STEREOTYPE THREAT AND SELF-AFFIRMATION: HOW SELF-AFFIRMATION PROTECTS THE PERFORMANCE OF STIGMATIZED INDIVIDUALS

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CHAPTER I: INTRODUCTION

Available evidence has demonstrated the existence of a persistent gender gap in mathematics intensive domains (Fennema & Sherman, 1977; Hyde, Fennema, & Lamon, 1990). For instance, empirical investigations have shown that male students routinely demonstrate superior performance on standardized measures of mathematical ability – such as the Scholastic Achievement Test (SAT) – beginning in high school and persisting through college (Hyde et al., 1990). Further, available evidence suggests that females are less likely to pursue math-related college majors and occupations compared to their male counterparts (American Association of University Women, 1999; College Board, 2016; Hyde et al., 1990; Snyder & Dillow, 2012; Williams, & Barnett, 2009). Historically, explanations for gender differences in mathematical performance and interest have emphasized the role of innate differences in the mathematical ability of males and females and the influence of differential mathematical expectations stemming from exposure to sociocultural factors – such as gender differentiated mathematical expectations endorsed by caretakers (Benbow & Stanley, 1982a; 1982b; Eccles, Jacobs, & Harold, 1990). However, amidst evidence questioning the sufficiency of genetic and sociocultural explanations, researchers have postulated an alternative theoretical account emphasizing the role of immediate situational threat in the underperformance of females in math-related domains (Steele & Aronson, 1995; Steele, 1997).

Stereotype Threat Theory

In the first published description of stereotype threat, Steele and Aronson (1995) postulated the chronic underperformance of stigmatized individuals is the result of a “social-psychological predicament” resulting from the consideration of negative group-based stereotypes within performance events. According to Steele and Aronson (1995), members of stigmatized
social groups routinely encounter situations where they fear their behavior will be interpreted as evidence validating negative stereotypes associated with their social identity (Steele, 1997; Steele & Aronson, 1995; Spencer, Logel, & Davies, 2016). Steele argued this apprehension – known as stereotype threat – undermines performance by creating extra pressure that stigmatized individuals must manage while working to complete stereotype-relevant tasks. In the past 20 years, a substantial body of literature has developed examining the influence of stereotype threat on immediate performance, demonstrating that stereotype threat activates behavioral, cognitive, and emotional reactions that interfere with effective maintenance and manipulation of task-relevant information (Lamont, Swift, & Abrams, 2015; Nguyen & Ryan, 2008; Spencer et al., 2016).

Steele and Aronson (1995) also predicted prolonged exposure to stereotype threat might prompt defensive reactions among stigmatized individuals, potentially undermining motivation and interest in stereotype-relevant domains. As such, chronic activation of negative stereotypes can lead stigmatized individuals to restructure their self-concept to minimize the importance of stereotype-relevant domains in an effort to prevent future episodes of stereotype threat – a process called disidentification (Steele, 1997). Supporters of stereotype threat theory have claimed disidentification as one of the most damaging outcomes of stereotype threat (Aronson, Blanton, & Cooper, 1995; Steele, 1997). However, researchers have only recently begun to design and conduct experiments to test the influence of stereotype threat on individual’s identification with stereotype-relevant domains (Spencer et al., 2016).
Stereotype Threat and Female Math Performance

Explorations of societal stereotypes have uncovered evidence of persistent negative stereotypes related to the mathematical ability of females (Jacob & Eccles, 1985). For instance, many in our society hold stereotypical beliefs that females possess inferior mathematical ability compared to their male counterparts (Eccles, Jacobs & Harold, 1990). Given the prevalence of negative stereotypes related to female mathematical performance in contemporary society, stereotype threat theory holds that reminders of this negative stereotype (e.g., numerical imbalance, stereotypic advertisements, etc.; Davies et al., 2002; Murphy et al., 2007) will generate feelings of stereotype threat, contributing to the underperformance of females on mathematical tasks (Spencer, Steele, & Quinn, 1999). Research has confirmed this broad expectation by demonstrating that females exposed to threatening contextual cues (e.g., suggestions of gender differences on mathematical tasks) routinely perform worse on measures of mathematical ability – such as the SAT and GRE – than females working within situations devoid of threatening cues (O’Brien & Crandall, 2003; Nguyen & Ryan, 2008; Spencer et al., 1999).

Studies exploring the influence of negative societal stereotypes on performance have employed a variety of methods of evoking stereotype threat within experimental settings. For example, researchers commonly maximize the experience of stereotype threat by emphasizing the diagnostic ability of experimental materials (i.e., Davies et al., 2002), noting the existence of performance differences between stereotyped and non-stereotyped groups on ability measures (Brown & Pinel, 2003), and exposing individuals to primes designed to make group identity salient prior to a performance event (Schamder & Johns, 2003). While the use of these various manipulations has been beneficial in establishing the generalizability of stereotype threat effects,
they have generated considerable confusion regarding the true nature of stereotype threat (Wout, Danso, Jackson, & Spencer, 2008). That is, it is unclear whether stereotype threat is best conceptualized a unique form of evaluative pressure, or a broad construct consisting of multiple forms of threat characterized by distinct triggers and independent mediational pathways through which threat can affect performance (Schmader et al., 2008; Wout et al., 2008).

Despite considerable evidence implicating stereotype threat in the underperformance of females in math-related domains, researchers remain unclear as to when females first become susceptible to the influence of stereotype threat (McKown, & Weinstein, 2003). Studies of the developmental trajectory of stereotype threat effects among female students have focused on the identification of individual difference variables that increase individuals’ susceptibility to stereotype threat (Aronson, 2002). Available evidence has indicated stigma consciousness as one of the primary determinants of individuals’ susceptibility to stereotype threat (Aronson, 2002). Stigma consciousness has been conceptualized as an individual’s awareness of stereotypes endorsed by social others and the extent to which he or she believes those stereotypes will influence interactions with social others (Pinel, 1999). Stereotype threat researchers have implicated perspective taking ability in the development of stigma consciousness (McKown & Weinstein, 2003). Logically, the development of stigma consciousness should coincide with developmental advancements in the ability to effectively consider and infer the social beliefs of others (McKown & Weinstein, 2003; Pinel, 1999; 2002). Empirical investigations have confirmed this broad prediction by demonstrating that females become increasingly susceptible to stereotype threat as they develop the capacity to infer negative societal stereotypes (McKown & Weinstein, 2003).
Mechanisms Contributing to Stereotype Threat Effects

While the negative impacts of stereotype threat on performance are well documented (Nguyen & Ryan, 2008; Spencer et al., 2016), researchers have been unable to come to a consensus regarding the mechanisms that contribute to underperformance among members of stigmatized groups. Contemporary researchers have developed two competing theoretical frameworks which they believe detail the most proximal mediator of the relationship between stereotype threat and performance. The first theoretical orientation – the Threat-Induced Potentiation of Prepotent Response Model – emphasizes the role of motivational factors and individual’s efforts to disconfirm negative stereotypes as the cause for performance difficulties (Jamieson & Harkins, 2007). The second theoretical orientation – the working memory depletion account – suggests underperformance is the result of behavioral, cognitive, and emotional processes that consume working memory resources required for optimal performance (Schmader et al., 2008).

Threat-Induced Potentiation of Prepotent Response Model

A key proposition of stereotype threat theory is the assertion that the effect occurs among members of stigmatized social groups who are highly motivated to disconfirm the content of negative stereotypes when confronted with stereotype activating contextual cues (Schmader & Beilock, 2012; Steele & Aronson, 1995). Consistent with the propositions of classic drive theory (Hull, 1943) and explanations of social facilitation effects (Cottrell, 1972), the Threat-Induced Potentiation of Prepotent Response Model (TIPPR) account suggests the activation of negative group-based stereotypes and the associated concern that their performance will be evaluated increases non-specific arousal and consequently the emission of dominant or well-learned response patterns (Jamison & Harkins, 2007; Schmader & Beilock, 2012). Generally speaking,
when confronted with a task that requires cognitively simple or well-learned responses, increased drive is predicted to result in increased performance. However, when confronted with a task that requires the implementation of cognitively complex or novel responses, increased drive is predicted to lead to reductions in performance (Zajonc, 1969; Waterman, 1969). In support of the TIPPR, studies have demonstrated that stereotype threat interacts with task difficulty to influence performance. Under stereotype threat conditions, individuals commonly demonstrate enhanced performance on simple tasks (e.g. three-digit multiplication problems; O’Brien & Crandall, 2003) but decreased performance on cognitively complex tasks (e.g., quantitative SAT problems; Ben-Zeev, Fein, & Inzlicht, 2005).

The Working Memory Depletion Account

A substantial body of empirical evidence has demonstrated that stereotype threat reduces performance on tasks requiring the storage and manipulation of complex information (Spencer et al., 2016). Extending from this general finding, supporters of the working memory depletion view have proposed that the activation of negative stereotypes contributes to a multitude of affective, cognitive, and behavioral processes that severely inhibit the efficiency of working memory (Schmader, Johns, & Forbes, 2008). While it is common for stereotype threat researchers to utilize different conceptualizations of working memory in their studies (e.g., multicomponent view, Baddeley, 2012; limited-capacity executive view, Shipstead, Lindsey, Marshall, & Engle, 2016), supporters of a working memory account universally agree that stereotype threat undermines performance by interfering with the efficiency of the system responsible for the coordination and implementation of cognitive operations (Schmader et al., 2008). Numerous studies conducted over the past 25 years demonstrated that individuals
experiencing stereotype threat experience reduced working memory capacity compared to non-threatened individuals (Beilock et al., 2007; Schmader & Johns, 2003).

Despite considerable evidence linking reductions in working memory capacity to stereotype threat effects, little is known about the specific cognitive mechanisms that are impacted by stereotype threat. Recent research has attempted to clarify our understanding of the relationship between working memory and stereotype threat effects through systematic investigations designed to determine if specific facets of working memory are more strongly impacted by stereotype threat than others (Rydell, Van Loo, Boucher, 2014). Preliminary findings from this line of research have suggested stereotype threat interferes with optimal mathematical performance by disrupting working memory updating - or the ability to recall, transform, and substitute task-relevant information in working memory (Rydell et al., 2014).

**Reconciling the Threat-Induced Potentiation of Prepotent Response Model and Working Memory Depletion Accounts**

Exploration of extant literature reveals that the commonly used research designs employed within investigations of stereotype threat have not been able to effectively disentangle the effects of drive and working memory interference on performance among stigmatized individuals (Schmader et al., 2008). Recent work has clarified this issue by proposing that increased drive and reductions in working memory capacity work in tandem to produce stereotype threat effects. For instance, Mazerolle, Regner, Morisset, Rigalleau, and Huguet (2012) explored the impact of stereotype threat on the automatic and controlled memory processes of older adults. Results of their examination indicated that stereotype threat intensifies the emission of automatic response patterns while simultaneously undermining controlled cognitive processes required for the manipulation of complex information and inhibition of
undesirable responses. While the work of Mazerolle et al. (2012) provides provisional evidence of the compatibility of the TIPPR and working memory depletion accounts, future work is needed to determine if these findings generalize to members of other stigmatized social groups.

**Self-Affirmation Intervention Techniques**

Given the persistence of stereotype threat effects across time, domain, and social group, researchers have devoted considerable effort to the identification of methods of reducing stereotype threat (Aronson, 2002; Johns, Schmader, & Martens, 2005). Results of these efforts have identified several intervention techniques with the ability to reduce stereotype threat related performance deficits within controlled laboratory situations. For instance studies have demonstrated the effectiveness of methods designed to: (1) remove contextual cues that contribute to the activation of negative group-based stereotypes (Davies, Spencer, Quinn, & Gerhardstein, 2002), (2) expose stigmatized individuals to positive role models (Marx & Roman, 2002), (3) provide stigmatized individuals the opportunity to misattribute arousal to external source (Ben-Zeev et al., 2005), and (4) teach stigmatized individuals about the impact of stereotype threat (Johns, Schmader, & Martens, 2005).

Despite the existence of empirical findings demonstrating methods that can be used to reduce stereotype threat (Ben-Zeev et al., 2005; Davies et al., 2002; Marx & Roman, 2002), researchers have struggled to translate most methods into interventions for use within real-world performance situations (Johns et al., 2005; Shapiro, Williams, Hambarchyan, 2013). However, one technique that is practical, effective, and can be applied in multiple performance contexts is prompted self-affirmation activities (Martens, Johns, Greenburg, & Schimel, 2006).

Self-affirmation theory predicts that individuals are highly motivated to maintain a personal image that supports the perceived integrity of the self (Steele, 1988). However, over the
course of the lifespan individuals encounter innumerable environmental stimuli that threaten their perceived self-integrity (Cohen & Sherman, 2014; Steele, 1988). According to self-affirmation theory, individuals implement a variety of defensive responses designed to restore self-integrity when confronted with threats to the self-image (Campbell & Sedikides, 1998; Fein & Spencer, 1997; Sherman, Nelson, & Steele, 2000). Explorations in this domain have identified self-affirmation – or the process of reflecting on important personal characteristics – as one of the most effective methods of restoring self-integrity when confronted with threatening environmental cues. Proponents of self-affirmation theory believe the process of self-affirmation restores the self-image by providing individuals the opportunity to consider aspects of life that strengthen their sense of moral adequacy and agency over important life outcomes (McQueen & Klein, 2006).

Steele and Aronson (1995) described stereotype threat as a situational predicament stemming from exposure to situational cues that threaten the integrity of individuals’ social identity. Therefore, researchers have suggested and successfully demonstrated that providing individuals the opportunity to engage in self-affirmation can buffer against stereotype threat and improve performance in stereotype-relevant domains (Martens, Johns, Greenburg, & Schimel. 2006; Taillander-Schmitt, Esnard, & Mokounkolo, 2012).

Although empirical investigations have demonstrated the benefits of self-affirmation among those confronted with self-integrity threats (Martens, et al., 2006; McQueen & Klein, 2006; Taillander-Schmitt et al., 2012), the causal mechanisms that contribute to the protective influence of self-affirmation remain unknown (Harris, Harris & Miles, 2016; McQueen & Klein, 2006). Early work exploring the mechanism underling the benefits of self-affirmation focused primarily on the role of motivational factors such as improvements in self-esteem and increases
in positive affect (Kimble Kimble, & Croy, 1981; Koole, Smeets, van Knippenberg, & Dijksterhuis, 1999). Unfortunately, results of these investigations have provided inconsistent findings that have done little to advance our understanding of self-affirmation effects (McQueen & Klein, 2006). As a result, contemporary research has begun to explore the role of cognitive factors – such as working memory and executive functioning – in the facilitative benefits of self-affirmation. Although this line of research is still in its infancy, empirical investigations have provided evidence suggesting that engaging in the process of self-affirmation improves working memory functioning. For instance, recent studies have demonstrated engaging in prompted self-affirmation activities results in improvements in working memory functioning (Logel & Cohen, 2012; Harris et al., 2016).

**Current Study**

The purpose of the current study is to identify the relationships among stereotype threat, self-affirmation, and working memory. Specifically, this study is designed to investigate the following research questions:

*RQ1: Does the activation of negative stereotypes impact the performance of females working to complete a math-related task?*

Steele and Aronson (1995) proposed the fear of being judged stereotypically or behaving in a manner that confirms negative group-based stereotypes generates a situational threat with the potential to interfere with optimal performance. Over the last 25 years, numerous empirical investigations have demonstrated the debilitative influence of negative stereotypes on the performance of members of stigmatized social groups – including women in situations that elicit negative stereotypes related to mathematical ability (Nguyen & Ryan, 2008). Therefore, it is
hypothesized women experiencing high levels of stereotype threat will exhibit significantly worse mathematical test performance than women experiencing low levels of stereotype threat.

**RQ2: Does the activation of negative stereotypes disrupt working memory processes?**

Investigations into the mechanisms contributing to stereotype threat effects have implicated working memory as an important mediator of the relationship between stereotype threat and performance. Researchers have demonstrated that stereotype threat triggers suppression and monitoring processes that interfere with the efficiency of the working memory system (Beilock et al., 2007; Schmader & Johns, 2003). Recent research has attempted to better understand the cognitive processes through which stereotype threat undermines effective performance by exploring if specific facets of working memory are more strongly impacted by stereotype threat than others. Preliminary findings from this line of research has suggested stereotype threat interferes with optimal mathematical performance by disrupting individuals’ ability to recall, transform, and substitute task-relevant information in working memory (i.e., memory updating; Rydell et al., 2014). Given prior research, it is hypothesized that females experiencing high levels of stereotype threat will demonstrate significantly worse updating ability than women experiencing low levels of stereotype threat. Further, it predicted participants experiencing high levels of stereotype threat will demonstrate significantly worse working memory maintenance compare to participants experiencing low levels of stereotype threat.

**RQ3: Does self-affirmation protect the mathematical performance of females experiencing high levels of stereotype threat?**

Research in related domains has suggested individuals implement a variety of defensive mechanisms (e.g., self-serving attributions, defensive processing) when confronted with self-image threats to restore the integrity of the self-system (Cohen & Sherman, 2002; Steele, 1988).
Empirical investigations have suggested engaging in self-affirmation is one of the most effective methods of restoring self-integrity when confronted with a self-image threat – such as stereotype threat (Martens, et al., 2006; Taillandier-Schmitt et al., 2012). Given prior research demonstrating the effectiveness of self-affirmation, it is hypothesized that female experiencing high levels of stereotype threat who engage in self-affirmation will outperform females experiencing high levels of stereotype threat who do not engage in self-affirmation. Further, it is predicted females experiencing high levels of stereotype threat who engage in self-affirmation will exhibit mathematical performance that is comparable to females experiencing low levels of stereotype threat.

**RQ4: Does self-affirmation protect specific facets of working memory from the disruptive influence of stereotype threat?**

Much research has been conducted exploring the process of self-affirmation and has contributed to a greater understanding of the benefits that typically follow periods of personal reflection (Cohen & Sherman, 2014). For instance, empirical investigations have demonstrated that engaging in self-affirmation before an evaluative event can eliminate the performance deficits that are commonly observed among members of stigmatized groups experiencing stereotype threat (Martens et al., 2006). Despite the established benefits of self-affirmation, self-enhancement theorists still know little about the specific causal mechanisms that contribute to self-affirmation effects (McQueen & Kline, 2006). Recent work has suggested that engaging in the process of self-affirmation improves performance on tasks requiring effective self-regulation by increasing the amount of working memory resources that can be deployed for task completion (Harris, Harris, & Miles, 2016; Logel & Cohen, 2012). Given extant literature demonstrating the positive benefits of reflecting on personally important values, is hypothesized that females
experiencing high levels of stereotype threat who engage in self-affirmation condition will exhibit significantly higher working memory maintenance and updating ability than females experiencing high levels of stereotype threat who did not engage in self-affirmation. Further, it is predicted that females experiencing low levels of stereotype threat who engage in self-affirmation will not demonstrate significant differences in working memory maintenance and updating ability compared to females experiencing low levels of stereotype threat conditions who do not engage in self-affirmation.
Chapter II: REVIEW OF THE LITERATURE

Over the past 100 years, there have substantial advances in our understanding of how individual difference variables, pedagogical approaches, and aspects of the learning environment interact to influence student learning and academic achievement at the primary, secondary, and post-secondary level (Inzlicht & Schmader, 2012). Concurrently, many countries across the globe have exhibited substantial changes in their views regarding social equality and have begun to endorse egalitarian principles emphasizing the importance of equal opportunity and access to all members of society (Inzlicht & Schmader, 2012). The adoption of egalitarian principals has manifested in a multitude of structural changes designed to ensure that members of historically marginalized social groups are granted equal access to career and educational opportunities historically for reserved for members of socially privileged groups (Inzlicht & Schamder, 2012). Given these advances, many logically assumed there would be a gradual decrease in - and eventual elimination of – social group-based disparities in academic performance and career advancement among members of traditionally marginalized social groups.

