LESSONS LEARNED FROM A CLOCKWORK ORANGE: HOW RETRAINING IMPLICIT ATTITUDES AND STEREOTYPES AFFECTS MOTIVATION AND PERFORMANCE UNDER STEREOTYPE THREAT

by

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A Dissertation Submitted to the Faculty of the

DEPARTMENT OF PSYCHOLOGY

In Partial Fulfillment of the Requirements
For the Degree of

DOCTOR OF PHILOSOPHY

In the Graduate College

THE UNIVERSITY OF ARIZONA

2009
THE UNIVERSITY OF ARIZONA
GRADUATE COLLEGE

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TABLE OF CONTENTS

LIST OF FIGURES ........................................................................................................ 8

ABSTRACT .................................................................................................................... 9

Chapter 1

INTRODUCTION .......................................................................................................... 10

- Explicit and Implicit Attitudes vs. Stereotypes .................................................... 14
- Implicit Attitudes Predict Motivation .................................................................. 18
- Stereotype Activation Undermines Cognitive Capacity ....................................... 21
- Hypotheses ............................................................................................................. 24

OVERVIEW OF STUDIES ......................................................................................... 26

Chapter 2

PILOT STUDY ............................................................................................................. 28

- Methods ............................................................................................................... 28

  - Participants ..................................................................................................... 28
  - Procedure ..................................................................................................... 28
  - Pre and Post Assessment of Explicit Math Liking .......................................... 31

- Results ............................................................................................................... 31

  - Explicit math liking ........................................................................................ 31
  - Implicit math liking ...................................................................................... 31

Chapter 3

STUDY 1 .................................................................................................................... 35

- Methods ............................................................................................................. 35

  - Participants ..................................................................................................... 35
  - Procedure ..................................................................................................... 36
  - Measures ...................................................................................................... 37
## TABLE OF CONTENTS - *Continued*

- Post-experiment Questionnaire ........................................... 40
- Results .................................................................................. 41
  - Math identification and liking ........................................... 41
  - Math effort ......................................................................... 41
  - Language effort ................................................................... 43
  - Working memory ................................................................... 43
  - Math test performance ....................................................... 43
  - Effects of implicit vs. explicit attitude on motivation .......... 44
- Discussion ............................................................................... 45

### Chapter 4

**STUDY 2** ................................................................................. 48

- Methods .................................................................................. 50
  - Participants ......................................................................... 50
  - Procedure ............................................................................ 50
  - Post-experiment Questionnaire ........................................... 52
- Results .................................................................................. 53
  - Assessment of conscious contextual interpretations ............ 53
  - Math identification and liking ........................................... 55
  - Math effort ......................................................................... 55
  - Language effort ................................................................... 57
  - Math test performance ....................................................... 58
  - Effects of implicit vs. explicit attitude on motivation and performance .. 59
  - Post-hoc analyses ............................................................. 60
- Discussion ............................................................................... 61

### Chapter 5

**STUDY 3** ................................................................................. 64

- Methods .................................................................................. 64
  - Participants ......................................................................... 65
TABLE OF CONTENTS - Continued

Procedure & Measures ......................................................... 65
Post-experiment Questionnaire ............................................ 67

Results ................................................................................. 67

Math identification and liking ............................................. 67
Math effort ............................................................................. 68
Language effort ..................................................................... 70
Working memory .................................................................... 70
Effects of implicit vs. explicit attitude on motivation .......... 70
Effects of implicit stereotype vs. explicit stereotype knowledge on working memory ...................... 72

Discussion ............................................................................. 72

Chapter 6

STUDY 4 ................................................................................. 75

Methods ................................................................................ 76

Participants ........................................................................... 76
Procedure .............................................................................. 76
Pre & Post-experiment Questionnaire ................................. 77

Results .................................................................................. 78

Assessment of conscious contextual interpretations .......... 78
Post-test math identification ............................................... 79
Working memory ................................................................... 79
Math test performance ......................................................... 79
Mediation analyses ............................................................... 82
Effects of implicit stereotypes vs. explicit stereotype knowledge on working memory and math test accuracy .......... 85

Discussion ............................................................................. 86

Chapter 7

GENERAL DISCUSSION .......................................................... 88

The role of implicit attitudes and stereotypes in stereotype threat .......... 88
TABLE OF CONTENTS – Continued

The role of implicit and explicit processes in stereotype threat and motivation .......................................................................................................................... 92

The role of implicit and explicit knowledge of the stereotype in stereotype threat .................................................................................................................. 96

Study limitations .......................................................................................................................................................................................... 100

Future directions & implications ...................................................................................................................................................... 102

APPENDIX A:

