tend to lack belief in their capability to engage with math-related material. Results also supported hypotheses regarding negative correlations between an individual's affective and cognitive experiences of math shame (MSS-ACES) and their experiences of self-compassion and self-reassurance, r (487) = -.39, $p < .001$, and r (487) = -.22, $p < .001$, respectively. This suggests that individuals who experience high levels of affective and cognitive math-related shame are less likely to engage with themselves in self-compassionate and self-reassuring ways. Additional correlations between all six components are presented in Table 12.

Table 11

Correlations of the MSS with Measures of Efficacy and Self-compassion

	MSS-ACES	MSS-SE
MSEAQ-SE	-.75**	-.38**
FSCRS-Reassure	-.22**	-.23**
SCS	-.39**	-.33**

Note. ** *p* < .001. For the MSS: ACES = Affective and Cognitive Experiences of Shame, SE = Situational Experiences; For the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ): MSEAQ-SE = Math Self-Efficacy; For the Forms of Self-Criticizing/Attacking and Self-Reassuring Scale (FSCRS): FSCRS-Reassure = Self-Reassurance Tendencies; SCS = Self-Compassion Scale.

Table 12

Correlations of MSS Components with Measures of Efficacy and Self-compassion

	ACES	PCE	MIE	PE	SSE	IMA
MSEAQ-SE	-.75**	-.23**	-.41**	-.30**	-.28**	-.09
FSCRS-RE	-.22**	-.20**	-.16**	-.18**	-.16**	-.14**
SCS	-.39**	-.22**	-.25**	-.30**	-.23**	-.18**

Note. ** *p* < .001. For the MSS: ACES = Affective and Cognitive Experiences of Shame, PCE = Parents/Caregivers Experiences, MIE = Math Instructor Experiences, PE = Peer Experiences, SSE = Sibling/Similarly-aged Experiences, IMA = Inadequate Math Abilities; For the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ): MSEAQ-SE = Math Self-Efficacy; For the Forms of Self-Criticizing/Attacking and Self-Reassuring Scale (FSCRS): FSCRS-Reassure = Self-Reassurance Tendencies; SCS = Self-Compassion Scale.

Criterion Validity: Relationship Between MSS and Math Grades

A summary of the results is presented in Table 13. The MSS scales showed significant negative relationships with self-reported average and most recent math course grades (reported on a 4.0 scale). Both correlations between the MSS-ACES and an individual's average math course grade and the correlation between the MSS-ACES and an individual's most recent course grade were significant, r (487) = -.48, $p < .001$ and r (487) = -.34, $p < .001$, respectively. This suggests that individuals who experience high levels of affective and cognitive math-related shame tend to perform more poorly in math-related courses. Additional correlations between all six components are presented in Table 14.

Table 13

Relationship Between MSS and Average and Most Recent Math Course Grades

	MSS-ACES	MSS-SE
Average Math Grade	-.48**	-.22**
Most Recent Math Grade	-.34**	-.13*

Note. * $p = .002$. ** $p < .001$. For the MSS: ACES = Affective and Cognitive Experiences of Shame, SE = Situational Experiences.

Table 14

Relationship Between MSS Components and Average and Most Recent Math Course Grades

	ACES	PCE	MIE	PE	SSE	IMA
Average Math Grade	-.48**	-.23**	-.25**	-.09*	-.13**	-.03
Most Recent Math Grade	-.34**	-.14**	-.18**	-.04	-.07	-.08

Note. * $p < .05$. ** $p < .001$. For the MSS: ACES = Affective and Cognitive Experiences of Shame, PCE = Parents/Caregivers Experiences, MIE = Math Instructor Experiences, PE = Peer Experiences, SSE = Sibling/Similarly-aged Experiences, IMA = Inadequate Math Abilities.