While structural changes designed to increase access to educational and career opportunities have contributed to declines in gender and ethnic achievement gaps, they have been unable to eliminate group-based performance disparities. Available evidence suggests the existence of a persistent gap in the performance of males and females in the domain of mathematics that appears during the high school years and persists through college. For instance, a substantial body of literature investigating gender differences in math performance have demonstrated that males often outperform females on standardized measures of math ability designed to access complex problem-solving ability – such as the quantitative portion of the Scholastic Achievement Test and Mathematics Advanced Placement exam (College Board,
Perhaps even more concerning is the preponderance of evidence suggesting that females are substantially less likely to pursue college majors and vocational paths in math-intensive fields (American Association of University Women, 1999; Snyder & Dillow, 2012; Williams, & Barnett, 2009).

Researchers have proposed numerous theoretical accounts to explain gender differences in mathematical performance. These theoretical positions can be categorized as falling under one of two broad views emphasizing either the contribution of genetic or sociocultural factors to performance differences. Supporters of biological explanations believe group-based performance deficits are best explained by genetic differences that contribute to variations in general intelligence and intellectual functioning (Inzlicht & Schamder, 2012). For example, prominent researchers in the domain of education and assessment have interpreted available evidence as suggesting that gender differences in mathematical performance can be attributed to genetic factors that interfere with the innate ability of females to develop a complex understanding of mathematical concepts (Benbow & Stanley, 1982a; 1982b). On the other side of the argument are researchers that suggest a myriad of societal forces work in tandem to undermine the mathematical performance of females. For instance, considerable evidence suggests structural, and gender role constraints stemming from differential expectations for males and females may undermine motivation and interfere with achievement in math-relevant domains (Eccles, Jacobs, & Harold, 1990). Despite their popularity, some have called into question the sufficiency of genetic and sociocultural explanations in explaining the gender differences in mathematical performance and suggested alternatives emphasizing the impact of situational factors.
Overview of Stereotype Threat Theory

Stereotype threat theory originated as a model to explain patterns of academic underperformance commonly observed among African American students that could not be fully explained by exposure to societal disadvantages – such as socioeconomic shortcomings and limited access to quality educational experiences (Steele, 1992; 1997). In his seminal theory, Steele (1992; & Aronson, 1995; 1997) postulated that members of stigmatized groups often experience self-evaluative threats stemming from the activation of negative stereotypes (Steele & Aronson, 1995). That is, stigmatized individuals routinely encounter situations where they fear their behavior (a) will be interpreted in a stereotypical manner or (b) will confirm the content of negative group-based stereotypes. This apprehension - referred to as stereotype threat – is believed to generate an “extra psychological burden” that stigmatized students must manage while working to complete academic tasks (Steele & Aronson, 1995).

Proponents of stereotype threat theory have suggested that stereotype threat can result in both short – term and long – term consequences for threatened individuals (Steele, 1997). For instance, much research has demonstrated that stereotype threat undermines immediate performance by activating behavioral, emotional, and cognitive responses that interfere with individuals’ ability to attend to task-relevant information (Steele, 1997; Steele & Aronson, 1995). Further, stereotype threat theory predicts that threatened individuals will implement a defense mechanism – involving the restructuring of the self-concept – to prevent the experience of stereotype threat when confronted with the chronic activation of negative stereotypes (Steele, 1997). That is, individuals who experience prolonged periods of stereotype threat will re-structure their self-concept to exclude the stereotyped domain as a component of their self-identity to reduce the potential for further episodes of self-evaluative threat – a process known as
disidentification (Steele, 1997). Proponents of stereotype threat theory have identified disidentification as one of the most damaging outcomes of stereotype threat because of its potential to undermine motivation and engagement within stereotype-relevant domains (Aronson, 2002; Aronson, Blanton, & Cooper, 1995; Steele, 1997). While studies have only recently begun to investigate the influence of stereotype threat on individual’s identification with stereotype-relevant domains (Spencer et al., 2016), numerous studies have identified domain identification as a moderator of stereotype threat effects. That is, stereotype threat effects are generally limited to members of stigmatized groups who strongly identify (i.e., value) the stereotyped domain (Aronson et al., 2002).

The earliest support of stereotype threat theory can be found in Steele and Aronson’s (1995; Study1) study of Caucasian and African American undergraduate students (n = 117). The participants randomly assigned to the diagnostic condition (i.e., the high stereotype threat condition) were instructed that they would be completing a genuine test of their verbal abilities and limitations. Participants randomly assigned to the non-diagnostic condition were instructed that there were taking part in a study designed to better understanding personal factors associated with reading and verbal reasoning ability. Participants then completed an exam consisting of difficult verbal reasoning items taken from GRE study guides. As predicted by stereotype threat theory, African American subjects demonstrated depressed performance compared to Caucasian participants under the high stereotype threat conditions, with no differences arising in the low stereotype threat conditions. These findings support the assertion that exposure to contextual cues that make societal stereotypes generates an extra situational burden that interferes with optimal academic performance (Steele & Aronson, 1995).
While stereotype threat theory was originally conceptualized to explain the academic underperformance of African American students, proponents of the theory note that stereotype threat has the potential to interfere with the performance of members of social groups from whom there exists a negative stereotype (Steele, 1997). An ever-expanding body of literature has confirmed this broad expectation by demonstrating that stereotype threat can interfere with the performance of members of stigmatized groups within a multitude of domains. For example, empirical investigations have demonstrated that stereotype threat has the potential to impair the: (1) memory performance among older adults (Lamont et al., 2015; Mazerolle, Renger, Morisset, Rigalleau, & Huguet, 2012), (2) quantitative performance of racial minority students (e.g., African American students, Mexican American students, etc.; Nguyen et al., 2008), and (3) negotiation ability of female business students (Kray, Galinsky, Thompson, 2002).

**Stereotype Threat and the Underperformance of Female in Mathematics**

Given empirical evidence suggesting a relationship between stereotype threat and mathematical performance of members of stigmatized social groups (Nguyen et al., 2008; Spencer et al., 2016), some have postulated that the short- and long-term consequences of stereotype threat may contribute to the underperformance and underrepresentation of females in math-intensive domains (Spencer, Steele, & Quinn, 1999). Explorations of commonly held societal beliefs have demonstrated the existence of persistent negative stereotypes regarding the ability of females in mathematics and related domains (Fennema & Sherman, 1977; Jacob & Eccles, 1985). For example, these investigations have shown that many in our society are aware of negative stereotypes suggesting that females possess lower mathematical ability than their male counterparts (Eccles, Jacobs & Harold, 1990). Given the widespread knowledge of negative stereotypes regarding female mathematical ability, stereotype threat theory predicts exposure to
contextual cues that activate negative stereotype stereotypes will contribute to defensive responses that undermine immediate performance, and over time contribute to decreased motivation and interest in mathematics related domains.

The earliest empirical evidence of the influence of stereotype threat on the mathematical performance of females can be found in Spencer, Steele, and Quinn’s (1999; Study 1) study of male \((n = 28)\) and female \((n = 28)\) undergraduate students. Upon reporting to the researcher’s laboratory, participants were informed they would be taking part in a study designed to evaluate several new tests that were intended to be distributed among the student body. Participants randomly assigned to the low difficulty condition were asked to complete a timed math exam consisting of questions adapted from the quantitative section of the GRE general exam while participants randomly assigned to the high difficulty condition were asked to complete questions adapted from the advanced GRE mathematics exam. Participants completed the timed test in small mixed-sex groups in the presence of a male experimenter. Results of the study revealed that female participants demonstrated significantly lower performance compared to males on the difficult mathematics exam. Further, findings indicated there were no differences in the math performance of male and female participants assigned to the low difficulty condition.

Researchers believed their results supported stereotype threat theory by demonstrating that women exhibited reductions in math performance under conditions believed to contribute to stereotype threat (Spencer et al., 1999; Study 1).

O’Brien and Crandall (2003) examined the influence of stereotype threat on the mathematical performance of male \((n = 105)\) and female \((n = 59)\) undergraduate students. Stereotype threat was manipulated in the examination through slight alterations to the study descriptions. For instance, participants assigned to the stereotype threat condition were led to
believe the mathematics exam has revealed gender differences in performance during previous administrations. Conversely, those in the no-threat condition were led to believe the mathematics exam had not been shown to produce gender difference. The mathematics examination used in the study was comprised of both “easy” and “difficult” math problems. “Easy” math items took the form of three-digit multiplication problems while “difficult” math items were taken directly from the quantitative portion of the Scholastic Achievement Test (SAT). Results indicated women in the stereotype threat condition exhibited better performance on “easy” math problems than women in no-threat condition. Further, it was revealed that women experiencing stereotype threat demonstrated significantly worse performance than their no-threat peers when working to complete “difficult” math problems. Performance of male participants on the easy and difficult math items was not influenced by the experimental manipulation.

Examination of the literature reveals considerable evidence supporting the assertion that the activation of negative group-based stereotypes adversely impacts performance (Nguyen & Ryan, 2008). However, there is disagreement among experts in the field regarding the true nature of stereotype threat. Early work in the field conceptualized stereotype threat as a unique form of evaluative pressure that adversely impacts performance by preventing effective information processing (Steele & Aronson, 1995). However, some contemporary researchers have adopted a multi-treat approach suggesting the existence of qualitatively different “stereotype threats” that are distinguished by individuals’ consideration of the target (i.e., self or social group) and source (i.e., self, outgroup members, in-group members) of threat (Shapiro & Neuberg, 2007).

Wout, Danso, Jackson, and Spencer (2008; Study 2) examined the viability of the multi-threat approach in a study investigating the impact of self-focused and group-focused stereotype threat on the mathematical performance of female undergraduate students. Stereotype threats
were manipulated in the examination through slight alterations to the study descriptions provided
to participants. Participants randomly assigned to the no threat condition the experimental
materials were designed to assess the cognitive processes underlying mathematical problem-
solving ability but could not be used to assess actual mathematical competence. Participants
randomly assigned to the self-threat condition were informed they would be completing
materials highly diagnostic of mathematical ability. Participants randomly assigned to the group-
threat condition were again instructed they would be completing materials diagnostic of
mathematical ability. Critically, participants in this condition received additional instructions
emphasizing experimenters are not interested in individual performance but instead were
interested comparing the average performance of males and females on the experimental task.
Following the stereotype threat manipulation, participants completed a gender identification
measure and timed mathematical test consisting of items taken from the Necessary Arithmetic
operations test. Results of the study revealed that participants assigned to the self and group
threat conditions demonstrated significantly lower performance compared to participants in the
no threat condition on the timed mathematical test. Perhaps most notably, findings indicated
mathematical test performance was moderated by gender identification among those in the
group-threat condition. However, group identification was not a significant moderator among
participants assigned to the no-threat and self-threat conditions. Researchers believed their
results supported the multithread approach by demonstrating the existence of distinct forms of
stereotype threat that negatively impact performance and have unique moderators (Wout et al.,
2008).
Developmental Differences in the Experience of Stereotype Threat

As detailed above, a wide body of research has demonstrated the debilitative influence of negative stereotypes on the math performance of adult females. However, much less is known about when females first become susceptible to the effects of negative stereotypes. Recent work has worked to clarify developmental trends in the experience of stereotype threat by exploring when stereotype threat effects first appear among members of stereotyped groups.

Ambady, Shih, Kim, and Pittinsky (2001; Study 1) explored the impact of positive and negative stereotypes on the cognitive performance of Asian American females in lower elementary (Kindergarten – 2nd grade; Ages 5 – 7; n = 20), upper elementary (grades 3 – 5; n = 29), and middle school (grades 6 – 8; n = 28). Participants involved in the study were randomly assigned to one of three experimental conditions: (1) female identity activated, (2) Asian identity activated, and (3) no identity activated. The participants randomly assigned to the female identity activated and Asian identity activated condition completed an age appropriate activity designed to make either their ethnic or gender identity salient. For instance, early elementary school children in the Asian identity activated condition were asked to color a picture depicting two individuals engaging in stereotype – consistent behaviors (e.g., children eating rice using chopsticks). Participants assigned to the no identity activated condition were asked to engage in “neutral” tasks that were unrelated to their gender or ethnic identity. For instance, upper elementary and middle school students assigned to the no identity activated condition were asked to complete a brief questionnaire assessing their opinions toward factors unrelated to the experimental sessions (e.g., favorite season, favorite animal, etc.). Following the identity manipulation, all participants were asked to complete a standardized math test. Results revealed participants in middle school and lower elementary school performed significantly better on the
math test when their Asian identity was activated. Conversely, participants in upper elementary school exhibited significantly better performance when their gender identity was emphasized during the experimental session. Researchers note the general patterns of results – with the exception of upper elementary school students – were in line with prior stereotype threat research noting the facilitative benefits of positive stereotypes and the debilitating impact of negative stereotypes. Researchers believed the enhanced performance of upper elementary school students that occurred when their gender identity was activated could be explained by general increases in chauvinism that are observed among young children. That is, developmental researchers commonly find that children in their upper elementary school years endorse beliefs regarding the superiority of their gender (Powlishta, 1995; Yee & Brown, 1995). Therefore, researchers believed that upper elementary school children’s focus on the superiority of their own gender may have been able to effectively counteract the influence of stereotype threat. Overall, results of the study demonstrated that the activation of negative stereotypes can have a dramatic impact on the mathematical performance of young females (Ambady et al., 2001; Study 1).

Muzzatti and Agnoli (2007; Study 1) sought to clarify the development of stereotype threat-related underperformance in a study of male ($n = 264$) and female ($n = 212$) elementary school students (grades 2 – 5). The participants assigned to the experimental (i.e., high stereotype threat) condition were exposed to a gender imbalanced vignette containing images of famous mathematicians. The visual array was designed to imply that females are underrepresented in math-related domains. Participants randomly assigned to the control (i.e., low stereotype threat condition) were shown a visual array containing neutral images – such as different species of flowers and fruits. Immediately following the stereotype threat induction, participants were asked to complete a mathematics exam containing questions taken from the Italian translation of
the Primary Mental Ability Test (Rubini & Rossi, 1985a; 1985b). Results revealed traditional stereotype threat effects among 5th-grade participants. Specifically, females assigned to the high stereotype threat condition demonstrated worse math performance that their counterparts assigned to the low threat condition while no differences were observed among 5th grade males assigned to the high - and low - stereotype threat conditions. Notably, results observed no reliable stereotype threat effects among 2nd, 3rd, and 4th-grade participants. These findings suggest that the activation of negative group stereotypes begin to under undermine the academic performance of young females in late elementary school.

**Stereotype Consciousness and Vulnerability to Stereotype Threat Effects**

Extant research has demonstrated that the impact of stereotype threat on the math performance of females is not limited to the adult years. Notably, the existing literature indicates that salient negative stereotypes can contribute to the academic underperformance of young female students (Ambady et al., 2001; Muzzatti and Agnoli, 2007). However, available evidence suggests members of stigmatized groups differ in their susceptibility to stereotype-based expectations that are associated with their social category (i.e., stereotype vulnerability; Aronson, 2002; Aronson & Inzlicht, 2004). For instance, some studies indicate stereotype threat effects first appear in early elementary school and some indicating they first appear during the middle school years (Ambady et al., 2001; McKown, & Weinstein, 2003; Muzzatti and Agnoli, 2007). Prominent figures in the field of stereotype threat have suggested that variability in the appearance of stereotype threat effects among female students may be associated with individual risk factors – such as levels of stigma consciousness – that increase individuals’ susceptibility to stereotype threat (Aronson, 2002).
Stigma consciousness refers to an individuals’ awareness of the stereotypes endorsed by social others and the extent to which members of stigmatized groups believe those stereotypes will influence their interactions with outgroup members (Pinel, 1999; 2002). Classic stereotype threat theory (Steele & Aronson, 1995) contends that stereotype threat stems from the fear of being viewed in a stereotypical manner. As such, researchers have logically hypothesized the existence of a relationship between stigma consciousness and stereotype threat such that stigmatized individuals higher in stigma consciousness should be more susceptible to stereotype threat. Further, available evidence suggests the ability to understand the nature of societal stereotypes is likely tied to the development of the ability to effectively consider and infer the social beliefs of others (McKown & Weinstein, 2003). For instance, research has demonstrated that children often struggled to consider and understand the beliefs of others at young ages and typically begin to exhibit an understanding of the psychological perspective of social others around age 6 (Selman, 1980). Therefore, some have suggested the onset of stereotype threat effects may correspond with the development of perspective taking ability and associated increases in knowledge of societal stereotypes (McKown & Weinstein, 2003).

Brown and Pinel (2003) sought to explore the relationship among stereotype threat, math performance, and stigma consciousness in their study of female undergraduate students. Before the primary data collection session, participants (n = 336) completed measures designed to assess the importance of mathematics to their self-concept (Mathematics Identification Questionnaire; Brown & Josephs, 1999) and their level of gender-based stigma consciousness (Stigma Consciousness Questionnaire; Pinel, 1999). Participants who identified highly with mathematics and demonstrated scores falling within the upper and lower third on the Stigma Consciousness Questionnaire were asked to participate in the main study. At the onset of the data collection
session, participants were randomly assigned to either the low or high stereotype threat conditions. Stereotype threat was manipulated through slight alteration to the study instructions. For instance, participants in the high threat condition were led to believe that the experimental materials had produced gender differences in the past while participants in the low threat condition were informed that males and females had performed equally well on the experimental materials during past administrations. Following the stereotype threat experimental manipulation, participants were asked to complete a multiple choice math exam consisting of items that were adapted from GRE practice tests. Consistent with predictions, results revealed math performance differed as a function of stigma consciousness and stereotype threat. That is, no performance differences were observed among participants high and low in stigma consciousness within the low stereotype threat condition. Perhaps most notably, participants high in stigma consciousness exhibited lower math performance than participants low in stigma consciousness within the high stereotype threat condition. Collectively, these findings suggest that individuals high in stigma consciousness are likely to experience greater levels of underperformance when confronted with societal stereotypes compared to those low in stigma consciousness.

Further evidence of the moderating role of stigma consciousness in stereotype treat effects can be found in a series studies conducted by McKown and Weinstein (2003) exploring the developmental trajectory of stereotype consciousness. Using a linked study method, researchers sought to explore the development of stereotype consciousness (Study 1) and the influence of stereotype consciousness on cognitive test performance under conditions of stereotype threat (Study 2). Participants were 202 school aged children attending a summer enrichment program for gifted and talented students (Male n = 101, Female n = 101, Ages 6–
During Study 1, participants were presented with two vignettes about an imaginary land (i.e., Kidland) inhabited by green and blue children. For each of the presented vignettes, participants were asked to select a green or blue child to complete an academic task (e.g., be a member of a school spelling team) and explain why the child was chosen. During the presentation of the first vignette, participants were not given any additional information about the inhabitants of Kidland to support their decision making. However, before the presentation of the second vignette, participants were informed that “green children think blue children are not smart” (McKown & Weinstein, 2003, pg. 503). Following the vignette task, participants were asked to describe ways Kidland was similar to the real world. Trained raters then evaluated participants’ responses to determine if stereotypical information was used as justification for their decision when evaluating the second vignette and if information related to ethnic stereotypes were reported in their comparison of Kidland and the real world. Ability to infer group-based stereotypes and knowledge of ethnic stereotypes was used an indicator of stereotype (i.e., stigma) consciousness. Results indicated participants’ ability to infer another’s stereotype and knowledge of societal stereotypes increased with age. Notably, results indicated a difference in the knowledge of social stereotypes between members of stigmatized and non-stigmatized groups. That is, participants from stigmatized groups demonstrated a greater understanding of societal stereotypes than non-stigmatized groups across all age groups.