List of words representing math, language, idiosyncratic items and idiosyncratic actions presented in the retraining tasks ........................................................................... 106

REFERENCES ................................................................................................................................................................................ 107


<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>32</td>
</tr>
<tr>
<td>Figure 2</td>
<td>42</td>
</tr>
<tr>
<td>Figure 3</td>
<td>44</td>
</tr>
<tr>
<td>Figure 4</td>
<td>56</td>
</tr>
<tr>
<td>Figure 5</td>
<td>69</td>
</tr>
<tr>
<td>Figure 6</td>
<td>71</td>
</tr>
<tr>
<td>Figure 7</td>
<td>80</td>
</tr>
<tr>
<td>Figure 8</td>
<td>84</td>
</tr>
</tbody>
</table>
ABSTRACT

While evidence suggests stereotype threat effects invade conscious levels of processing, less is known about the role that implicit processes play in stereotype threat. Results from four studies indicate that implicit attitudes and stereotypes play a unique role in motivation and performance in stereotype threatening contexts. Women trained to have positive implicit math attitudes exhibited increased math motivation in general (Study 1). This effect was magnified among stereotype threatened women when negative stereotypes had either been primed subtly (Study 2) or implicitly reinforced (Study 3). Implicit attitudes had no effect on working memory capacity or performance however. Conversely, after retraining women to associate their gender with being good at math, they exhibited increased working memory capacity (Studies 3 and 4) and increased math performance (Study 4) in stereotype threatening situations. The enhanced performance that resulted from the positive stereotype reinforcement was mediated by the increased working memory capacity. Thus while implicit attitudes appear important for motivating stigmatized individuals to engage with stigmatized domains, stereotypes play a key role in undermining cognitive capacity that is critical for success in the domain.
Chapter 1

INTRODUCTION

Despite dramatic advancements in gender equality over the past 30 years, women still face an uphill battle when they progress into the upper echelon of math and science related domains. Indeed, to this day women are far less likely than men to major in Math, Science, or Engineering programs, and they are likely to perform worse than men on tests of advanced mathematical ability from the time they are in junior high school through college (Hyde, Fennema, & Lamon, 1990; National Science Foundation, 2003; Brown & Josephs, 1999; but see Hyde & Linn, 2006 for evidence that the gap between men and women is narrowing). Interestingly even when women persist in the math and science domain, they are still likely to exhibit stronger negative associations between their concept of “woman” and their concept of “math” and more negative implicit attitudes towards math compared to their male counterparts (Nosek, Banaji, & Greenwald, 2002a).

While many accounts have been offered to explain these phenomena, one possibility is that these discrepancies are in part due to the negative stereotypes that pertain to women’s math ability in our society. Over the past 13 years, a bevy of research has revealed that stigmatized individuals are likely to underperform on tests of ability because of stereotype threat, a situational pressure that stigmatized individuals experience when they fear their performance will confirm the negative stereotypes pertinent to their group (Steele & Aronson, 1995, Steele, 1997). Stereotype threat can be elicited by simply telling women they are going to take a standardized math test and having them
indicate their gender before they begin, and once primed it is likely to engender poor performance on complex cognitive tasks (Schmader & Johns, 2003).

The experience of stereotype threat is likely to manifest at multiple levels of cognitive processing. Evidence that stereotype threat effects can invade conscious levels of processing has been documented in the literature as stereotype threat has been shown to engender conscious evaluative concerns and negative cognitions that can interfere with performance (Schmader, Forbes, Zhang, & Berry Mendes, in press; Cadinu, Maass, Rosabianca, & Kiesner, 2005). For example, Cadinu et al. (2005) found that when stereotype threatened women were asked to list whatever thoughts came to mind, they were more likely to report more negative self and math test-related cognitions that ultimately mediated underperformance on a difficult math test. Many moderators of stereotype threat have been identified via explicit measurements as well, including gender identification (Schmader, 2002), math identification (Spencer, Steele, & Quinn, 1999), stigma consciousness (Brown & Pinel, 2003), and self monitoring (Inzlicht, Aronson, Good, & McKay, 2006). Threatened individuals are also more likely than non-stigmatized individuals to report both self and group related concerns that their actions will be interpreted in a stereotype-consistent manner (for a comprehensive review see Shapiro & Neuberg, 2007), suggesting again that the phenomenological experience of stereotype threat can manifest at conscious levels of cognitive processing.