Discussion

The present analysis supports the MSS as a reliable and valid measure of math-related shame consisting of two subscales: a 14-item measure of affective and cognitive experiences of math shame (i.e., MSS-ACES) and a 16-item measure of potential math-related shaming situations or events experienced (i.e., MSS-SE). The MSS-ACES and the MSS-SE showed excellent internal consistency and displayed good component structure. Component analysis supported the proposed structure of math-related shame in terms of affective and cognitive experiences and situational experiences, specifically experiences with math instructors, parents/caregiver, peers, and siblings/similarly-aged relatives.

Furthermore, this study provided evidence of construct validity for the MSS scales, illuminating relationships between experiences of math shame and other measures that would be expected to relate to math shame. Results revealed strong positive relationships between both MSS scales and general shame, general anxiety, math anxiety, test anxiety, and self-critical tendencies. In addition, the MSS scales were inversely related to self-compassion, self-reassurance tendencies, and math self-efficacy. These findings are consistent with the initial examination of the MSS and relevant literature, further supporting relationships between self-compassion and shame (Woods & Proeve, 2014) and self-critical tendencies and experiences of shame (Gilbert & Procter, 2006).

Moreover, this study provided evidence for criterion validity through the inverse relationship between the MSS scales and an individual's self-reported average and most recent math course grades. The extant literature supports the relationship between high levels of math anxiety and poorer performance on math-related tasks, specifically standardized math achievement tests, math professors' grades, and researcher-made math achievement tests (Ma, 1999). These results align with existing patterns of poorer math performance and negative emotional and cognitive reactions to math. This further supports the validity of the MSS scales as measurements of math shame. However, it is important to note that the relationship between math shame and poorer grades is correlational in nature, which leaves the causal direction ambiguous. In other words, math shame could be leading to poorer math grades, poorer math grades could be leading to math shame, a combination of both, or a third variable could be affecting the relationship.

Distinctions Between MSS-ACES and MSS-SE

Given the distinct constructs the MSS-ACES and the MSS-SE scales of the MSS attempt to measure, it is important to highlight their differences. Although both scales showed significant positive and negative correlations, the MSS-ACES was consistently more strongly correlated with other measures, especially measures related to math self-efficacy, math anxiety, and math course grades. When comparing the MSS-ACES and the MSS-SE on non-math-related measures, specifically with general measures of shame, self-compassion, and self-evaluation tendencies, the MSS-ACES and the MSS-SE produced more congruent correlations.

One aspect to consider is the absences of a math-related anchor in two of the math shaming situation (MSS-SE) items within the parents/caregivers, peers, and siblings/similarly-aged relatives categories. The MSS-SE items “made me feel incompetent” and “displayed hostile behavior,” when not asked in relation to experiences with math instructors, provides a level of ambiguity about whether or not these items are being asked in reference to experiences with math. It is possible that individuals responded in a general matter, answering whether, for example, their parent/caregivers were hostile to them in all types of situations. Potentially, when compared to the MSS-ACES, the MSS-SE produced lower correlations with math-related experiences due to the lack of a math-related anchor. Anchoring the above-mentioned items to math-related experiences (e.g., “made me feel incompetent in math” and “displayed hostile behavior in math-related situations”) could ensure that participants understood that these items specifically targeted math-related shaming experiences. Further research could modify these items, exploring the effect this change has on the observed correlations and component structures of the MSS-SE.

Additionally, the inadequate math ability (IMA) component obtained in the preliminary analysis and the MSS-SE analysis presents possible evidence of the potential for indirect math-related shaming experiences. The items of the MSS-SE were developed with the intention to measure the presence of direct experiences of math shaming, such as a math instructor behaving hostilely towards an individual or a sibling responding to an individual in a way that make that individual feel incompetent about their math abilities. The presence of the IMA component suggests that an individual's perception about his or her family members' math abilities could be important to his or her experiences of math shame.