During Study 2, participants were asked to complete a series of cognitively demanding tasks either under high stereotype threat or low stereotype threat conditions. Stereotype threat was manipulated through task instructions. For instance, participants in the high - threat condition were informed that the experimental materials were high diagnostic of general academic ability while students in the low - threat condition were instructed the experimental
materials were designed to help researchers better understand how student solve problems. Following the stereotype threat manipulation, participants were asked to complete a letter writing task (i.e., listing as many of the alphabet as possible going backward from Z) and word puzzle task (i.e., identify a word that is not similar to others presented in a group). Results of the examination indicated that student’s ability to infer the stereotypes did not influence cognitive performance under conditions of stereotype threat. Perhaps most notably, results indicated knowledge of societal stereotypes moderated the impact of stereotype threat on performance. That is, participants who were aware of negative group stereotypes assigned to the high threat condition demonstrated significantly worse performance on the letter writing task than participants assigned to the low threat condition. No performance differences were observed on the experimental materials among participants who were not aware of societal stereotypes. Collectively, the linked studies demonstrate knowledge of societal stereotypes influences individuals susceptibility to stereotype threat effects. Further, given the developmental trajectory of stereotype consciousness, results indicate susceptibility to stereotype threat likely increases over time as individuals develop a greater understanding negative societal stereotypes.

**Mechanisms Contributing to Stereotype Threat Effects**

In the years since Steele and Aronson’s (1995) seminal article introducing the concept of stereotype threat, considerable empirical evidence has demonstrated the debilitating influence of stereotypes on a variety of academic and non-academic tasks (Lamont, Swift, & Abrams, 2015; Nguyen & Ryan, 2008). Despite general agreement regarding the existence of stereotype threat effects, researchers have been unable to come to a consensus regarding the mechanisms that contribute to underperformance among members of stigmatized groups. Contemporary researchers have formulated a variety of theoretical frameworks they believe identify the most
proximal mediator of stereotype threat effects within complex social and cognitive performance situations (Schmader, Johns, & Forbes, 2008; Spencer, et al., 2016). The first theoretical orientation – The Threat-Induced Potentiation of Prepotent Response Model – argues performance difficulties among stigmatized individuals are the result of increased drive stemming from the potential for evaluation (Jamieson & Harkins, 2007). The second theoretical orientation – the working memory depletion account – argues that stereotype threat undermines performance by activating behavioral, cognitive, and emotional processes that tax available working memory resources (Schmader et al., 2008).

**Threat-Induced Potentiation of Prepotent Response Model**

The TIPPR proposes that the activation of negative group-based stereotypes and the associated fear among stigmatized individuals that others will evaluate their performance is a source of non-specific arousal (Jamieson & Harkins, 2007; Schmader & Beilock, 2012). Prior research has clearly demonstrated that animal and human participants demonstrate differential levels of performance on simple and complex tasks when confronted with situational factors that increase arousal and activate drive states oriented toward returning the biological system to a state of homeostasis (Pallak & Pittman, 1972; Zajonc, 1965; Zajonc, Hiengartner, & Herman, 1969; Woodworth, 1918). A drive theory perspective proposes the differential influence of arousal on performance is tied to the facilitation of dominant response patterns within performance situations (Cottrell, 1972). Prominent drive theorists have argued that arousal – and subsequent drive states - interact with habit strength to facilitate the emission of learned responses (Cottrell, 1972; Hull, 1943). That is, it is assumed that high arousal states increase the occurrence of high probability (i.e., dominant, habitual, or well-learned) responses within performance situations (Hull, 1943; Zajonc, 1965). Extending from this logic, researchers have
hypothesized that increased drive will have differential impacts on performance depending on the difficulty of encountered tasks (Hull, 1943; Pallack & Pittman, 1972). When dominant response patterns are likely to be correct – as is often the case in simple tasks – arousal is predicted to exert a facilitative influence on performance. However, when dominant responses patterns are unlikely to be correct – as is often the case on cognitively demanding tasks – increased arousal is predicted to be a substantial barrier to optimal performance (Schmader & Beilock, 2012; Spencer et al., 2016).

Ben-Zeev, Fein, and Inzlicht (2005; Study 1) conducted one of the first studies exploring the role of arousal in stereotype threat effects. In their study, male \((n = 20)\) and female \((n = 39)\) undergraduates were randomly assigned to either a threat or no-threat condition. The participants assigned to the threat condition were instructed that they would be completing a standardized math exam that had produced gender differences in the past while participant assigned to the no-threat condition were informed they would be completing an exam devoid of gender bias. Following the stereotype threat manipulation, participants were informed that would be completed an unrelated cognitive task before the math exam. At this point, participants were randomly assigned to complete an easy (i.e., standard name writing) or difficult (i.e., writing name backward in cursive) task. Consistent with the predictions of drive theory, results indicated that females in the threat condition performed significantly better on the easy name writing task than females assigned to the no threat condition. The reverse pattern of performance was observed among females working to complete the difficult name writing task. Specifically, females assigned to the threat condition demonstrated significantly worse performance on the difficult name writing task than participants assigned to the no threat condition. No performance differences were observed among males assigned to the threat and no threat conditions on the
experimental tasks. Given these patterns of findings, researchers concluded that stereotype threat triggers increased drive which facilitated performance on a well-learned task and interfered with performance on a novel task (Ben-Zeev et al., 2005; Study 1).

In the first empirical exploration of stereotype threat, Steele and Aronson (1995; Study 4) provided evidence that the fear of conforming to a negative group stereotype does little to undermine the motivation of stigmatized individuals within performance events. In that study, Steele and Aronson (1995) asked participants assigned to low and high stereotype threat conditions to estimate the amount of effort they expended to complete the experimental materials while tracking the amount of time spent working to complete each of the presented problems. Their results indicated there were no differences in the amount of perceived effort devoted to solving the presented problems between participants in the high and low stereotype threat conditions. However, participants assigned to the high stereotype threat condition spent significantly more time working to complete test questions than participants assigned to the low threat conditions. Based upon these findings, Steele and Aronson (1995; Study 4) concluded individuals confronted with stereotype threat are highly motivated to disconfirm negative stereotypes but are unable to demonstrate their best performance because of anxious responses that interfere with processing efficiency.

Because stereotype threat influences the motivation to do well and task engagement, the TIPPR also predicts that individuals experiencing stereotype threat will devote effort to rectifying incorrect responses emitted during a performance situation (Schmader & Beilock, 2012). However, researchers have posited that increased effort to rectify incorrect responses will only manifest when individuals: (a) possess the ability to recognize incorrect responses, (b) can
identify the correct response pattern, and (c) are given the opportunity (i.e., time) to demonstrate the correct behavior or response within a performance situation (Jamieson & Harkins, 2007).

While studies have provided evidence implicating arousal and drive states in stereotype threat effects (Ben-Zeev et al., 2005, O’Brien & Crandall, 2003), Jamieson and Harkins (1997) argued that standard stereotype threat paradigms have not allowed for a compelling test of other key propositions of the TIPPR – namely the impact of stereotype threat on efforts to rectify incorrect responses. To remedy this potential limitation, Jamieson and Harkins (1997) developed a novel experimental paradigm – incorporating an adapted version of the classic antisaccade task (see Roberts, Hager, & Heron, 1994) – to explore the mechanisms underlying stereotype threat effects. During an antisaccade task, participants are asked to focus on a fixation point located in the center of a visual display. After a variable amount of time, a distractor cue is presented and is shortly followed by a target stimulus – which typically takes the form of an arrow. Participants are instructed to ignore the appearance of the distractor cue and to focus on efforts on identifying the orientation of target stimulus (e.g., left, right, or up).

Researchers who utilize the antisaccade task are typically interested in the saccades (i.e., reflexive, corrective, and correct) elicited by the appearance of the distractor and target stimulus. Reflexive saccades refer to instances where an individuals’ attention (i.e., eye gaze) is automatically captured by the presentation of the distractor cue. Jamison and Harkins (2007) argued that shifts in attention from the fixation point to the distractor cue are an excellent indicator of individuals’ dominant (i.e., instinctive) response tendency when presented with a visual stimulus. Corrective saccades refer to instances where an individual makes an effort to shift his or her focus to the target stimulus after inadvertently attending to the distractor cue. Jamison and Harkins (2007) believed corrective saccades to be an indicator of the effort
individuals devote to rectifying an incorrect initial response. Finally, correct saccades reference to instances where individuals are able to successfully ignore the presentation of the distractor cue and appropriately attend to the presentation of the target stimulus.

Across four studies involving male and female undergraduate students, Jamieson and Harkins (2007) explored the role of mere effort in stereotype threat effects by asking participants to complete an adapted version of the antisaccade tasks under either high threat or low threat conditions. Participants randomly assigned to the high-threat condition were informed that the experimental task had produced gender differences during past administrations while participants assigned to the low threat condition were informed that the task was gender fair. Following the stereotype threat manipulation, participants were asked to complete the antisaccade task. Further, Jamieson and Harkins (2007), systematically altered the characteristics of the antisaccade task across the four studies to test key predictions of the mere effort account.

During Study 1, participants assigned the low and high threat conditions were asked to complete an antisaccade task that limited the response window to 150 ms. Further, during Study 1, the antisaccade test was calibrated to focus solely on participants’ response accuracy. Consistent with extant literature, results of Study 1 indicated that females assigned to the high threat condition exhibited significantly worse performance on the antisaccade task than females assigned to the low threat condition. No performance differences were observed among males assigned to the high and low threat conditions.

During Study 2, participants were asked to complete a version of the antisaccade task that extended the response window to 250 ms. Results of Study 2 indicated that extending the response effectively eliminated performance deficits between females assigned to the high threat and low threat conditions. That is, when participants were given additional time to respond
during the antisaccade task no stereotype threat effects were observed. This finding supports the mere effort account by showing that stereotype threat does not lead to a complete inability to perform at an optimal level on complex tasks. Instead, results indicate individuals may be able to overcome stereotype threat effects when given adequate opportunity to identify and rectify incorrect responses.

Study 3 and Study 4 sought to conduct a more explicit test of the prediction of the mere effort account by assessing the types of eye movements (i.e., saccades) produced by participants working to complete the antisaccade task. Results of Study 3 and Study 4 demonstrated differential patterns of eye movement among participants assigned to the high and low threat conditions. That is, results indicated participants in the stereotype threat condition exhibited more correct saccades than participants assigned to the low threat condition. More importantly, results indicated that the participants assigned to the high threat condition engaged in more reflexive and corrective saccades during the antisaccade task than participants in the no-threat conditions. Collectively, these findings support the mere effort account by demonstrating that stereotype threat facilitates proponent responses (i.e., reflexive saccades) and undermines performance within situations where individuals are not given the opportunity to rectify initial response tendencies. However, the studies of Jamieson and Harkins (2007) demonstrated that threatened individuals devote considerable effort to rectifying incorrect responses (i.e., number of corrective saccades) and are able to perform at an optimal level when given adequate time to do so.

The Working Memory Depletion Account

An alternative explanation for stereotype threat effects implicates the working memory system as a key mediator of the relationship between stereotype threat and performance (Beilock,
Rydell, & McConnell, 2007; Schmader & Beilock, 2012; Schmader & Johns, 2003, Spencer et al., 2016). Consistent with research in related domains (i.e., test anxiety), the working memory depletion view posits stereotype threat contributes to affective, cognitive, and behavioral processes that consume working memory resources required to successfully perform tasks requiring the manipulation and maintenance of task-relevant information (Schmader, Johns, & Forbes, 2008).

**Defining Working Memory.** Numerous examinations exploring the relationships among stereotype threat, working memory performance, and task performance have relied upon Baddeley’s influential multicomponent theory of working memory (Baddely, 1986; 2000; 2012; Baddeley & Hitch, 1974). According to Baddeley and colleagues, the coordination and implementation of basic cognitive operations are guided by an overarching executive system and multiple subordinate systems – referred to as the phonological loop, the visuospatial sketchpad, and episodic buffer (Baddeley, 2012).

The overarching executive system – referred to as the central executive – is believed to be responsible for the processes required to (1) focus attentional resources on environmental stimuli, (2) split attention among multiple environmental stimuli, and (3) effectively switch attentional resources from one task to another (i.e., task-switching). The phonological loop is perhaps the most well-studied component of Baddeley’s multicomponent system and is believed to be comprised of two primary subcomponents - the phonological store and articulatory control process. Supporters of the multi-component theory suggest the phonological store is primarily responsible for the short-term storage of speech-based information while the articulatory control process primarily responsible for transferring text-based information into an auditory form capable of being processed by the phonological store (Baddeley, 2012). Further, research has
demonstrated the articulatory control processes guides activities that are required to successfully maintain auditory based information in the phonological store – such as sub-vocal rehearsal. Within the multi-component framework, the visuospatial sketchpad is posited to be responsible for the storage and manipulation of non-text information stored in a visual and/or spatial format. The episodic buffer is a relatively new contribution to the multicomponent theory of working memory and was included to reconcile conceptual issues related to the formation of mental representations formed from the integration of information from multiple memory systems – which would not be possible if each component were an isolated entity as suggested by Baddeley (2000) (i.e., phonological loop, visuospatial sketchpad, and/or central executive). That is, it is believed that the episodic buffer is the system responsible for collecting and transforming information from the other components of the working memory system – and long-term memory – into multidimensional representations believed to contribute to conscious awareness (Baddeley, 2012).

Despite the existence of evidence supporting the multicomponent view of memory (Baddeley, 2012), contemporary researchers suggest an alternative model that views working memory as a limited capacity system responsible for the allocation of attentional resources and regulation of goal directed behavior (Engle, 2001; Engle, Tuholski, Laughlin, & Conway, 1999). Supporters of the working memory as executive attention view suggest “working memory” corresponds to the ability to organize attentional resources toward the completion of goal-relevant tasks. Within the domain-general framework, it is assumed two primary mechanisms are responsible for the effective allocation of cognitive resources. The first mechanism is known as intentional maintenance and refers to the effortful focusing of attentional resources on task-relevant stimuli (Shipstead, Lindsey, Marshall, & Engle, 2016). It is widely believed the act of
focusing attention increases the durability of important information by protecting against sources of interference while simultaneously allowing for the inhibition of task-irrelevant information (Engle, 2001; Shipstead et al., 2016). The second mechanism – known as intentional disengagement or memory updating – is responsible for the removal of information from active processing. It is believed the process of disengagement decreases the probability that attentional resources will be devoted to the processing of outdated – and potentially irrelevant – information (Shipstead, Harrison, Engle, 2015; Shipstead et al., 2016). While it is common for stereotype threat researchers to utilize different conceptualizations of working memory within in their studies (Schmader & Johns, 2003; Beilock et al., 2007), there is universal consensus among supporters of a working memory account that stereotype threat prevents optimal performance by disrupting the cognitive processes required to focus attention and regulate goal-directed behavior (Schmader et al., 2008).

**Empirical Research Testing the Working Memory Depletion Account.** Schmader and Johns (2003; Study 1) tested the role of working memory depletion in stereotype threat effects. In their initial study, male (n = 40) and female (n = 35) undergraduates were randomly assigned to complete an adapted operation span task (La Pointe & Engle, 1990) under either stereotype threat or no-threat conditions. Stereotype threat was elicited in the examination by telling participants that differences in the quantitative ability of males and females are due to differences in “quantitative capacity” and that each participant would be completing a reliable measure of quantitative capacity during the experimental session (i.e., the working memory task). Participants in the control condition were led to believe the experimental task was a measure of working memory capacity while emphasizing a lack of gender differences. In support of the working memory depletion view, results revealed women in the stereotype threat condition
demonstrated significant reductions in working memory capacity compared to females in the control condition and males in both conditions.

To better understand the relationship between working memory depletion and task performance, Schmader and Johns (2003; Study 3) conducted a follow-up analysis testing whether depletions in working memory capacity mediated the relationship between stereotype threat and academic performance. In their examination, female undergraduate students ($n = 31$) were asked to complete a difficult math test and a working memory task under threat and no-threat conditions. Stereotype threat was manipulated during the working memory task by altering the gender representation of participants during the testing situations. Researchers primed stereotype threat during the mathematics test by asking participants to first report their gender and by emphasizing the test is a reliable measure of individuals’ overall mathematics ability. As predicted, it was found that women performed significantly worse on the math test when confronted with stereotype threat (Schmader & Johns, 2003). Further, results demonstrated the relationship between stereotype threat and performance was mediated by working memory capacity. Given this pattern of findings, researchers concluded stereotype threat negatively impacts performance by reducing resources available for the effortful processing of task-relevant information.

Despite the existence of studies demonstrating that reductions in working memory capacity are associated with performance deficits among those experiencing stereotype threat (Beilock et al., 2007; Schmader & Johns, 2003), the field lacks empirical studies of the specific cognitive mechanisms that are impacted by stereotype threat. Recent research has attempted to address this gap in our understanding by examining which cognitive processes contribute to performance deficits within stereotype-relevant domains. For instance, Rydell, Van Loo, and
Boucher (2014; Study 1) explored the relationships among stereotype threat, inhibition, shifting, and memory updating in a study of male ($n = 93$) and female ($n = 75$) undergraduates. At the onset of the data collection session, participants were randomly assigned to either a high – threat or low – threat condition. Participants assigned to the high – threat were informed that the purpose of the investigation was to explore why females are generally worse at math than males. The participants assigned to the low threat condition were given a study explanation that made no reference to gender differences in math performance. Following the stereotype threat induction, participants completed measures of inhibition (i.e., Stroop task), shifting (i.e., number-letter task), updating (i.e., letter memory task), and math performance (i.e., modular arithmetic problems). Results of the analysis revealed that females experiencing high levels of stereotype threat exhibited significantly worse math performance than females experiencing low levels of stereotype threat. No performance differences were observed among males in the high and low threat conditions. Perhaps most notably, results of a mediation analysis indicated that the relation between math performance and stereotype threat was partially mediated by reductions in working memory updating. Overall, results of this examination provide preliminary evidence that stereotype threat undermines the math performance of females by disrupting specific cognitive functions (i.e., updating; Rydell, Van Loo, & Boucher (2014; Study 1).

Factors Contributing to Working Memory Depletion. To better support learners confronted with the experience of stereotype threat, researchers have devoted considerable time and effort to the identification of the mechanisms contributing to working memory deficits among those confronted with stereotype threat. Contemporary frameworks suggest the consideration of negative stereotypes activates monitoring and suppression processes that hijack
working memory resources required for optimal performance on many cognitively demanding tasks.

**Monitoring Processes.** Steele and Aronson (1995) argued stereotype threat is experienced as a self-evaluative threat stemming from the fear of conforming to negative group stereotypes. Schmader, Johns, & Forbes (2008) extended upon this general idea by suggesting stereotype threat stems from the activated propositional relation of interrelated self-concepts. That is, stereotype threat will only occur in situations that: (1) activate knowledge related to potential group deficiencies in a given domain, (2) prime individuals to view themselves in terms of a particular group membership within a performance situation, and (3) activate knowledge related to the importance of the stereotyped domain to the self-concept. When met, these opposing propositional links are believed to generate cognitive inconsistency individuals are motivated to eliminate. Therefore, individuals will devote increased attention to performance cues, internal states, and environmental stimuli that may prove useful in eliminating – or reducing – the experience of cognitive inconsistency (Schmader et al., 2008). While these efforts have the potential to restore cognitive balance when confronted with stereotype threat, they are believed to interfere with optimal performance due to their reliance on the same cognitive resources (i.e., working memory) required to successfully complete complex tasks (Schmader et al., 2008).

Support for the association between increased monitoring and stereotype threat can be found in a recent study by Murphy, Steele, and Gross (2007). In their study, male and female undergraduate students majoring in Math, Science, and Engineering were asked to evaluate a fictitious recruitment video for a Stanford University Math, Science, and Engineering leadership conference. Stereotype threat was manipulated in the examination by altering the gender
representation of students appearing in the recruitment video (i.e., gender balanced or gender unbalanced). Researchers believed observing a video depicting females as a numeric minority would be sufficient to evoke feelings of stereotype threat among the female participants. At the conclusion of the video, participants were asked to complete measures assessing their memory of the conference video and the experimental location. Scores on these measures were then averaged to create an index of cognitive vigilance. In support of the working memory depletion view, it was found that women under stereotype threat recalled significantly more details about the experimental setting and recruitment video (i.e., demonstrated increased cognitive vigilance). These findings provide evidence suggesting stereotype threat can lead individuals to devote increased attention to environmental cues limiting their available working memory resources for focusing on the task at hand.

**Suppression of Task-Irrelevant Thoughts and Negative Feelings.** The recognition that a negative stereotype could be used to interpret ones’ performance creates a situational threat contributing to negative phenomenological experiences among members of stigmatized groups within performance situations (Steele, 1997; Schmader et al., 2008). For instance, empirical evidence suggests stereotype threat can induce a multitude of negative responses with the potential to interfere with effective performance – such as thoughts of self-doubt, negative thoughts, and task – related worries (Spencer et al., 2016). Consistent with reasoning underlying performance deficits associated with others forms of evaluation apprehension, efforts to suppress negative reactions associated with the activation of negative group-based stereotypes have been shown to compete for working memory resources and interfere with the ability to effectively store and manipulate task-relevant information (Ramirez & Beilock, 2011, Schmader et al., 2008; Spencer et al., 2016).
Cadinu, Maass, Rosabianca, and Kiesner (2005) sought to explore the influence of negative thinking on stereotype threat effects. Female undergraduate students (*N* = 60) were asked to complete two blocks of difficult mathematics problems taken from the Graduate Records Exam. Before each block, participants were asked to share any thoughts they were experiencing. Participants were also assigned to either a control or stereotype threat condition. Consistent with prior research, stereotype was elicited by reminding participants of negative stereotypes related to the mathematical ability of females. Results revealed females under stereotype threat performed significantly worse on mathematics problems contained in the second experimental block. Cadinu et al. (2005) also observed a significant increase in the amount of negative math related thoughts experienced by those in the stereotype threat condition compared to those in the control condition. Perhaps most notably, their examination provided evidence that the relation between mathematics performance and stereotype threat was partially mediated by the occurrence of negative thoughts prior to the testing situation.

Using the multicomponent theory as a guide, Beilock, Rydell, and McConnell (2007; Study 3B) investigated the role of cognitive interference in the phonological loop in stereotype threat effects. Participants were randomly assigned to either a stereotype threat or no-threat condition. Participants in the stereotype threat condition were informed of the existence of a negative stereotype suggesting male students demonstrate superior performance on all forms of math problems compared to female students and data collected in the examination would be used to inform the underlying processes contributing the observed performance gap. All participants then completed a series of low and high demand modular arithmetic problems presented in a horizontal or vertical orientation. The researchers decided to include problems in a horizontal and vertical manner because of prior research that has demonstrated horizontal problems require
more phonological resources to complete effectively than problems presented vertically (Trbovich & LeFervre, 2003). Following the modular arithmetic problems, participants were asked to complete a verbal thought questionnaire designed to assess the types of thoughts experienced while working to complete the experimental task.

Results revealed a significant three-way interaction for threat condition, working memory demand, and problem orientation. Exploration of the interaction effect revealed performance was only negatively impacted under conditions of stereotype threat when arithmetic problems were cognitively demanding and presented in a horizontal fashion – which requires greater phonological efficiency to complete. Further, results indicated differences in the types of thoughts reported by participants assigned to the high – threat and low – threat conditions while working to complete the modular arithmetic problems. Specifically, participants in the high threat condition reported experiencing a higher proportion of thoughts focusing on the fear of confirming negative stereotypes and more thoughts focused on performance monitoring. Collectively, these findings suggest situation related worries and efforts to monitor performance interfered with optimal performance by hijacking verbal working memory resources to complete modular arithmetic problems effectively.

**Reconciling the Threat -Induced Potentiation of Prepotent Response Model and Working Memory Depletion Accounts**

Prominent researchers in the field of stereotype threat research have suggested that existing evidence cannot effectively distinguish between the effects of response facilitation and working memory interference on the performance of stigmatized individuals (Schmader et al., 2008). That is, the majority of investigations have not included measures that effectively allow researchers to determine conclusively if performance deficits are the results of the increased
emission of well-learned response patterns – as predicted by the TIPPR – or the results of working memory impairment that interfere with the ability to implement cognitions and behaviors required for successful task completion – as predicted by the working memory account (Schmader et al., 2008).

To better understand the relation between response facilitation, working memory, and stereotype threat, Mazerolle, Regner, Morisset, Rigalleau, and Huguet (2012) conducted a study exploring the impact of stereotype threat on the automatic and controlled memory processes of older adults. Participants randomly assigned to the high-threat condition were informed they would be completing tasks that were highly diagnostic of working memory ability. Participants randomly assigned to the low-threat condition were informed they would be completing memory tasks that are age-fair and do not produce performance differences between younger and older adults. Immediately following the stereotype threat manipulation, participants were asked to complete a cued-recall task. At the onset of the cued-recall task, participants were asked to study a list of 40 to-be-remembered words. Following the study period, participants were presented with a series of word stems and were instructed to complete each stem in a manner that either produced a previously studied word (inclusion condition) or a new word (exclusion condition). Using responses provided within the inclusion and exclusion trails researchers were able to estimate the contribution of automatic and controlled processes in recall. Results of the examination demonstrated that stereotype threat enhanced the use of automatic processes and undermined the use of controlled processes during the cued recall task. Researchers believed their findings support the compatibility of the mere effort and working memory depletion account by demonstrating that stereotype threat simultaneously facilitates the emission of
dominant responses while undermining controlled cognitive processes required for executive attention (Mazerolle et al., 2012).

**Reducing Stereotype Threat**

Empirical research has demonstrated that the intellectual performance of stigmatized individuals is compromised when confronted with contextual reminders of negative stereotypes (Lamont et al., 2015; Nguyen, & Ryan, 2008). Given the persistence of stereotype threat effects across time, domain, and social group, leaders in the field have called for the identification of intervention techniques with the potential to protect performance against stereotype threat (Johns, Schmader, & Martens, 2005).

**Reconstrual Interventions**

Reconstrual interventions are designed to remediate stereotype threat effects thought to be sparked by situational predicaments characterized by the fear of being evaluated through the lens of a negative stereotype. Empirical investigations have identified multiple explicit (e.g., messages emphasizing the inferiority of a particular social group) and implicit (e.g., tests that are labeled as diagnostic of ability) contextual cues with the potential to activate stereotype threat (Nguyen, & Ryan, 2008). Logically, researchers have reasoned that the removal of the contextual cues that contribute to the activation of negative group stereotypes stereotype should boost performance among members of stigmatized groups (Davies, Spencer, Quinn, & Gerhardstein, 2002; Steele & Aronson, 1995). Evidence for this simple assertion exists within a multitude of empirical investigations that have shown efforts to “redefine” the nature of a performance event can alleviate stereotype threat effects.

Spencer, Steele, and Quinn (1999; Study 2) explored the influence of stereotype “relevance” on the mathematics performance of male ($n = 24$) and female ($n = 30$)
undergraduate students. Upon reporting to the researcher’s laboratory, participants were informed they would be taking part in a study designed to evaluate a newly developed math test. The participants assigned to the *high relevance condition* (i.e., the high stereotype threat condition) were instructed that the math test had shown gender differences in the past while participants assigned to the *low relevance condition* were instructed the math test had not produced gender differences during past administrations. Participants then completed a timed exam consisting of difficult mathematics GRE problems. As predicted, the relevance of the mathematics exam had a significant impact on performance. Specifically, females demonstrated significantly lower performance relative to males when the exam was presented as having produced gender differences in the past (i.e., high-stereotype threat condition). However, the performance of female participants did not significantly differ from male participants when the exam was portrayed as not having produced gender difference in the past. These findings support the assertion that removing threatening contextual cues can reduce stereotype threat effects by demonstrating that efforts to reduce stereotype relevance during a performance event can boost the math performance of stigmatized individuals.

Further evidence supporting the potential benefits of reconstrual interventions can be found within a study exploring the influence of the gender composition of the immediate environment on stereotype threat effects (Inzlicht & Ben-Zeev, 2000; Study 1). At the onset of the experimental session, female undergraduate students (*n* = 72) were informed they would be taking part in a study designed to validate an educational training program for enhancing standardized test performance and that they would be completing a standardized math test. Participants assigned to the *same sex condition* (i.e., low-stereotype threat condition) completed the experimental materials in the presence of 2 other female participants. The participants
assigned to the *minority condition* (i.e., high stereotype threat condition) completed the experimental materials in the presence of two male confederates. The experimental materials completed by participants consisted of either difficult mathematics or verbal reasoning questions taken from the Graduate Records Exam. Based on research demonstrating that numerical imbalances are sufficient to produce self-identity threats (Abrams, Thomas, & Hogg, 1990; McQuire, McGuire, Child, & Fujioka, 1978), Inzlicht and Ben-Zeev (2000; Study 1) predicted being outnumbered by males in the evaluative situation would be sufficient to generate stereotype threat among females and reduce mathematical performance, which was confirmed. Further, results revealed the composition of the experimental session also influenced the performance of females on the verbal reasoning test. This pattern of results clearly illustrates the potential benefits of reconstrual-based interventions by demonstrating the ability to attenuate stereotype threat effects by removing situational cues that activate negative group stereotypes.

**Boosting Performance Expectations**

Early work on the topic of stereotype threat identified performance expectations as a potential mediator of the relationship between stereotype threat and intellectual performance. In the first empirical investigation of stereotype threat, Steele and Aronson (1995) postulated the activation of a negative stereotype might cause individuals to interpret performance difficulties as evidence of the group-based inferiority described within the stereotype. Further, early work assumed maladaptive attributions often leads members of stigmatized groups to question their ability and their overall expectations for success in stereotype relevant domains (Steele & Aronson, 1995). Based on research in related disciplines, (i.e., self-efficacy; Bandura, 1986; Carver, Blaney, & Scheier, 1979; Pyszczynski, & Greenberg, 1983), the progenitors of stereotype threat theory believed reductions in performance expectations could have disastrous
consequences for those confronted with stereotype threat. That is, it is assumed reductions in personal efficacy set in motion a series of maladaptive behavior patterns - characterized by effort withdrawal and decreased achievement motivation – that interfere with future performance in the stereotyped domain. (Steele & Aronson, 1995). As such, the proposition followed that boosting performance expectations could have buoying an effect on performance by allaying stereotype threat. Researchers have devoted attention to the identification of intervention methods that can buffer the performance expectations of stigmatized students.

In his influential self-efficacy theory, Bandura proposed judgments of personal capability – commonly referred to as self-efficacy beliefs – are an important determinant of competence and effective functioning (Bandura, 1997; 2005). Self-efficacy theory posits that efficacy beliefs largely determine how well individuals can effectively organize and implement the cognitive, social, emotional, and behavioral skills required for optimal performance within a particular domain (Bandura, 1997). Bandura (1977) identified four primary sources of information that guide the formation of efficacy beliefs including (1) performance accomplishments, (2) verbal persuasion, (3) emotional arousal, and (4) vicarious experience.

Bandura’s (1977; 2005) conceptualized performance accomplishments simply as the history of mastery and failure experiences one has had when attempting to overcome obstacles. Logically, self-efficacy theory assumes personal mastery experiences increase self-efficacy while personal failure experiences reduce perceptions of self-efficacy. Verbal persuasion refers to attempts that are made to convince others that they possess the skills and ability required to complete a task. While exposure to persuasive messages has the potential to boost efficacy beliefs, empirical studies have noted a history of failure experiences often undermines boosts in efficacy generated through verbal persuasion (Bandura, 1977; 2005). Self-efficacy theory further
assumes information gathered from the examination of one’s physiological and emotional states influence the formation of efficacy beliefs. Prior research has demonstrated that individuals utilize their physiological states – in part – to evaluate the level of anxiety and/or stress they may be feeling when attempting to complete a task (Bandura, 1977; 2005). Unfortunately, the experience of stress and anxiety often triggers maladaptive cognitions and behavior that impair optimal performance (Bandura, 1977; 2005). Therefore, self-efficacy theory posits individuals are most likely expect success when they are not confronted with debilitative levels of anxiety within performance situations. Finally, Bandura (1977) proposed it is possible to experience increases in performance expectations after observing the success of others. That is, self-efficacy theory posits that individuals can develop increased confidence in their abilities after observing similar others persist and engage in behaviors that allow them to overcome situational difficulties (Bandura, 1977; 2005).

Unfortunately, the debilitative influence of stereotype threat often prevents individuals from performing at an optimal level (Flore & Wicherts, 2014) and has been shown to result in increased anxiety among members of stereotyped groups (Spencer et al., 2016). Therefore, the nature of stereotype threat may prevent individuals from developing efficacy belief through the consideration of prior mastery experience, examination of the content of persuasive appeals, and consideration of emotional states. Extending from this logic, some have suggested it may be possible to protect the expectancy beliefs of individuals confronted with stereotype threat by informing them of similar others who have experienced success in stereotype relevant domains (Herrmann, Graudejus, Okun, & Kwan, 2016).

Marx and Roman (2002; Study 1) explored how the presence of a positive female role model influenced the math test performance of women under stereotype threat. Participants
involved in the study were male \((n = 21)\) and female \((n = 22)\) undergraduate students recruited from a standard undergraduate research pool. Upon their arrival at the researcher’s laboratory, participants were greeted by one of three male or female research assistants. The research assistants then provided an overview of the study to the participants that emphasized their role in the development of the mathematical assessment they would be taking to establish their expertise and competence. Stereotype threat was induced in all participants thorough instructions describing the mathematical task as being diagnostic of mathematical ability. After hearing an overview of the study, participants were given 25 minutes to complete difficult math problems taken from the quantitative portion of the Graduate Records Exam. Consistent with predictions of stereotype threat theory, results revealed that females demonstrated significantly lower performance compared to males on the math test. Further, results revealed a significant interaction between the gender of the participant and the gender of the experimenter. Simple effects revealed females underperformed compared to males only in conditions where the test was administered by a male researcher, whereas stereotype threat had no impact in the presence of a female researcher. Researchers believe their findings demonstrated the power of positive role models by suggesting the presence of a competent female researcher is able to eliminate stereotype threat effects.

In a subsequent study, McIntyre, Paulson, and Lord (2003; Study 2) sought to clarify the influence of positive role models on stereotype threat effects. Specifically, the researchers were interested in determining how the consideration of the achievements of competent others who are not present during a performance situation impacts stereotype threat. The participants were undergraduate males \((n = 32)\) and females \((n = 74)\) who participated in exchange for course credit. At the onset of the experimental session, the participants were provided with instruction
that led them to believe they would be taking part in two separate studies – one focusing on the evaluation of stimulus materials for use in future experiments and another designed to provide norming information about mathematical Graduate Records Exam questions.

During the “evaluation of stimulus materials” portion of the study, participants were instructed they would be reviewing a series of biographical essays. The participants in the successful female conditions were provided with four, short essays detailing how females in the domains of medicine, law, architecture, and invention had overcome gender bias to achieve successes in their respective fields. The participants assigned to the successful corporation condition were provided with identical biographical essays with the exception that success was attributed to various corporations instead of individual females. After reading the biographical essays, participants transitioned to the “Graduate Records Exam norming” portion of the study. Prior to completing the math test, participants were informed of empirical research suggesting males often outperform females on tests of mathematical ability. McIntyre, Paulson, and Lord (2003; Study 1) included this brief mention of gender differences in mathematical performance to elicit stereotype threat during the experimental task.

Results revealed standard stereotype threat effects with males demonstrating better performance on difficult GRE items than females. Most notably, planned comparisons revealed that the consideration of successful others prior to test administration had a significant impact on math performance. Specifically, results revealed females who read about successful women performed better than females who read about successful corporations and as well as men in both conditions. McIntyre, Paulson, and Lord’s (2003; Study 2) research supports the protective influence of positive role model by demonstrating that the consideration of group successes can
buoy the performance of female undergraduates confronted with the experience of stereotype threat.

**Misattribution of Arousal and Performance Difficulties**

Some in the domain of stereotype threat have suggested members of stigmatized groups experience increased arousal when confronted with the possibility of confirming a negative stereotype. Research in related domains has suggested heightened arousal has an energizing effect of behavior that increases the emission of dominant response patterns (Martinie, Olive, & Milland, 2010; Pallack & Pittman, 1972; Waterman, 1969). Similar to the mere effort account, enhanced arousal is assumed to interfere with optimal performance on complex tasks where habitual responses are likely to be incorrect and increase performance on simple tasks that often required the emission of well-learned behaviors. Given the proposed relationship between arousal and stereotype threat, researchers have posited that intervention efforts designed to provide individuals with a situational explanation for increased arousal may be able to effectively reduce stereotype threat effects (Ben-Zeev, Fein, & Inzlicht, 2005).

To examine the association between stereotype threat and arousal, contemporary researchers have adopted the use of misattribution paradigms common to dissonance research (Zanna & Cooper, 1974). Misattribution paradigms operate under the assumption that emotional experiences are a combination of physiological arousal and cognitive labeling (see Schacter & Singer, 1962 for more information). As such, arousal – and associated performance patterns – should be impacted by manipulations that influence the cognitive label attributed to arousal states (i.e., Zanna & Cooper, 1974; Storm & Nisbett, 1970).

Ben-Zeev, Fein, and Inzlicht (2005; Study 2) explored the contribution of arousal on performance deficits observed under conditions of stereotype threat. In their study, 37
undergraduate students were asked to complete difficult math problems taken from the Graduate Records Exam (GRE) test guide. Participants selected for the experiment were assumed to identify highly with the mathematics domain due to high scores on the quantitative portion of the SAT and above average scores on the Mathematics Identification Questionnaire. Researchers manipulated levels of stereotype threat by altering gender representation within the experimental session. For instance, female participants were randomly assigned to be in the minority during the testing situation (i.e., high stereotype threat condition) or to take the assessment with same sex-peers (i.e., low stereotype threat condition). Further, researchers randomly assigned a portion of the participants a “misattribution condition” where they were led to believe the subliminal noise was being projected into the laboratory space with the potential to lead to increased arousal, nervousness, and anxiety – thereby providing them the opportunity to misattribute their arousal to external factors.

Consistent with prior literature, females in the stereotype threat condition performed significantly worse than their no-threat counterparts. Most notably, Ben-Zeev and colleagues (2005) found providing the opportunity to misattribute had a reliable impact on performance. Specifically, results revealed participants under stereotype threat, who were given the opportunity to misattribute their arousal to external noise performed significantly better than those who were not given the opportunity to misattribute (Ben-Zeev, Fein, & Inzlicht, 2005). These findings support the notion stereotype threat can be reduced by providing a situational explanation for arousal, by demonstrating the performance impairments observed under conditions of stereotype threat are attenuated when individuals are given the opportunity to misattribute the source of arousal.
Results of several different studies also suggest the existence of a relationship between self-handicapping behaviors and stereotype threat effects. As detailed by Jones and Berglas (1978), self-handicapping can serve an important ego-protecting function among those confronted with failure experience. That is, self-handicappers protect their self-worth by emphasizing factors and endorsing handicaps that reduce feelings of personal responsibility for instances of poor performance (i.e., misattributing sources of performance difficulties). Investigations in the domain of stereotype have demonstrated stigmatized individuals often engage in self-handicapping behavior following poor performance in stereotype relevant domains. For instance, Steele and Aronson (1995; Study 3) found that African American students under stereotype threat were more likely to endorse the existence of situational impediments to performance following a performance event (e.g., lack of sleep, the presence of unfair questions on the exam, etc.). In the time since Steele and Aronson’s (1995) article, researchers have noted examinations of self-handicapping and stereotype threat has focused largely on behavioral responses occurring after performance events. However, some have argued this provides an incomplete representation of the role of self-handicapping and stereotype threat as attributions made within performance events may assist stigmatized individuals in coping with concern stemming from stereotype threat (Brown & Josephs, 1999).