Parallel to the stereotype threat literature, individuals may view their family as a social group, of which they are a part, who have a negative stereotype about their math ability. This reasoning suggests that individuals may potentially acquire experiences of math shame indirectly, through hearing their family members talk about their math inabilities or by witnessing their family members struggle with math, providing the cognition that, "my family is poor at math, and since I am a part of my family, I, also, must be poor at math." This suggests that identifying one's family as having inadequate math abilities could be a precursor to cognitive and affective experiences of math shame. However, it is important to note that the IMA component produced the lowest correlations with the various measures used to assess construct validity. Given the data suggesting the internal consistency of the component and its placement within the component structure, the IMA component, and its relationship with math shame, merits further study.

Despite the similarities in the correlational results found for the MSS-SE and the MSS-ACES, they appear to measure different aspects of math shame, with the MSS-ACES measuring felt experiences and cognitive attributes of math shame, while the MSS-SE measures situations that could potentially serve as math-related shaming events. Therefore, the MSS-ACES should be considered a true measure of experienced math shame, while the MSS-SE should be considered a measure of math-related shaming situations, which may or may not lead to affective and cognitive experiences of math shame. For this reason, it makes sense to score these scales separately rather than to combine them into an omnibus score.

In conclusion, separately, the current results support the MSS-ACES and the MSS-SE as reliable and valid measures of math-related shame and potential math-shaming experience. It is important to consider the implications of this evidence for the proposed theory of math anxiety. As discussed previously, the theory proposes that math anxiety stems from a shame-related experience or series of experiences that allow for situational, emotional, and cognitive events to create and maintain contexts in which math anxiety is created, elaborated, and perpetuated. The validation of the MSS scales allow for future research to systematically focus on experiences of shame in math. For example, future research could group individuals on the self-reported presence or absence of math-shaming experiences and utilize the MSS scales to explore participants' cognitive, and affective experiences of math shame, anxiety, and performance. Group differences could provide empirical evidence for the role of math-related shaming events in producing math shame as well as related anxiety and impaired math performance.

As suggested above, the MSS provides a research tool that can assist in understanding the dynamics of math anxiety, especially in reference to the posited role that math-shame plays in math anxiety. The MSS is the only known measure of math shame, which provides researchers with the ability to gather a fuller understanding of the etiology and maintenance of math anxiety so that future interventions that target the maintenance pattern of math anxiety can be effectively designed.

The limitations of this study include the use of a single sample and the self-report nature of the criterion validity data (i.e., recent and last math grades). Future studies that seek to verify the validation of the MSS may benefit from multiple, larger sample sizes that administer the MSS at multiple junctures. Additionally, it may be beneficial to assess the criterion validity of the MSS against an individual's official transcripts rather than relying on self-report.

With these limits in mind, the most intriguing concept to further explore is the potential utility of the MSS to investigate experiential situations of math anxiety and math shame. Inducing math-related experiences of shame in a laboratory setting could provide vital information to further examine the current proposed theory of math anxiety. Using the MSS to further investigate the theory of math anxiety, by exploring cognitive, affective, and situational experiences of math shame, could reveal potential gender, age, ethnicity or situational differences in experiences of math shame, similar to the differences in math performance when women or minorities are under stereotype threat (see Johnson et al., 2012).

Most importantly for current and future teachers, parents, and educational boards, the MSS provides further avenues to research the effects of math shame on an individual's educational and career choices. It is important to continue to gather information that links math shame to math anxiety, but provides evidence of their separate functions. A deeper understanding of their similarities and their differences will provide a wealth of knowledge for those interested in creating interventions that target difficulties with math.

In conclusion, this study supported the MSS scales as reliable and valid measures of affective and cognitive math shame and situational experiences of math shame. This investigation validates a measure of math shame for future research in the area of math anxiety, math learning, and educational experiences of shame. These areas are currently, and continuing to become, increasingly important in our mathematically-driven society. Only when individuals' experiences with math can be understood in a fuller, richer context, can society, parents, peers, professors, and individuals alike, gain the ability to engage with math in a curious rather than anxious manner.

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