In a representative example, Brown and Joseph (1999; Study 2) explored the impact of an external handicap on the performance of male ($n = 39$) and female ($n = 35$) undergraduate students. Participants involved in the examination were instructed to complete a timed math test consisting of multiple choice items taken from the quantitative portion of the GRE. Researchers elicited stereotype threat in the current examination by emphasizing that the results of the math test would be used to identify students who possess relatively weak mathematical abilities. To
explore the impact of personal handicapping on performance when under stereotype threat, researchers provided a subset of participants the opportunity to attribute failure to aspects of the immediate context. Specifically, participants assigned to the external attribution condition were led to believe they would be given the opportunity to complete a series of practice problems prior to the math exam. However, at the onset of the experimental session, these participants were informed the computer system was experiencing technical issues that made the completion of the practice problems impossible. Participants in the control condition completed the math exam without any mention of practice problems or computer system issues.

Consistent with their predictions, Brown and Josephs (1999; Study 2) observed a significant interaction between gender and the presence of an external handicap. Exploration of the interaction effect indicated there were no significant differences in math performance between male participants assigned to the control and handicap conditions. However, female participants assigned to the handicap condition demonstrated *significantly greater* math test performance than females assigned to the control condition. Consistent with work in other domains (Jones & Berglas, 1978), results of the examination revealed that providing female participants the opportunity to attribute failure to external factors served an ego-protecting function that allowed them to better manage the anxiety associated with the activation of negative group stereotypes.

**Teaching About the Nature of Stereotype Threat**

As detailed above, empirical investigations have repeatedly demonstrated the power of situational attributions in alleviating stereotype threat effects (Ben-Zeev, Fein, & Inzlicht, 2005; Brown & Josephs, 1999). Extending from the logic misattribution studies, some in the field have reasoned that providing information about the impact of stereotype threat may exert a protective
influence on performance by providing learners the opportunity to attribute performance
difficulties to factors beyond their personal ability level (i.e., the activation of negative
sterotypes; Brown & Josephs, 1999).

Johns, Schmader, and Martens (2005) explored the impact of educational messages on
stereotype threat in a study of male ($n = 42$) and female ($n = 75$) introductory statistics students.
Researchers randomly assigned participants to one of three experimental conditions: (1) a
problem-solving condition, (2) a math test condition, and (3) a teaching intervention condition.
Participants assigned to the problem-solving condition were instructed they would be completing
an instrument designed to assess the cognitive processes underlying problem solving (i.e., low-
threat condition). Consistent with prior studies exploring stereotype threat, participants assigned
to the math test condition (i.e., high-threat condition) were instructed they would be taking part
in a study designed to better understand the factors contributing to gender differences in
quantitative ability. Finally, participants assigned to the teaching intervention condition (i.e.,
intervention condition) were also informed they would taking part in a study exploring factors
contributing to gender differences in math performance. However, participants in this condition
were also provided information on stereotype threat and instructed to remember that feelings of
anxiety stemming from the activation of negative stereotypes are not related to their ability to
performance the task effectively. Participants in all three conditions then completed a timed
mathematics test consisting of 30 difficult multiple choice items taken from the Graduate
Records Exam.

Results of their examination revealed a significant interaction between gender and
condition. Follow-up analyses revealed females in the standard stereotype threat condition
demonstrated significantly lower math test performance compared to those in the low-threat
condition. Most importantly, results suggested the math performance of females in the intervention condition was significantly greater than those in the standard stereotype threat condition and comparable to the performance of females in the low-threat condition. Overall, these findings provide compelling evidence that merely providing learners with information about stereotype threat may mitigate its negative influence on performance (Johns, Schmader, & Martens, 2005).

**Self-Affirmation Based Techniques for Reducing Stereotype Threat**

While laboratory-based investigations have demonstrated the effectiveness of various intervention techniques – such as the removal of stereotype-provoking situational cues and the misattribution of arousal – in reducing stereotype threat, researchers have struggled to translate these techniques into interventions for use within real-world performance situations (Johns, Schmader, & Martens, 2005). As such, researchers have begun exploring empirical findings from related domains to identify simple and practical methods with the potential to reduce the effects of stereotype threat. One promising avenue of research on easily implemented strategies has identified self-affirmation as a viable alternative to traditional stereotype threat interventions (Martens, Johns, Greenburg, & Schimel, 2006).

**Self-Affirmation Theory**

Self-affirmation theory posits that individuals are motivated to maintain a global, positive view of the self. That is, self-affirmation theory posits that individuals strive to create and maintain perceptions of the self as being morally adequate (i.e., “I am a good person”) and having the potential to influence important life circumstances (i.e., human agency; Cohen & Sherman, 2014; Steele, 1998). In his description of self-affirmation theory, Steele (1998) proposed that people are routinely confronted with environmental and interpersonal demands
that threaten the perceived integrity of the self. When confronted with potential threats to the self, self-affirmation theory predicts individuals will implement defensive processes focused on restoring the perceived integrity of the self-system (Sherman & Cohen, 2006; 2014; Steele, 1998).

Past studies have demonstrated that individuals have a high level of flexibility regarding the methods that can be used to restore the self-image following perceived threats to self-integrity (Cohen & Sherman, 2014). For instance, researchers have demonstrated individuals restore self-integrity through defensive reactions such as: (1) engaging in self-serving attributions (Campbell & Sedikides, 1998), derogating outgroup members (Fein & Spencer, 1997) and (3) processing threatening information in a biased, highly critical manner (Sherman, Nelson, & Steele, 2000). The tremendous flexibility that has been observed in the defensive reactions elicited by self-image threats is believed to be related to the goals of integrity restoring process. That is, the goal of self-integrity restoring processes is not to manage the source of the provoking self-integrity threat. Instead, the primary goal of defensive processes is to affirm one’s sense of moral adequacy and agency (Steele, 1998). Therefore, individuals are free to make use of whatever strategy best allows them to preserve their self-image in a given situation (Cohen & Sherman, 2014).

While the methods described above have been shown to be effective in protecting integrity, some have questioned their practical utility because of the potential negative outcomes that are associated with the explanations, rationalizations, and behaviors (i.e., biased decision-making, prejudice behavior; Fein & Spencer, 1997; Sherman, Nelson, & Steele, 2000). As such, leaders in the field have called for the identification of methods with a similar level of practical utility that do not place individuals at-risk for negative “side effects”. This drive for a more
positive approach to restoring or preserving the self-image has led to greater attention toward self-affirmation – a process where individuals deal with threat to the self-image by reflecting on important personal characteristics (Cohen & Sherman, 2014). Self-affirmation is believed to restore individuals’ self-image by providing the opportunity to consider other aspects of life that solidify their sense of moral adequacy and agency over important life outcomes (McQueen & Klein, 2006).

**Self-Affirmation and Stereotype Threat**

Research conducted over the past 30 years have demonstrated the power of self-affirmation in alleviating threats to the self-image that are associated with the activation of negative group stereotypes. For instance, Martens, Johns, Greenburg, and Schimel (2006; Study 1) explored the effectiveness the self-affirmation in reducing the performance deficits associated with stereotype threat in a study of female \( n = 77 \) and male \( n = 70 \) undergraduate students. At the onset of the experiment, researchers randomly assigned participants to either a self-affirmation or no self-affirmation condition. Participants in both conditions were asked to rank order a series of personal attributes in regard to personal importance. After ranking the presented attributes, participants in the self-affirmation condition were asked to reflect on their most important personal characteristics while those in the no self-affirmation condition were asked to reflect on their least important characteristic. Following the self-affirmation manipulation, participants were asked to complete a series of multiple-choice math problems taken from the Graduate Management Test (GMAT). Stereotype threat was manipulated by providing a portion of the participants the opportunity to report their gender at the onset of the session.

Results of the examination revealed a significant interaction among self-affirmation, threat manipulation, and gender. Consistent with prior literature, Martens et al., (2006) observed
a significant reduction in the math performance among females assigned to the high threat condition compared to females in the no-threat condition and males in both threat conditions. More notably, results indicated that engaging in self-affirmation prior to the exam exerted a protective influence on the math performance of females in the high-threat condition (Martens et al., 2006).

While studies have demonstrated the effectiveness of self-affirmation in reducing stereotype threat within controlled laboratory settings, some have questioned whether the observed benefits translate into more ecologically valid performance situations. Taillander-Schmitt, Esnard, and Mokounkolo (2012) explored this question in their study investigating the benefits of self-affirmation among female nursing students \((n = 95)\) experiencing stereotype threat within an occupational training context. At the onset of the study, participants were randomly assigned to either a self-affirmation or control condition. Consistent with prior research, the self-affirmation manipulation utilized by Taillander-Schmitt and colleagues (2012) involved ranking and reflecting on important personal characteristics. Participants in the self-affirmation condition were asked to reflect on how a particular important personal characteristic played a role in their lives while participants in the control were asked reflect on how their least important personal characteristic has been important to close others. Following the self-affirmation manipulation, participants were asked to engage in an occupational training exercise involving the calculation of appropriate medication dosages for fictitious patients. Stereotype threat was manipulated through the task instructions provided to participants. Participants in the high-threat condition were informed of a stereotype suggesting females tend to struggle on the task compared to males. The participants in the low-threat condition the task was described as a
typical training exercise, and no mention was given to negative stereotypes or gender differences in performance.

Consistent with the findings of traditional laboratory-based studies, results revealed a marginally significant interaction between level of threat and self-affirmation. Exploration of the interaction effect indicated that females assigned to the self-affirmation condition outperformed females assigned to the no-affirmation condition under high-threat conditions. No performance differences were observed between females in the self-affirmation and no-affirmation conditions under low-threat conditions. Overall, results of the examination suggest engaging in self-affirmation can alleviate the stereotype threat effects among stigmatized individuals within situations with greater ecological validity (Taillander-Schmitt et al., 2012).

Mechanisms Contributing to the Benefits of Self-Affirmation

Despite clear empirical evidence demonstrating the benefits of self-affirmation among those confronted with threats to the self-image, the causal mechanisms that contribute to the protective influence of self-affirmation remain in question. Early work dedicated to identifying the causal mechanisms of self-affirmation emphasized the role of affective and motivational states – such as self-esteem (Kimble Kimble, & Croy, 1981; Stone & Cooper, 2003), positive affect (Koole, Smeets, van Knippenberg, & Dijksterhuis, 1999), and physiological stress response (Creswell, et al., 2005) in self-affirmation effects. Following recent work (McQueen & Kline, 2006) calling into question the role of these “hot” constructs in self-affirmation effects, researchers have shifted their focus toward understanding how more cognitive factors contribute to the facilitative effects of self-affirmation (Harris, Harris, & Miles, 2016; Legault, Al-Khindi, & Inzlicht, 2012; Logel & Cohen, 2012). Based on the logic that self-affirmation is associated with a diverse set of positive outcomes, some have suggested that the consideration of personally
important attributes must influence domain-general abilities that have far reaching consequences on behavior and performance (Logel & Cohen, 2012). Extending from this logic, recent research has begun to explore the impact of self-affirmation on aspects of executive functioning and working memory.

Logel and Cohen (2012) examined the relationship among self-affirmation, weight-loss, and working memory within women ($n = 45$) experiencing weight-related stress. Participants in the examination were informed that they would be taking part in a multisession study designed to explore the effectiveness of a new weight loss intervention. At the onset of session 1, participants were randomly assigned to either a self-affirmation or control condition. The females assigned to the self-affirmation condition were asked to write a brief essay explaining why their most important personal attribute is important to them. Conversely, females assigned to the control condition were asked to write a brief essay describing why their least important personal attribute might be important to social others. All participants selected their most/least important personal attribute from a list of potential values (e.g., close relationships, music, etc.) that was provided during the experimental session. After taking part in the self-affirmation manipulation, each participant was weighted. After a delay period of approximately two months, participants once again reported to the researcher’s laboratory for session 2. During session 2, participants were weighed and completed a measure of working memory capacity (i.e., N-back task).

Consistent with the researcher’s predictions, results revealed females in the self-affirmation condition demonstrated greater weight loss compared to females assigned to the no self-affirmation condition. Most importantly, results indicated that increased working memory performance was positively associated with weight loss among those assigned to the self-
affirmation condition. Logel and Cohen (2012) suggested their results provide evidence that self-affirmation supports effective self-regulation by freeing up the working memory resources that are typically consumed by weight-related stress. However, some have suggested (Harris et al., 2016) the research design employed by Logel and Cohen (2012) makes it difficult to ascertain whether self-affirmation exerts an immediate or delayed impact of working memory performance given there was no immediate assessment of working memory performance.

To address this potential limitation, Harris, Harris, and Miles (2016) explored the immediate impact of self-affirmation on components of executive functioning – namely inhibition and working memory – in a study of male ($n = 18$) and female ($n = 64$) undergraduate psychology students. Participants were randomly assigned to either a self-affirmation or control condition at the onset of the experimental session. Consistent with prior self-affirmation research, participants assigned to the self-affirmation condition were asked to identify and reflect on their most important personal attribute while participants assigned to the control condition were asked to identify their least important personal attribute and describe how it might be important to social others. Following the self-affirmation manipulation, participants completed measures of working memory (i.e., 2-back task) and inhibition (i.e., Stroop task). Consistent with predictions, results indicated participants assigned to the self-affirmation condition demonstrated significantly greater working memory performance. Further, results indicated marginally significant differences between those in the self-affirmation and no self-affirmation conditions on the Stroop task. Specifically, results revealed participants assigned to the self-affirmation condition demonstrated a reduction in the classic Stroop effect compared to those in the control condition. Taken together, these findings suggest that engaging in self-affirmation contributes to
improvements in executive functioning as indicated by enhanced performance on measures of working memory and inhibition.

**Summary and Conclusion**

Research examining the influence of societal stereotypes clearly demonstrates that activating negative stereotypes about one's social identity contributes to underperformance on stereotype-relevant tasks (Ben-Zeev, Fein, & Inzlicht, 2005; Steele & Aronson, 1995; Spencer et al., 2016). Since the first empirical demonstration of stereotype threat effects, researchers have devoted considerable effort to the identification of intervention methods with the potential to protect the performance of individuals experiencing stereotype threat (Schmader et al., 2008). Results of these efforts have provided compelling evidence that allowing stigmatized individuals to reflect on important personal characteristics prior to a performance event is sufficient to eliminate the debilitating influence of stereotype threat on performance (Cohen & Sherman, 2014; Martens et al., 2006; Taillander-Schmitt et al., 2012). A review of the existing literature indicates a need still exists for investigations exploring the mechanisms contributing to the protective influence of self-affirmation. That is, empirical studies have been unable to come to a definitive conclusion regarding the mechanism or mechanisms underlying the benefits of self-affirmation-based interventions among those experiencing stereotype threat. Recent work has attempted to clarify these processes by demonstrating that prompted self-affirmation exercises often enhance working memory performance and aspects of executive functioning (Harris et al., 2016; Logel & Cohen, 2012). While these investigations have provided tentative evidence that the benefits of self-affirmation may be associated with improved working memory performance and executive functioning, no study to date has explored whether self-affirmation protects the working memory performance of individuals experiencing stereotype threat. Therefore, the
The current study is designed to extend the current literature by identifying the nature of the relation between stereotype threat, working memory, and self-affirmation.
Chapter III: Method

Participants

Examination of the empirical literature indicates considerable variability in the effect sizes observed in stereotype threat research. Despite this variability, many researchers believe that the magnitude of stereotype threat effects is generally small (Nguyen & Ryan, 2008; Walton & Cohen, 2003). Using Cohen’s (1992) guidelines for interpreting the magnitude of effect sizes, we determined values corresponding to the upper and lower bounds of “a small effect size” for $f^2$ effect size index. Then, a series of a priori power analyses were conducted using the G*Power software (Faul, Erdfelder, Lang, & Buchner, 2007) to determine the sample size necessary to replicate effects with magnitudes falling within the identified effect size range. Results indicated approximately 264 participants would be required to detect an effect with a magnitude at the lower bound and 44 participants would be required to detect an effect with a magnitude at the upper bound with an alpha .05 for a study with .80 power. Therefore, data was collected from 219 participants with approximately equal numbers in each condition to ensure adequate statistical power in the current study.

Participants ($M \ Age = 19.20, SD = 1.50$) were undergraduate female students attending a mid-sized public university located in the Midwestern United States. A portion of the participants were recruited through a standard undergraduate research pool and received partial course credit in exchange for their involvement in the study. In an attempt to recruit a more diverse sample, participants were also recruited through campus wide recruitment messages. Participants recruited in this manner received $10 in exchange for their involvement in the study. Data collection sessions were arranged using an online research management system and were scheduled at a time that best met the needs of interested participants. Participants completed the
experimental procedure in small groups ranging in size from 1 – 8 participants. Each data
collection session took place in a private laboratory space equipped with desks and the computer
software required to complete the experimental materials. Demographic characteristics of the
sample are presented in Table 1.

Table 1. Demographic Characteristics of the Sample

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caucasian</td>
<td>180</td>
<td>75.9</td>
</tr>
<tr>
<td>African American</td>
<td>15</td>
<td>6.3</td>
</tr>
<tr>
<td>Hispanic</td>
<td>2</td>
<td>0.8</td>
</tr>
<tr>
<td>Asian</td>
<td>5</td>
<td>2.1</td>
</tr>
<tr>
<td>Two or more races</td>
<td>9</td>
<td>3.8</td>
</tr>
<tr>
<td>Missing</td>
<td>8</td>
<td>3.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year in University</th>
<th>N</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshman</td>
<td>109</td>
<td>46</td>
</tr>
<tr>
<td>Sophomore</td>
<td>42</td>
<td>17.7</td>
</tr>
<tr>
<td>Junior</td>
<td>31</td>
<td>13.1</td>
</tr>
<tr>
<td>Senior</td>
<td>27</td>
<td>0.4</td>
</tr>
<tr>
<td>Doctoral Student</td>
<td>1</td>
<td>0.4</td>
</tr>
<tr>
<td>Missing</td>
<td>9</td>
<td>4.1</td>
</tr>
</tbody>
</table>

Procedure

Each data collection session was randomly assigned to one of four experimental
conditions: (1) low stereotype threat – self-affirmation (N = 32), (2) low stereotype threat – no
self-affirmation (N = 74), (3) high stereotype threat – self-affirmation (N = 63), and (4) high stereotype threat – no self-affirmation (N = 50). The use of a verbal stereotype threat manipulation to ensure participants were attentive to a key study manipulation precluded randomization at the individual level. Specifically, it was impossible to provide the verbal instructions to both high and low threat participants in a single session without threatening the validity of the stereotype threat manipulation. At the onset of the data collection session, participants were told that the purpose of the study is to better understand the factors that influence the mathematical performance of undergraduate student and then participants provided informed consent. Immediately following informed consent, participants were assigned a unique numeric identifier that was placed on experimental materials to ensure participant data could be confidentially linked for the purpose of data analyses. Participants then completed the following materials: (1) self-affirmation manipulation, (2) stereotype threat manipulation, (3) operation span task, (4) letter-memory task, (5) modular subtraction problems, (6) stereotype threat scale, (7) domain identification scale (8) self-integrity scale, and (9) demographic questionnaire. The presentation of the working memory tasks (i.e., operation span task & letter-memory task) were counterbalanced to avoid potential order effects. The stereotype threat manipulation, operation span task, letter-memory task, and modular arithmetic problems were programmed and presented using the E-Prime 3.0 software. (http:// www.pstnet.com; Psychology Software Tools Inc., Sharpsburg, Pennsylvania, USA). The self-affirmation manipulation was presented in a paper-and-pencil format and the Stereotype Threat Scale, Self-Integrity Scale, Domain Identification Scale, and demographic questionnaire were presented using the Qualtrics online survey management system. At the conclusion of the data collection session, participants were debriefed and thanked for their time.
**Materials**

**Self-affirmation induction.** Participants in the study were randomly assigned to either the self-affirmation condition or the no self-affirmation condition. All participants were instructed to rank order a list of 10 personal characteristics and values in terms of personal importance (1 = *Most Important*, 10 = *Least Important*). The personal characteristics used in the current study were adapted from those appearing in prior self-affirmation studies (Martens et al., 2006; Sherman, Nelson, Steele, 2000).

After ranking the presented attributes, participants took part in a self-affirmation induction that involved writing a short essay related to their personal values. Specifically, the participants assigned to the self-affirmation condition were instructed to consider the personal characteristic they ranked as being most important and describe a time that identified characteristic had been important in their lives. Participants in the no self-affirmation condition were instructed to consider their least important personal characteristic and to describe a time that the identified characteristic had been important to others. Recent reviews of self-affirmation research have identified this “value essay manipulation” as one of the most widely used and efficacious methods of allowing individuals to affirm their self-integrity within experimental settings (Cohen & Sherman, 2014; McQueen & Klein, 2006;). Full instructions and stimuli presented during the self-affirmation task are provided in Appendix A.

**Stereotype threat induction.** Participants involved in the current study were randomly assigned to either a low stereotype threat condition or high stereotype threat condition. Consistent with prior research, levels of stereotype threat were manipulated by introducing indirect stereotype threat-activating cues into the experimental procedure. All participants read that they were taking part in a research study designed to explore factors influencing the
mathematical performance of undergraduate students. The participants in the high stereotype threat condition were presented with written and verbal instructions indicating that the experimental materials they would be completing during the data collection session were highly diagnostic of mathematical ability. Participants assigned to the low-threat condition were informed that the study is designed to pilot test materials that the researchers hope to use in future studies. Recent meta-analytic work has demonstrated that the use of indirect threat-activating cues generates larger stereotype threat effects among female participants than moderately explicit and blatant cues (Nguyen & Ryan, 2008). Full instructions and stimuli presented during the stereotype threat manipulation are provided in Appendix B.

Operation span task. Participants completed a computerized version of the operation span task (adapted from Foster et al., 2014). The operation span task is a working memory span task that is believed to assess an individual’s ability to attend to and maintain goal-relevant information while avoiding environmental distractions (i.e., maintenance ability, Conway, Kane, Bunting, Hambrick, Wilhelm, & Engle, 2005; Shipstead, Lindsey, Marshall, & Engle, 2014). During the operation span task, participants were shown a series of to-be-remembered letters presented in a sequential fashion. Each letter appeared in the center of a computer monitor for 750ms. Following the presentation of each letter, participants engaged in a distractor task that required participants to judge the accuracy of a simple math equation (i.e., \((7 \div 1) - 2 = 5\)). Each math equation appeared in the center of a computer monitor for a maximum period of 8000ms or until participants have reported on the accuracy of the equation. At the conclusion of each trial, participants were asked to recall the to-be-remembered letters in the order that they were presented. Consistent with prior research (Foster et al., 2014), an index of maintenance ability was calculated by calculating the percentage of letters accurately recalled in the correct
order during the task (i.e., partial span). Prior research has demonstrated acceptable levels of internal consistency for the measure when applied to undergraduate populations (Cronbach’s $\alpha = .87$; Foster et al., 2014). Further, empirical investigations have suggested performance on the operation span accounts for a large amount of variance ($\geq 60\%$) in working memory performance (Foster et al., 2014). Full instructions and stimuli presented during the operation span task are provided in Appendix C.

**Letter-memory task.** Participants were asked to complete an adapted version of the letter-memory task (Morris & Jones, 1990; Rydell et al., 2014). The letter memory task was developed to assess updating ability, which refers to an individual’s ability to monitor information in working memory and effectively remove and replace irrelevant information (Miyake & Friedman, 2012; Morris & Jones, 1990). Extant research has suggested updating ability plays an important role in effective working memory functioning as updating ability often shares a strong, positive relationship with performance on measures of working memory capacity (Miyake et al., 2000; Shipstead et al., 2016). During the task, participants completed 12 trials during which a series of letters were presented in a sequential fashion. Each letter appeared in the center of a computer monitor for 2500ms. Consistent with prior research (Rydell et al., 2014), the 12 trials involved lists of differing lengths (four 5-letter lists, four 7-letter lists, four 9-letter lists). Participants were instructed to maintain the last three letters presented in their working memory using a sub-vocal rehearsal strategy. Each trial concluded with a prompt to recall the last three letters presented during that trial. Prior research has demonstrated that the letter-memory task is a valid measure of individuals’ ability to monitor and rapidly alter the contents of working memory (i.e., updating; Miyake & Friedman, 2012; Morris & Jones, 1990). An index of updating ability was created by calculating the percentage of letter triads correctly recalled.
during the experimental session. Full instructions and stimuli presented during the letter memory task presented in Appendix D.

**Modular arithmetic problems.** Participants were asked to complete a series of novel and difficult (i.e., high memory demand) modular subtraction (MS) problems (adapted from Beilock, Rydell, & McConnell, 2007). At the onset of the task, participants were provided with detailed instructions describing how to solve modular subtraction problems. Specifically, participants were instructed that the task involves judging the accuracy of mathematical equations (i.e., \(51 \equiv 19 \ (mod\ 4)\)). To judge the accuracy of each equation, participants must first subtract the middle number from the first number in the equation (i.e., \(51 - 19\)). Next, participants must divide the difference by the final number (i.e., \(32 \div 4\)). If the result is a whole number, the presented equation is “true.” However, if the result is not a whole number the presented equation is “false.” Thirty MS problems were presented sequentially in the center of a computer monitor and remained until participants reported on the accuracy of the equation. The use of modular subtraction problems in the current examination affords several advantages over other forms of mathematical problem used within stereotype threat research (i.e., GRE quantitative reasoning problems). First, prior research has demonstrated that the working memory demands of MS problems can be easily manipulated by designing problems that include large numbers and require a borrow operation to solve. For instance, designing problems that require a borrow operation to solve effectively requires participants to maintain more information in their working memory system to solve the problems effectively (Beilock et al., 2007). Further, the use of MS problems allows researchers to control for prior experience solving complex mathematical problems given that problems derived from modular arithmetic are often novel to undergraduate students (Beilock & Carr, 2005). Within the current examination,
participants were presented with 30 high-working memory demand items (True = 15, False = 15). An index of mathematical performance was created by calculating the percentage of modular arithmetic problems correctly answered during the experimental session. Full instructions and stimuli for the modular arithmetic problems are presented in Appendix E.

**Stereotype Threat Scale.** The Stereotype Threat Scale (STS; Rangel, Enders, & Delgado, 2002) is a 7-item measure designed to assess an individual’s belief that he or she will conform to negative group-based stereotypes or will be judged in a stereotypical manner during an evaluative situation. Participants were asked to report their level of agreement with each statement using a 7-point Likert-type scale (1 = strongly disagree, 7 = strongly agree). An index of stereotype threat was created by averaging participants’ responses to the 7 items such that higher values indicate greater levels of stereotype threat. Prior research with the STS has demonstrated that the instrument exhibits excellent reliability when applied to undergraduate female students (Cronbach α = .92; Tagler, 2003). Further, prior investigations have supported the construct validity of the measure through finding demonstrating that individuals under stereotype threat report higher scores on the STS than participant not under stereotype threat (Rangel et al., 2002). The STS demonstrated excellent internal consistency in the current examination (Cronbach α = .94). The STS is presented in Appendix F.

**Domain Identification Scale.** The domain identification scale (Lesko & Corpus, 2006) is a 4-item measure designed to assess the importance of mathematical ability to participant’s self-concept. Participants reported their level of agreement with each statement using a 7-point Likert-type scale (1 = strongly disagree, 7 = strongly agree). Following the published convention, reverse-scored items were recoded to produce consistency in the scale. An index of the degree to which participants are math identified was created by averaging participants’
responses to the 4 items. The responses were averaged such that higher values indicate stronger identification with the domain of mathematics. Prior research has demonstrated that the domain identification scale is a reliable measure of mathematics domain identification when applied to undergraduate populations (Cronbach $\alpha = .85$; Lesko & Corpus, 2006). Further, the modified versions of the domain identification scale have been widely within stereotype threat research to assess the importance of mathematical ability to participant’s self-concept. The measure of domain identification demonstrated acceptable internal consistency within the present study (Cronbach $\alpha = .82$). The domain identification scale is presented in Appendix G.

**Self-Integrity Scale.** The Self-Integrity Scale (Cohen et al., 2009) is an 8 - item measure designed to assess participants’ perceptions of their ability to control important life outcomes (i.e., sense of moral and adaptive adequacy). Participants reported their level of agreement with each scale item using a 7-point Likert-type scale (1 = strongly disagree, 7 = strongly agree). A self-integrity score was created by averaging participants’ responses to the presented statements. The scores were averaged such that higher values indicate greater levels of self-integrity. Prior research using the self-integrity scale has demonstrated that the instrument exhibits high levels of internal consistency when administered to undergraduate samples (Cronbach $\alpha = .84$; Cohen et al., 2009). Further, evidence of the construct validity of the instrument can be found within examinations demonstrating that participants exposed to guided self-affirmation manipulations report significantly higher scores on the Self-Integrity Scale than participants who do not engage in guided self-affirmation activities (Cohen et al., 2009). The self-integrity scale demonstrated acceptable internal consistency within the presented investigation (Cronbach $\alpha = .88$). The self-integrity scale is presented in Appendix H.
Demographics questionnaire. Participants completed a brief questionnaire designed to capture basic demographic information including: (1) ethnicity/race, (2) class standing, (3) age, (4) cumulative university grade-point average, and college entrance exam scores (SAT/ACT) (See Appendix I).
Chapter IV: Results

The purpose of the current study was to identify the individual and interactive influence of stereotype threat condition (i.e., low stereotype threat, high stereotype threat) and self-affirmation condition (i.e., self-affirmation, no self-affirmation) on math performance and working memory functioning (i.e., maintenance & updating) of female undergraduate students. Preliminary analyses were conducted to assess the influence of stereotype threat and self-affirmation condition on theoretically related constructs. Following the preliminary analyses, a multivariate analysis of covariance was conducted to explore the relationships among the variables of interest and answer the stated research questions.

**RQ1: Does the activation of negative stereotypes impact the performance of females working to complete a math-related task?**

- **H1:** Females experiencing high levels of stereotype threat will demonstrate significantly worse mathematical test performance.

**RQ2: Does the activation of negative stereotypes disrupt working memory processes?**

- **H2:** Females experiencing high levels of stereotype threat will demonstrate significantly worse updating ability than women experiencing low levels of stereotype threat.

- **H3:** Females experiencing high stereotype threat will demonstrate reduced performance on a task of working memory maintenance compared to females experiencing low levels of stereotype threat.

**RQ3: Does self-affirmation protect the mathematical performance of females experiencing high levels of stereotype threat?**
• H4: Females experiencing high levels of stereotype threat who engage in self-affirmation will outperform females experiencing high levels of stereotype threat who do not engage in self-affirmation.

RQ4: Does self-affirmation protect specific facets of working memory from the disruptive influence of stereotype threat?

• H5: Females experiencing high levels of stereotype threat who engage in self-affirmation condition will exhibit significantly higher working memory updating ability than females experiencing high levels of stereotype threat who did not engage in self-affirmation.

**Manipulation Checks**

A 2 x 2 Analysis of Variance’s (ANOVA) was conducted to explore the influence of the self-affirmation intervention on participants’ perception of self-integrity. The independent variables in the analysis were stereotype threat condition (i.e., low stereotype & high stereotype threat) and self-affirmation condition (i.e., no self-affirmation & affirmation). Prior to the analysis, the assumptions of normality, linearity, independence, and homogeneity of variance were assessed and determined to be met. Based upon prior research (Cohen et al., 2009), it was expected that the analysis would produce a main effect of self-affirmation condition such that participants in the self-affirmation condition report significantly higher levels of self-integrity than their non-affirmed counterparts. Results of the analysis revealed a non-significant main effect of self-affirmation condition, a non-significant main effect of stereotype threat condition, and a non-significant interaction effect, F(1, 169) = 0.00, p = .97, $\omega^2 = .005$, F(1, 169) = 0.19, p = .66, $\omega^2 = .004$, & F(1, 169) = 0.07, p = .78, $\omega^2 = .005$ respectively. Contrary to expectations, these results indicate that engage in the process of self-affirmation did not influence participants’ self-integrity.
A 2 x 2 Analysis of Covariance’s (ANCOVA) was conducted to explore the influence of the stereotype threat intervention on participants’ perceptions of stereotype threat. The independent variables in the analysis were stereotype threat condition (i.e., low stereotype & high stereotype threat) and self-affirmation condition (i.e., no self-affirmation & affirmation). Domain identification was entered as a covariate to control for individual differences in the importance of mathematical ability to the self-concept – a factor that has been shown to influence participants’ susceptibility to stereotype threat effects in prior research (Steele, 1995; Aronson et al., 1999). Prior to the analysis, the assumptions of normality, linearity, independence, homogeneity of variance, independence of the covariate and treatment effect, and homogeneity of regression slopes were assessed and determined to be met. Based upon prior research (Rangel et al., 2002; Steele et al., 1995), a significant main effect of stereotype threat condition was anticipated such that participants in the stereotype threat condition would report significantly more fear of confirming negative group-based stereotype than participants in the no-threat condition. Additionally, it is expected that the analysis will produce a significant interaction effect between stereotype threat and self-affirmation. Specifically, it is anticipated that participants in the stereotype threat condition who were given the opportunity to self-affirm would report significantly lower levels of stereotype threat than participants in the stereotype threat condition who were not given the opportunity to self-affirm. Counter to expectations, results of the analysis revealed a non-significant main effect of stereotype threat condition, and a non-significant interaction effect between the independent variables, F(1, 169) = 0.54, p = .46, $\omega^2 = -.002$ & F(1, 169) = 0.00, p = .94, $\omega^2 = -.005$, respectively. The analysis also revealed a non-significant main effect of self-affirmation, F(1, 169) = 0.02, p = .88, $\omega^2 = -.005$. The domain identification covariate did not share a significant relationship with participants’ perceptions of
stereotype threat, F(1, 169) = 0.95, p = .33, \( \omega^2 = .0003 \). These results suggest that the stereotype threat condition, the self-affirmation condition, and their interactive influence did not impact perceptions of stereotype threat among participants in the current sample.

Table 2. Mean Scores on Survey Materials Disaggregated by Experimental Conditions

<table>
<thead>
<tr>
<th>Measure</th>
<th>No ST Condition M(SD)</th>
<th>ST Condition M(SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No SA Condition</td>
<td>SA Condition</td>
</tr>
<tr>
<td></td>
<td>M(SD)</td>
<td>M(SD)</td>
</tr>
<tr>
<td>SIS</td>
<td>5.60 (.76)</td>
<td>5.63 (.77)</td>
</tr>
<tr>
<td>STS</td>
<td>2.88 (1.18)</td>
<td>2.85 (1.28)</td>
</tr>
<tr>
<td></td>
<td>5.59 (.78)</td>
<td>5.65 (.83)</td>
</tr>
<tr>
<td></td>
<td>3.04 (1.35)</td>
<td>2.99 (1.57)</td>
</tr>
</tbody>
</table>

NOTE: ST = Stereotype Threat; SA = Self-Affirmation; SIS = Self-Integrity Scale; Stereotype Threat Scale; Mean Values represent estimated marginal means.

**Primary Analyses**

A 2 x 2 Multivariate Analysis of Covariance (MANCOVA) was conducted to explore group differences on three dependent variables including mathematical performance (i.e., modular arithmetic accuracy), updating ability (i.e., Letter Memory Task accuracy), and working memory maintenance (i.e., Operation Span Task - Partial Average). The independent variables in the analysis were stereotype threat condition (i.e., low stereotype & high stereotype threat) and self-affirmation condition (i.e., no self-affirmation & affirmation). Consistent with stereotype threat research, domain identification was entered as a covariate to control for individual differences in the importance of mathematical ability to the self-concept (Steele, 1995; Aronson et al., 1999). Consistent with best practices, significant multivariate effects were explored using discriminate analysis (Tabachnick & Fidell, 2013).

**Assumptions of MANCOVA**
Prior research has identified several key assumptions and practical considerations that must be met in order to ensure collected data are appropriate for MANCOVA analyses. The first practical issue is related to the presence of outliers – or unusual patterns – within collected data. Previous research has demonstrated that MANCOVA is extremely susceptible to the influence of univariate and multivariate outliers. Specifically, the presence of outliers in collected data has been shown to contribute to negative outcomes that interfere with researchers’ ability to make valid inferences regarding the relationships among variables of interest including inflated Type I error rates, inflated Type II error rates, reductions in statistical power, and biased parameter estimates (Tabachnick & Fidell, 2013). In the current examination, univariate outliers were identified by comparing the distance of a participant’s raw score on each of the dependent variables from the mean value considering the standard deviation. Univariate outliers were defined as raw scores that fell 2 standard deviations above or below the mean value. Examination of participant data revealed 27 univariate outliers across the three dependent variables. Participant data associated with univariate outliers were removed from subsequent analyses. Following the identification of univariate outliers, Mahalanobis distance values were calculated and inspected to determine the presence of multivariate outliers. Mahalanobis distance values were calculated using SPSS software (Version 21). Multivariate outliers were defined as Mahalanobis distance values that fell above a critical value on the $\chi^2$ distribution (df = 3, $\alpha = .001$, critical value = 16.3). Examination of Mahalanobis distance values indicated there were no multivariate outliers present in the collected data.

Another key assumption of MANCOVA is the assumption of multivariate normality. Multivariate normality was assessed using Mardia’s test of multivariate skew and kurtosis. Mardia’s test of multivariate skew and kurtosis was performed in R 3.3.2 (R Core Team, 2016).
using the psych package (Revelle, 2013). Results of Mardia’s test indicated there were no issues with multivariate kurtosis (kurtosis = -1.37, p = .17). However, results of the examination indicated issues with multivariate skew (skew = 26.04, p = .003), suggesting the assumption of multivariate normality was violated. However, prior research identifies that MANOVA is robust to issues with non-normality when total sample size exceeds 40 (Seo, Kanda, & Fujikoshi, 1995). Therefore, it was decided that the violation of multivariate normality would not be problematic in the current examination given the relatively large sample size.

Data subjected to MANCOVA analysis must also meet the assumption of homogeneity of variance-covariance matrices. To ensure variance and covariance matrices for the dependent variables were equivalent, data were subjected to Box’s M test of covariance. Results of the analysis were non-significant, Box’s M = 21.68, F (18, 47834.96) = 1.16, p = .28, indicating that the homogeneity of variance-covariance matrices was met in the current examination.

In order to effectively conduct a MANCOVA analysis, collected data must also meet the assumption of independence. To assess this assumption, we must examine the data and the sampling plan. Given that participants were sampled from a standard undergraduate subject pool and were randomly assigned to condition it is assumed the assumption of independence was met.

**MANCOVA Results**

Results of the MANCOVA analysis revealed a non-significant multivariate main effect of stereotype threat (Wilk’s λ = .99, F (3, 167) = 0.43, p = .73, η²_p = .01) as well as a non-significant multivariate main effect of self-affirmation (Wilk’s λ = .99, F (3, 167) = 0.31, p = .8, η²_p = .01). Most notably, results of the examination revealed a significant multivariate interaction effect between stereotype threat and self-affirmation (Wilk’s λ = .94, F (3, 167) = 3.29, p = .02, η²_p = .06). Finally, the domain identification covariate was shown to share a significant
relationship with the dependent variables. Average performance on the experimental materials is presented in Tables 3 & 4.

**Table 3.** Mean, Standard Deviation, Minimum, and Maximum Values for Experimental Material

<table>
<thead>
<tr>
<th>Task</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>OSPAN</td>
<td>.66</td>
<td>.16</td>
<td>.20</td>
<td>.98</td>
</tr>
<tr>
<td>LMT</td>
<td>.76</td>
<td>.15</td>
<td>.33</td>
<td>1</td>
</tr>
<tr>
<td>MA</td>
<td>.79</td>
<td>.17</td>
<td>.40</td>
<td>1</td>
</tr>
<tr>
<td>DI</td>
<td>4.29</td>
<td>1.01</td>
<td>1.50</td>
<td>6.75</td>
</tr>
</tbody>
</table>

**Table 4.** Average Performance on the Experimental Materials Disaggregated by Experimental Conditions

<table>
<thead>
<tr>
<th>Task</th>
<th>No ST Condition</th>
<th>ST Condition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No SA Condition M(SD)</td>
<td>SA Condition M(SD)</td>
</tr>
<tr>
<td>OSPAN</td>
<td>.65 (.17)</td>
<td>.68 (.14)</td>
</tr>
<tr>
<td>LMT</td>
<td>.76 (.14)</td>
<td>.77 (.16)</td>
</tr>
<tr>
<td>MA</td>
<td>.73 (.18)</td>
<td>.83 (.15)</td>
</tr>
<tr>
<td>DI</td>
<td>4.43 (1.06)</td>
<td>4.22 (0.95)</td>
</tr>
</tbody>
</table>

**NOTE:** ST = Stereotype Threat; SA = Self-Affirmation; OPSAN = Operation Span; LMT = Letter-Memory Task; MA = Modular Arithmetic; DI = Domain Identification

To better understand the influence of the covariate on the dependent variables, a series of correlational analyses were conducted to estimate the relationship between the covariate and each of the dependent variables. Results of the correlational analyses indicated that domain
identification did not share a significant association with working memory updating ability (i.e. Letter Memory Span Accuracy) or working memory maintenance ability maintenance ability (i.e., partial average scores). However, results of the analysis revealed a marginally significant positive relationship between domain identification and mathematical performance (i.e., modular arithmetic average) indicating that mathematical performance increased as the importance of math to the self-concept increased. Results of the correlational analysis is presented are presented in Table 6.

Table 5. Summary Table for Correlational Analyses Comparing the Relationship Among Domain Identification, Modular Arithmetic Performance, Operation Span Task Performance, & Letter-Memory Task Performance

<table>
<thead>
<tr>
<th></th>
<th>Domain Identification</th>
<th>OSPAN</th>
<th>LMT</th>
<th>MA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domain Identification</td>
<td>1</td>
<td>.12</td>
<td>.003</td>
<td>.19*</td>
</tr>
<tr>
<td>OSPAN</td>
<td>1</td>
<td>.38**</td>
<td>.45**</td>
<td></td>
</tr>
<tr>
<td>LMT</td>
<td>1</td>
<td></td>
<td>.28**</td>
<td></td>
</tr>
<tr>
<td>MA</td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

NOTE: OPSAN = Operation Span; LTM = Letter-Memory Task; MA = Modular Arithmetic; * = Correlation is significant at the .05 level (2 – tailed);

Following recommendations for best practice (Tabachnick & Fidell, 2013), the significant multivariate interaction was investigated using discriminant analysis. Specifically, discriminate analysis was used to generate discriminate functions that maximally separate groups included in the analysis. Following the identification of meaningful discriminate functions, total
canonical structure (TCS) values were assessed to determine which of the dependent variables best differentiates among groups included in the primary analysis. Using guidelines provided by Tabachnick & Fidell (2013), a variable was considered to meaningfully contribute to group differences if the total canonical structure value exceeded .30. Examination of total canonical structure values revealed that group differences were primarily driven by participants’ performance on the modular arithmetic problems (TCS = 0.94). Based on the .30 cut-value, participants’ performance on the operation span and letter memory tasks did not contribute to group differences detected in the significant multivariate interaction, TCS’s = .27, -.04 respectively.

Mean values on the modular arithmetic task for each condition were examined to better understand group differences on participants’ mathematical performance. Examination of mean values indicated that the process of self-affirmation facilitated math performance in the absence of stereotype threat. More specifically, self-affirmed participants demonstrated greater mathematical performance than their non-affirmed counterparts when completing the experimental materials in a situation designed to limit the experience of stereotype threat. Interestingly, engaging in the process of self-affirmation had a debilitative influence on math performance in stereotype threat-evoking situations. That is, self-affirmed participants exhibited reduced mathematical performance compared to non-affirmed participants when completing the experimental materials in a situation designed to elicit feelings of stereotype threat. Collectively, these findings suggest that engaging in the process of self-affirmation undermines performance within threatening situations by altering perceptions of the performance event leading to reductions in motivation and task engagement. Group means on the modular arithmetic items are presented in Figure 1.
Chapter V: Discussion

Available data suggest the existence of a persistent gap in performance and interest in math-related domains between male and female students. That is, female students reliably demonstrate reduced performance on assessments of mathematical ability, persistence in math-related domains, and interest in pursuing math-intensive careers beginning in the high school years and persisting through university (College Board, 2016; Hyde et al., 1990; Snyder & Dillow, 2012; Williams, & Barnett, 2009). Because of the potential educational and societal implications of this difference, researchers have attempted to identify mechanisms contributing to gender achievement gaps. One promising avenue of research comes from stereotype threat
theory, which emphasizes the debilitating influence of societal stereotypes on the academic performance and persistence of stigmatized students (Steele, 1997; Steele & Aronson, 1995).

Stereotype threat theory operates under the assumption that situational cues can lead to the consideration of negative stereotypes related to a salient social identity (Schmader et al., 2008; Steele & Aronson, 1995). The activation of negative group-based stereotypes is believed to contribute to situation-specific apprehension (i.e., stereotype threat) that performance will be interpreted stereotypically or as evidence of negative group-based stereotypes. Over the past two decades, researchers have provided evidence that stereotype threat generates affective, cognitive, and behavioral reactions that interfere with performance on stereotype-relevant tasks (Doyle & Voyer, 2016; Flore & Wicherts, 2014; Lamont, Swift, & Abrams, 2015; Nguyen & Ryan, 2008). Following the identification of stereotype threat effects, numerous interventions have been developed with the goal of protecting the performance of stigmatized students (Herrmann et al., 2016; Johns et al., 2005; Marx & Roman, 2002; Miyake et al., 2010). One promising intervention involves asking learners to reflect on personal characteristics before a performance event—a process known as self-affirmation. Empirical investigations have demonstrated self-affirmation protects the immediate performance of individuals confronted with stereotype threat (Martens et al., 2006) and has the potential to block negative recursive processes that contribute to patterns of chronic underperformance observed among stigmatized students (Sherman et al., 2013). While empirical research has been successful in demonstrating the benefits of self-affirmation (Martens et al., 2006; Taillander-Schmitt et al., 2012; Sherman et al., 2013), studies have been far less successful in identifying the causal mechanisms contributing to these benefits. Recent work has provided preliminary evidence that the protective influence of self-affirmation is related to increases in working memory capacity and executive functioning that follows reflecting on
personal characteristics. It is believed self-affirmation allows learners to better allocate cognitive resources by buffering people against social threats thereby preventing reactions that interfere with information processing. However, no study to date has directly investigated how self-affirmation interacts with stereotype threat to influence working memory functioning and performance on stereotype-implicated tasks. Therefore, the current study was designed to determine the influence of stereotype threat and self-affirmation on working memory functioning and mathematical task performance.

**Study Findings**

The general findings of the current study highlight the complexity of the relationships that exist among stereotype threat, self-affirmation, working memory, and mathematical performance. The results demonstrated that engaging in the process of self-affirmation in the absence of stereotype threat-inducing cues was associated with increased performance on a mathematical task. However, our results indicated that engaging in the process of self-affirmation in the presence of stereotype threat activating cues was associated with reductions in mathematical performance. Finally, results revealed there were no differences on tasks believed to assess processes critical to working memory functioning (i.e., updating & maintenance) associated with experimental condition.

**Perceptions of Stereotype Threat**

Participants completed a self-report measure designed to assess an individual’s belief that he or she will conform to negative group-based stereotypes or will be judged in a stereotypical manner while completing the experimental materials. Results indicated that there were no differences in perceptions of stereotype threat between participants assigned to the high - and low - threat conditions. At first glance, this finding seems inconsistent with prior work
demonstrating that stigmatized individuals are often highly aware of the instances where their social identity is the target of negative stereotypes (Johns et al., 2005; Marx & Goff, 2005; Purdie-Vaughns, Steele, Davies, Ditlmann, & Crosby, 2008). However, I believe these inconsistent findings can be explained using a multi-threat approach to stereotype threat. Critical examination of items contained within the Stereotype Threat Scale (Rangel, Enders, & Delgado, 2002) reveal a discrepancy between the form of stereotype threat assessed and the form of threat evoked in the experimental situation. Specifically, items on the STS are concerned with how performance on the experimental measure will impact societal perceptions of participants’ gender group (i.e., group-focused stereotype threat; “It makes me nervous to think that my scores on math tests may reflect poorly on other people in my gender group”. People may take my score on math exams as representative of all people in my gender group”) However, recent research has suggested stereotype threat manipulations emphasizing the diagnostic capabilities of experimental materials activate a form of stereotype threat driven primarily by the fear that an individual’s behavior will confirm that negative stereotypes about a salient social identify is true of them (i.e., self-focused stereotype threat; Shapiro & Neuberg, 2007; Wout et al., 2008).

Therefore, it is possible the failure to detect group differences in the perception of stereotype threat is the result of the measure assessing a form of stereotype threat not present in the current study.

**Self-Affirmation & Working Memory Performance**

Results of the MANCOVA analysis indicated that the self-affirmation manipulation did not influence performance on working memory measures. This finding is inconsistent with recent work demonstrating the process of self-affirmation is associated with improvements in working memory and executive functioning (Harris et al., 2016; Logel & Cohen, 2012). I believe
the disparate findings are a function of the measures used to assess working memory functioning within the current and past studies. Examination of the existing literature reveals studies showing improvements in working memory functioning following self-affirmation exercises have relied exclusively on the use of the n-back task (Harris et al., 2016; Logel & Cohen, 2012). Despite being widely used within field of cognitive neuroscience, researchers have only recently begun to investigate the validity of the measure. Results of these investigations have provided evidence that the validity of the n-back task is dependent upon the parameters that are established during the experimental procedure. For instance, versions of the n-back task that require participants to identify target items from familiar distractors have been shown to exhibit poor convergent validity well-validated measures of working memory (i.e., operation span task, Kane, Conway, Miura, & Colflesh, 2007; backward digit span, Miller, Price, Okun, Montijo, Bower, 2009). However, versions of the n-back task that require participants to freely recall previously presented items have been shown to strongly correlate with validated measures of working memory including the operation span task (Shelton, Metzger, & Elliot, 2007). These findings have led some to suggest that versions of the n-back tasks emphasizing different memory processes may in fact be measuring conceptually distinction constructs (Kane et al., 2007).

Careful examination of the work demonstrating improvements in working memory functioning following self-affirmation (Harris et al., 2016; Logel & Cohen, 2012) reveal that the n-back task used within both studies required participants to simply discriminate target cues from similar distractors. When considered in conjunction with findings noting differential validity for different versions of the n-back task, it is possible our disparate findings are the result of past examinations assessing a construct that is conceptually distinct from the latent construct assessed by the working memory measures used in the current examination. Perhaps more importantly,
these discrepant findings highlight the importance of considering task purity when interpreting results from tests of memory functioning. It is relatively commonplace for researchers to erroneously assume that memory measures effectively isolate specific memory systems or processes (i.e., are task pure; Jacoby, 1991). However, variations in conditions at information encoding and retrieval can lead individuals to use vastly different processes while working to complete memory tasks (Neath & Surprenant, 2005). Therefore, it is critical future work in this domain carefully consider encoding and retrieval demands of memory tests when interpreting collected data.

**Stereotype Threat & Working Memory**

The working memory deficit approach to stereotype threat effects suggests that inducing negative group-based stereotypes activates behavioral, emotional and cognitive reactions that consume working memory resources that are required to complete stereotype-relevant tasks (Schmader et al., 2008). In support of the working memory deficit approach, researchers have demonstrated that the relationship between stereotype threat and mathematical performance is mediated by reductions in working memory capacity (Schmader & Johns, 2003). Investigations have further clarified the nature of the relationship between stereotype threat, working memory, and math performance by demonstrating the negative influence of stereotype threat is often limited to specific aspects of working memory (i.e., phonological loop, Beilock et al., 2007; working memory updating, Rydell et al., 2014). However, results of the current examination failed to replicate prior findings. These discrepant findings once again highlight the importance of continued research focused on clarifying the nature of the relationship between stereotype threat and working memory functioning as well as continued clarity in the specific elements of working memory or executive functioning being assessed in each study.
The current study found that stereotype threat condition and self-affirmation condition interacted to influence performance on a series of modular arithmetic problems. Specifically, the examination indicated participants assigned to the self-affirmation condition exhibited boosted math performance when completing the task in low-threat conditions and reduced performance when completing the task in high-threat conditions. On the surface, the finding that reflecting on important personal characteristics was harmful in the presence of stereotype threat inducing cues seems contrary to previous research documenting the benefits of guided self-affirmation among those experiencing stereotype threat (Cohen & Sherman, 2014; Mertens et al., 2006; Taillander-Schmitt et al., 2012). However, this pattern of results is consistent with contemporary theoretical orientations emphasizing the importance of arousal and motivation in stereotype threat effects.

The Threat-Induced Potentiation of Prepotent Response (TIPPR) model (Seitchick, Brown, & Harkins, 2017) proposes that exposure to social identity-threatening cues generates physiological arousal that increases the emission of dominant response patterns. According to the TIPPR, the increased emission of dominant response patterns facilitates performance when the response is likely to be correct - as is often the case on simple or well-learned tasks (Jamieson & Harkins, 2007; Harkins et al., 2017; Pallack & Pittman, 1972). However, the potentiation of dominant responses patterns often reduces performance when the response is unlikely to be correct – as is often the case on complex or novel tasks (Jamieson & Harkins, 2007; Harkins et al., 2017; Pallack & Pittman, 1972). However, when individuals have the ability, motivation and opportunity to identify and rectify incorrect responses, the potentiation of dominant response patterns can lead to improved performance (Jamieson & Harkins, 2007; Harkins et al., 2017)
Empirical investigations testing key propositions of the TIPPR have demonstrated that the experience of stereotype threat is associated with increased arousal that facilitates performance on cognitively simple tasks and reduces performance on cognitively complex tasks (Ben-Zeev, Fein, & Inzlicht, 2005). Further, available data suggest that stereotype threat also has a motivating influence on stigmatized individuals that can lead to enhanced performance within certain testing situations. Specifically, research has demonstrated that participants exposed to stereotype threat-inducing cues are highly motivated to disconfirm negative group-based stereotypes and devote more effort to task completion and performance monitoring than non-threatened individuals (Steele & Aronson, 1995). As a result, participants under stereotype threat can exhibit performance that is on par or superior to non-threatened individuals when task conditions allow them the opportunity to recognize and overcome prepotent responses (Jamieson & Harkins, 2007). Therefore, it is possible that engaging in the process of self-affirmation successfully altered participants' perception of the performance event and reduced stereotype threat. If stereotype threat motivates or promotes task engagement, relieving that stressor through self-affirmation may have limited the desire to engage in the experimental tasks.

**Limitations of the Study and Directions for Future Research**

The current study contained several limitations that warrant discussion. The study used a series of high-working memory demand modular arithmetic problems to generate an index of mathematical performance - as stereotype threat effects are most pronounced when participants are working to complete difficult tasks. While the current study used guidelines found within the existing literature for developing difficult (i.e., high-working memory demand) questions (Ashcraft & Kirk, 2001; Beilock & Carr, 2005), performance levels on this task suggest the problems may not have been sufficiently difficult. This potential limitation can be addressed in
future work by generating a large pool of modular arithmetic items and conducting a pilot study designed to identify the characteristics of the questions to allow for the inclusion of only the most difficult problems.

Second, data were collected primarily from undergraduate students who volunteered to participate as part of their involvement in a standard undergraduate research pool. As a result, it is possible the results of the study may not generalize beyond the sample given the lack of variability observed in several demographic characteristics (i.e., age, ethnicity, etc.). Third, the design of the investigation did not allow for the collection of more precise data that would identify individual differences in mathematical ability. Following the conventions in this field of research (Ben-Zeev et al., 2003; Inzlicht & Ben-Zeev, 2000; Steele & Aronson, 1995) participants self-reported college entrance examination scores (i.e., SAT, ACT) - for inclusion in the final analysis. However, this self-report process resulted in a significant proportion of participants who were unable provide reliable indicators. Future studies could address this barrier by gaining access to institutional data tracking performance (i.e., student records).

Conclusions

Research has demonstrated that learners from stigmatized social groups routinely experience a form of evaluation apprehension tied to the activation of negative group-based stereotypes (Nguyen & Ryan, 2008; Steele & Aronson, 1995). Empirical efforts focused on the identification of effective stereotype threat reduction strategies have identified self-affirmation as an easily-scaled solution with the potential to improve the academic performance of stigmatized students (Cohen & Sherman, 2014). However, the causal mechanisms contributing to the apparent benefits of self-affirmation among stigmatized learners are still in question. The current study attempted to address this potential gap in the literature by systematically testing the
influence of stereotype threat and self-affirmation on working memory functioning and performance on a novel mathematical task. The results of this study highlight the reality that self-affirmation-based interventions may not be a viable solution for addressing performance gaps among individuals who do and do not experience stereotype threat. Instead, results indicate that efforts to alter students’ perceptions of threatening testing events may buffer the motivating influence of stereotype threat and reduce task performance.
References


Appendices
Appendix A: Self-Affirmation Manipulation

Instructions (Self-Affirmation):

During this portion of the study, you will be asked to engage in a brief writing exercise designed to help us better understand the opinions and experiences of typical undergraduate students. Please take your time as you work through the study and do your best to provide honest and thoughtful answers.

To begin, please rank order the following characteristics in order of personal importance (1 = Most Important, 10 = Least Important).

_____ Humor
_____ Creativeness
_____ Physical Attractiveness
_____ Social Skills
_____ Relations with Friends and Family
_____ Perseverance
_____ Good Citizenship
_____ Sportsmanship
_____ Sensitivity
_____ Solidarity

Now, we would like for you to consider your most valued characteristic (e.g., the item ranked "1"). In the space below please describe why your most valued characteristic is personally important and describe a time when your most valued characteristic has been particularly important in your life.

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________

______________________________________________________________________________
Instructions (No Affirmation Condition):

During this portion of the study, you will be asked to engage in a brief writing exercise designed to help us better understand the opinions and experiences of typical undergraduate students. Please take your time as you work through the study and do your best to provide honest and thoughtful answers.

To begin, please rank order the following characteristics in order of personal importance (1 = Most Important, 10 = Least Important).

______ Humor
______ Creativeness
______ Physical Attractiveness
______ Social Skills
______ Relations with Friends and Family
______ Perseverance
______ Good Citizenship
______ Sportsmanship
______ Sensitivity
______ Solidarity

Now, we would like for you to consider your least valued characteristic (e.g., the item ranked "10"). In the space below please describe why your least valued characteristic is important to other people and describe a time when your least valued characteristic has been particularly important for someone else.

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
Appendix B: Stereotype Threat Manipulation

**High Stereotype Threat Condition:**

Participants in the high stereotype threat condition will be instructed:

> During this portion of the study, you will complete a series of computerized tasks that are designed to assess math ability. Prior administrations of these tasks have demonstrated that they are highly diagnostic of students’ overall level of mathematical ability. Because we want an accurate measure of your mathematical ability, we want to ask you to try as hard you can to perform well on these tasks. At the end of the study, we can give you feedback which may be helpful in pointing out your strengths and weakness.

**Low Stereotype Threat Condition:**

Participants in the low-threat condition will be instructed:

> During this portion of the study, you will complete a series of computerized tasks that are designed to assess math ability. At this point, we would like to emphasize that we are not interested in evaluating your ability on these tasks. Instead, we hope to use the information we obtain from this session to further refine the measures for use in future research studies. Even though we are not evaluating your ability on these tasks, we want to ask you to try as hard as you can to perform well on these tasks. If you want to know more about your performance on the tasks, we can give you feedback at the end of the study.
Appendix C: OPSAN Task

Practice Set (Letters)

Slide 1

During this portion of the study, you see lists of letters with math problems inserted in between. Your job will be to decide if the math problems are correct while remembering all of the letters appearing in the list.

Press the “space bar” to advance

Slide 2

For this practice set, letters will appear on the screen one at a time.

Try to remember each letter in the order presented

After 2 – 3 letters have been shown, you will be prompted to recall the letters that were presented.

Specifically, your job is to enter each letter in the order presented. To do this, type the letters using the keyboard. The letters you type will appear at the top of the screen.

Press the “space bar” to advance

Slide 3

When you have entered all the letters, and they are in the correct order, hit the ENTER key.

If you make a mistake, hit the DELETE button to start over.

If you forget one of the letters, click the SPACE bar to mark the spot for the missing letter.

Remember, it is very important to get the letters in the same order as you see them. If you forget one, use the SPACE bar to mark the position.

Please ask the experimenter any questions you may have at this time.

When you are ready, Press the “space bar” to begin the letter practice.
<table>
<thead>
<tr>
<th>Trial</th>
<th>Letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HKT</td>
</tr>
<tr>
<td>2</td>
<td>SNR</td>
</tr>
</tbody>
</table>

**Practice Set (Math)**

*Slide 4:*

Now you will practice doing the math part of the experiment.

A math problem will appear on the screen, like this:

\[(2 \times 1) + 1 = ?\]

As soon as you see the math problem, you should compute the correct answer.

In the above problem, the answer 3 is correct.

When you know the correct answer, you will press the SPACE bar.

Press the “space bar” to advance

*Slide 5:*

You will then see a number displayed on the next screen.

If the number on the screen is the correct answer to the math problem, press the TRUE (“t”) button.

If the number is not the correct answer, press the FALSE (“f”) button.

For example, if you see the problem

\[(2 \times 2) + 1 = ?\]

and the number on the following screen is 5 press the TRUE button, because the answer is correct.
If you see the problem

\[(2 \times 2) + 1 = ?\]

and the number on the next screen is 6 press the FALSE (“f”) button, because the correct answer is 5, not 6.

After you press one of the buttons, the computer will tell you if you made the right choice.

Press the “space bar” to advance

_Slide 6:

It is very important that you get the math problems correct. It is also important that you try and solve the problems as quickly as you can.

Please ask the experimenter any questions you have at this time.

When you’re ready, press the SPACE bar to try some practice problems.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Problem</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>((1 \times 2) + 1 =)</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>((1 \div 1) - 1 =)</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>((7 \times 3) - 3 =)</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>((4 \times 3) + 4 =?)</td>
<td>16</td>
</tr>
</tbody>
</table>

_Practice Set (Both Tasks)_

_Slide 7:

Now you will practice doing both parts of the experiment at the same time.

In the next practice set, you will be given one of the math problems. Once you make your decision about the math problem, a letter will appear on the screen. Try and remember the letter.

In the previous section where you only solved math problems, the computer computed your average time to solve the problems. If you take longer than your average time, the computer will automatically move you onto the letter part, thus skipping the TRUE or FALSE part and will count as a math error. Therefore, it is VERY important to solve problems as quickly and as accurately as possible.

Press the “space bar” to advance.
**Slide 8:**

After the letter goes away, another math problem will appear, and then another letter.

At the end of each set of letters and math problems, a recall screen will appear. Use the keyboard to enter the letters you just saw. Try your best to get the letters in the correct order.

It is important to work **QUICKLY** and **ACCURATELY** on the math. Make sure you know the answer to the math problem before clicking to the next screen.

You will not be told if you answer to the math problem is correct.

Please ask the experimenter any questions you may have at this time.

Press the “space bar” to try some practice problems.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Problem</th>
<th>Answer</th>
<th>Letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>((2 \times 7) - 4) =?</td>
<td>13</td>
<td>P</td>
</tr>
<tr>
<td>1</td>
<td>((3 \times 3) - 5) =?</td>
<td>4</td>
<td>Q</td>
</tr>
<tr>
<td>2</td>
<td>((1 \times 9) - 1) =?</td>
<td>5</td>
<td>Y</td>
</tr>
<tr>
<td>2</td>
<td>((6 \times 2) + 9) =?</td>
<td>22</td>
<td>L</td>
</tr>
</tbody>
</table>

**Slide 10:**

This is the end of the practice.

The real trials will look like the practice you just completed.

First, you will get a math problem to solve, then a letter to remember.

When you see the recall screen, type the letters in the order presented. If you forget a letter, click the SPACE bar to mark where it should go.

Some sets will have more math problems and letters than others.

It is important that you do your best on both the math problems and the letter recall parts of this experiment.

Remember on the math you must work as **QUICKLY** and **ACCURATELY** as possible.

Press the “space bar” to begin.
### Experimental Trials

#### OSPAN Task

<table>
<thead>
<tr>
<th>Trial</th>
<th>Problem</th>
<th>NUMBER</th>
<th>ANSWER</th>
<th>Letter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(3 x 4) - 6 =</td>
<td>6</td>
<td>T</td>
<td>F</td>
</tr>
<tr>
<td>1</td>
<td>(8 ÷ 2) - 3 =</td>
<td>0</td>
<td>F</td>
<td>K</td>
</tr>
<tr>
<td>1</td>
<td>(9 ÷ 1) + 8 =</td>
<td>9</td>
<td>F</td>
<td>Q</td>
</tr>
<tr>
<td>1</td>
<td>(4 ÷ 1) - 1 =</td>
<td>11</td>
<td>F</td>
<td>R</td>
</tr>
<tr>
<td>1</td>
<td>(2 x 5) - 8 =</td>
<td>3</td>
<td>F</td>
<td>T</td>
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<tr>
<td>1</td>
<td>(3 ÷ 3) + 1 =</td>
<td>2</td>
<td>T</td>
<td>H</td>
</tr>
<tr>
<td>2</td>
<td>(3 ÷ 1) + 5 =</td>
<td>8</td>
<td>T</td>
<td>F</td>
</tr>
<tr>
<td>2</td>
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<tr>
<td>2</td>
<td>(6 ÷ 3) + 2 =</td>
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<td>2</td>
<td>(5 ÷ 1) + 1 =</td>
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<td>F</td>
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<tr>
<td>2</td>
<td>(5 x 2) - 6 =</td>
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<td>T</td>
<td>H</td>
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<td>3</td>
<td>(1 x 4) - 4 =</td>
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<tr>
<td>3</td>
<td>(1 x 2) - 0 =</td>
<td>1</td>
<td>F</td>
<td>N</td>
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<td>3</td>
<td>(7 x 2) - 4 =</td>
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<td>T</td>
<td>H</td>
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<tr>
<td>4</td>
<td>(6 ÷ 2) + 3 =</td>
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<td>F</td>
<td>J</td>
</tr>
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<td>28</td>
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<td>(8 x 2) + 9 =</td>
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<td>N</td>
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<td>5</td>
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<td>F</td>
<td>K</td>
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<tr>
<td>5</td>
<td>(1 ÷ 1) - 1 =</td>
<td>5</td>
<td>F</td>
<td>P</td>
</tr>
<tr>
<td>5</td>
<td>(2 x 6) + 1 =</td>
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<td>T</td>
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<tr>
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<td>(4 ÷ 1) + 3 =</td>
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<td>(5 x 3) - 2 =</td>
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<td>F</td>
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<tr>
<td>5</td>
<td>(3 ÷ 1) - 1 =</td>
<td>2</td>
<td>T</td>
<td>Q</td>
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<td>6</td>
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<td>P</td>
</tr>
<tr>
<td>6</td>
<td>(9 ÷ 9) - 1 =</td>
<td>3</td>
<td>F</td>
<td>R</td>
</tr>
<tr>
<td>6</td>
<td>(4 ÷ 1) + 4 =</td>
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<td>(2 x 5) + 3 =</td>
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<td>L</td>
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<tr>
<td>7</td>
<td>(4 ÷ 1) + 8 =</td>
<td>15</td>
<td>F</td>
<td>H</td>
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<tr>
<td>7</td>
<td>(7 x 2) - 7 =</td>
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<td>T</td>
<td>Y</td>
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<tr>
<td>7</td>
<td>(1 x 2) + 3 =</td>
<td>13</td>
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<td>T</td>
<td>Q</td>
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<td>13</td>
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<td>Q</td>
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<td>Y</td>
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<tr>
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<td>F</td>
<td>L</td>
</tr>
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<tr>
<td>14</td>
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<td>3</td>
<td>T</td>
<td>K</td>
</tr>
<tr>
<td>15</td>
<td>((5 \div 1) + 9 =)</td>
<td>14</td>
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<td>F</td>
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</tr>
<tr>
<td>15</td>
<td>((1 \times 7) + 6 =)</td>
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<td>T</td>
<td>P</td>
</tr>
<tr>
<td>15</td>
<td>((9 \div 1) - 1 =)</td>
<td>8</td>
<td>T</td>
<td>S</td>
</tr>
<tr>
<td>15</td>
<td>((3 \div 3) - 0 =)</td>
<td>0</td>
<td>F</td>
<td>L</td>
</tr>
</tbody>
</table>
Appendix D: Letter-Memory Task

Instructions:

During this portion of the study, you will see lists of letters. Each letter will be presented one at a time in the middle of the screen. Your job will be to always remember the last three letters presented.

At the conclusion of each list, you will be prompted to enter the LAST THREE LETTERS presented as quickly as you can using the keyboard. Press the “space bar” to continue.

Slide 2:

The graphic below provides a basic overview of the experimental procedure.

**Updating: Always Remember the Last Three Letters**

<table>
<thead>
<tr>
<th>M</th>
<th>K</th>
<th>P</th>
<th>T</th>
<th>C</th>
<th>Recall</th>
</tr>
</thead>
</table>

Please ask the experimenter any questions you may have at this time.

When you are ready, press the “space bar” to complete a brief practice.

Practice Set

<table>
<thead>
<tr>
<th>List ID</th>
<th>To Be Remembered Items</th>
<th>Correct Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Practice – Trial 1</td>
<td>KYNS</td>
<td>YNS</td>
</tr>
<tr>
<td>Practice – Trial 2</td>
<td>PSLN</td>
<td>SLN</td>
</tr>
</tbody>
</table>
Slide 3:

This is the end of the practice.

The real trials will look like the practice you just completed.

Please ask the experimenter any questions you may have at this time.

When you are ready, press the “space bar” to begin.

Experimental Trails

<table>
<thead>
<tr>
<th>List ID</th>
<th>To Be Remembered Items</th>
<th>Correct Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Five Item – Trial 1</td>
<td>SNYKQ</td>
<td>YKQ</td>
</tr>
<tr>
<td>Five Item – Trial 2</td>
<td>NLSRP</td>
<td>SRP</td>
</tr>
<tr>
<td>Five Item – Trial 3</td>
<td>FYHNP</td>
<td>HNP</td>
</tr>
<tr>
<td>Five Item – Trial 4</td>
<td>PHRTL</td>
<td>RTL</td>
</tr>
<tr>
<td>Seven Item – Trial 1</td>
<td>SYNFJRL</td>
<td>JRL</td>
</tr>
<tr>
<td>Seven Item – Trial 2</td>
<td>NFKTHYJ</td>
<td>HYJ</td>
</tr>
<tr>
<td>Seven Item – Trial 3</td>
<td>FKRYTSN</td>
<td>TSN</td>
</tr>
<tr>
<td>Seven Item – Trial 4</td>
<td>SJHNTFR</td>
<td>TFR</td>
</tr>
<tr>
<td>Nine Item – Trial 1</td>
<td>QFPTLNHRY</td>
<td>HRY</td>
</tr>
<tr>
<td>Nine Item – Trial 2</td>
<td>YJTLNKSRH</td>
<td>SRH</td>
</tr>
<tr>
<td>Nine Item – Trial 3</td>
<td>PYFKTJQHR</td>
<td>QHR</td>
</tr>
<tr>
<td>Nine Item – Trial 4</td>
<td>NQFHTJLKY</td>
<td>LKY</td>
</tr>
</tbody>
</table>
Appendix E: Modular Arithmetic Task

Slide 1: Introduction

“During this portion of the study, you will be asked to complete a math exam consisting of a series of modular subtraction problems”. Specifically, you will be asked to judge whether integers presented in a mathematical equation are congruent or incongruent.

Press the “space bar” to advance

Slide 2: Guide

It is possible to determine if two integers are congruent using modular subtraction by using the three steps listed below.

**Standard form of modular arithmetic problems**

\[ b \equiv a \ (modulo) \]

Step 1: Subtract \( b - a \)

Step 2: Divide the difference from step 1 by the modulo

Step 3: Examine the solution from step 2.

If the solution is a whole number (e.g., 8), the two integers ARE CONGRUENT.

If the solution is not a whole number (e.g., 1.5), the two integers ARE NOT CONGRUENT.

Press the “space bar” to advance

Slide 3: Example

Are the two integers congruent modulo \( m \)?

\[ 51 \equiv 19 \ (mod \ 4) \]

**Solution:**

Step 1: Subtract \( b - a \)

\[ 51 - 19 = 32 \]

Step 2: Divide the difference from step 1 by the modulo

\[ 32 \div 4 = 8 \]

Step 3: Examine the solution from step 2.
If the solution is a whole number (e.g., 8), the two integers ARE CONGRUENT.

If the solution is not a whole number (e.g., 1.5), the two integers ARE NOT CONGRUENT.

Since the solution is a whole number (e.g., 8), the two integers ARE CONGRUENT.

Slide 4:

You will be now presented with practice modular subtraction problems. For each problem, please judge the congruency of the presented integers.

If you believe the integers are congruent, please press the TRUE KEY (The “t” key)
If you believe the integers are not congruent, please press the FALSE KEY (The “f” key)

Press the “space bar” when you are ready to begin the practice.

Modular Subtraction Practice Problems

<table>
<thead>
<tr>
<th>Problems (TRUE)</th>
<th>Problems (FALSE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 ≡ 10 ((mod \ 5))</td>
<td>25 ≡ 10 ((mod \ 6))</td>
</tr>
<tr>
<td>24 ≡ 8 ((mod \ 8))</td>
<td>24 ≡ 8 ((mod \ 7))</td>
</tr>
<tr>
<td>31 ≡ 3 ((mod \ 7))</td>
<td>31 ≡ 3 ((mod \ 8))</td>
</tr>
</tbody>
</table>

Slide 5:

This is the end of the practice.

The real trials will look like the practice you just completed.

If you believe the integers are congruent, please press the TRUE KEY (The “t” key)
If you believe the integers are not congruent, please press the FALSE KEY (The “f” key)

Press the “space bar” when you are ready to begin.
## Modular Subtraction Problems

<table>
<thead>
<tr>
<th>Problems (TRUE)</th>
<th>Problems (FALSE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$42 \equiv 17 \pmod{5}$</td>
<td>$42 \equiv 17 \pmod{6}$</td>
</tr>
<tr>
<td>$24 \equiv 16 \pmod{8}$</td>
<td>$24 \equiv 16 \pmod{7}$</td>
</tr>
<tr>
<td>$31 \equiv 13 \pmod{9}$</td>
<td>$31 \equiv 13 \pmod{8}$</td>
</tr>
<tr>
<td>$41 \equiv 14 \pmod{3}$</td>
<td>$41 \equiv 14 \pmod{4}$</td>
</tr>
<tr>
<td>$26 \equiv 18 \pmod{4}$</td>
<td>$26 \equiv 18 \pmod{3}$</td>
</tr>
<tr>
<td>$25 \equiv 16 \pmod{3}$</td>
<td>$25 \equiv 16 \pmod{5}$</td>
</tr>
<tr>
<td>$54 \equiv 18 \pmod{6}$</td>
<td>$54 \equiv 18 \pmod{7}$</td>
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<td>$45 \equiv 17 \pmod{4}$</td>
<td>$45 \equiv 17 \pmod{5}$</td>
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<td>$51 \equiv 13 \pmod{3}$</td>
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<td>$42 \equiv 16 \pmod{2}$</td>
<td>$42 \equiv 16 \pmod{4}$</td>
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<td>$34 \equiv 16 \pmod{9}$</td>
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<td>$65 \equiv 39 \pmod{4}$</td>
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<td>$62 \equiv 17 \pmod{6}$</td>
</tr>
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<td>$74 \equiv 29 \pmod{5}$</td>
<td>$74 \equiv 29 \pmod{4}$</td>
</tr>
<tr>
<td>$53 \equiv 25 \pmod{7}$</td>
<td>$53 \equiv 25 \pmod{8}$</td>
</tr>
</tbody>
</table>
Appendix F: Stereotype Threat Scale

Directions: Each item below is a statement that a person may either agree with or disagree with. Indicate how much you agree or disagree with what the item says using the following scale:

1 – Strongly Disagree
2 – Disagree
3 – Disagree Somewhat
4 – Neutral
5 – Agree Somewhat
6 – Agree
7 – Strongly Agree

1. I’m afraid that, if I do poorly on math exams, people might attribute my performance to my gender.

2. If I do poorly on math exams, it could just go to show that people in my gender group are bad in math.

3. I feel pressure to do well on math tests to show that people of my gender can do well in math.

4. It makes me nervous to think that my scores on math tests may reflect poorly on other people in my gender group.

5. It makes me nervous that my gender will influence how people think about my performance on math tests.

6. People may take my score on math exams as representative of all people in my gender group.

7. I feel pressure to do well on math exams to set a good example for my gender group.
Appendix G: Domain Identification Scale

Directions: Each item below is a statement that a person may either agree with or disagree with. Indicate how much you agree or disagree with what the item says using the following scale:

1 – Strongly Disagree
2 – Disagree
3 – Disagree Somewhat
4 – Neutral
5 – Agree Somewhat
6 – Agree
7 – Strongly Agree

1. Being good at math is NOT an important part of who I am.
2. Doing well on mathematical tasks is very important to me.
3. Success in math is very valuable to me.
4. It usually doesn’t matter one way or the other how I do in math.
Appendix H: Self-Integrity Scale

Please indicate your agreement with the statements below using the following scale. Strongly disagree

1 – Strongly Disagree
2 – Disagree
3 – Disagree Somewhat
4 – Neutral
5 – Agree Somewhat
6 – Agree
7 – Strongly Agree

1. I have the ability and skills to deal with whatever comes my way.

2. I feel that I’m basically a moral person.

3. On the whole, I am a capable person.

4. I am a good person.

5. When I think about the future, I’m confident that I can meet the challenges that I will face.

6. I try to do the right thing.

7. Even though there is always room for self-improvement, I feel a sense of completeness about who I fundamentally am.

8. I am comfortable with who I am.
Appendix I: Demographic Questionnaire

1. What is your ethnicity/race?
   - _____ White, Not Hispanic or Latino Alone
   - _____ Black or African American
   - _____ Hispanic or Latino alone
   - _____ American Indian and Alaska Native alone
   - _____ Asian alone
   - _____ Native Hawaiian and Other Pacific Islander alone
   - _____ Some other race alone
   - _____ Two or more races

2. What is your class standing?
   - _____ Freshman
   - _____ Sophomore
   - _____ Junior
   - _____ Senior
   - _____ Graduate Student

3. What is your age? (In years)
   _____________________

4. What is your cumulative Grade Point Average (GPA)?
   _____________________

What were your college entrance examination scores? (e.g., Scholastic Aptitude Test (SAT) or ACT)

   _____ SAT Quantitative Reasoning Score
   _____ SAT Verbal Reasoning
   _____ ACT Math
   _____ ACT Verbal