At the same time it is also quite unlikely that stereotype threat effects are due to conscious processes alone as evidence for conscious awareness of stereotype threat is often mixed. Past research has indicated that sometimes people report feeling more
group-related concerns (Schmader et al., in press), but sometimes these self-report
measures show no effects from the stereotype threat manipulation (Schmader & Johns,
2003), people fail to report concerns about the stereotype (Steele & Aronson, 1995), or
self-report measures fail to mediate the relationship between stereotype threat and
underperformance (Bosson, Haymovitz, & Pinel, 2004; Wheeler & Petty, 2001). Despite
this lack of conscious awareness of stereotype threat effects, the deleterious effects of
stereotype threat on performance or domain-specific tasks were still robust. Clearly then
stereotype threat effects do not require conscious acknowledgement of the stereotype or
an awareness of how these stereotype relevant cues might be affecting performance. This
suggests that there might be a previously unexamined effect of implicit associations in
situations of stereotype threat.

While less is known about the role implicit processes play in stereotype
threatening situations, current theoretical accounts posit that stereotype threat is likely to
engender a cascade of cognitive, emotional, and physiological responses that undermines
stigmatized individuals’ performance at both implicit and explicit levels of cognitive
processing (Schmader, Johns, & Forbes, 2008). There is some evidence to support this
conjecture as anxiety (Bosson et al., 2004; Johns, Inzlicht, & Schmader, 2008),
performance monitoring for errors (Forbes, Schmader, & Allen, 2008), and stereotype
activation (Steele & Aronson, 1995; Kiefer & Sekaquaptewa, 2007) have all been shown
to play an implicit role in the stereotype threat process. Recent research suggests that
implicit attitudes may play a fundamental role in basic approach/avoidance behaviors
towards the domain as well (Kawakami, Steele, Cifa, Phillis, & Dovidio, 2008). What
precise role these implicit processes play in undermining performance in stereotype threatening contexts is an important issue that is less understood.

As such, the primary goal of this paper is to better understand the role that implicit processes, specifically the distinction between implicit stereotypes and attitudes, play in stereotype threatening contexts. We will provide evidence that suggests that whereas implicit stereotypes make one susceptible to reduced cognitive capacity in stereotype threatening contexts, implicit attitudes towards the domain influence motivational processes in that domain. Furthermore, we will demonstrate that these effects of implicit associations are distinct from people’s explicitly held attitudes and stereotypes.

What effects implicit attitude-based fluctuations in motivation and implicit stereotype-based fluctuations in cognitive capacity have on performance in stereotype threatening situations is a more complex issue. In examining the different ways performance can be undermined, it is conceivable to assume that to perform optimally on the sort of complex cognitive tasks where stereotype threat effects are observed (Spencer et al., 1999), one is likely to need cognitive resources as well as motivation and the desire to persist. While stereotype threat theory and research suggests that threatened individuals aren’t likely short on motivation (Steele, 1997; Jamieson & Harkins, 2007), they are likely short on cognitive capacity (Schmader & Johns, 2003). It is unclear however how implicit attitudes and stereotypes might affect motivation and undermine cognitive capacity, and how alterations in motivation and cognitive capacity may ultimately undermine, or conversely enhance, performance.
Examining these questions will illuminate an important distinction between having the motivation to do well, and having the cognitive resources to achieve that goal. Although it is assumed that situations of stereotype threat both increase motivation, while simultaneously reducing the cognitive resources needed for performance, the role of implicit associations in engendering these effects has not been clearly articulated or empirically tested. Thus we will first begin with a discussion of what exactly we mean by implicit stereotypes and attitudes and the difference between these two constructs, and proceed to examine how and why they should play a differential role in undermining cognitive capacity and motivation in stereotype threatening situations.

**Explicit and Implicit Attitudes vs. Stereotypes**

Attitudes and stereotypes are unique psychological constructs and manifest at multiple levels of cognitive and neurological processing. Whereas attitudes are broadly defined as a positive or negative *evaluation* of a psychological object that can be cognitively or affectively based (Eagly & Chaiken, 1993; Ajzen, 2001), stereotypes are thought to represent an overgeneralized *belief* one has towards different groups or psychological objects that are cognitive in nature (Allport, 1954; Fiske, 1998; Macrae, Milne, & Bodenhausen, 1994). Attitudes and stereotypes develop in response to all facets of one’s environment, including different performance domains, such that one can either like or dislike a performance domain, e.g. they like or dislike math or bowling, and be cognizant of both how others perceive their social group in the domain and expect them to feel towards the domain. Thus attitudes and stereotypes can be related (e.g., I don’t like bowling, people like me are terrible bowlers), but they can be orthogonal to
one another as well. For instance, a woman may like math, i.e. she has a positive attitude
towards the domain, but she may also possess the knowledge that society associates her
gender with being bad at math, i.e. she is cognizant of the negative stereotype that
pertains to her group’s math ability.

In addition, both attitudes and stereotypes can be held at either the conscious,
explicit level, or the unconscious, implicit level. Explicit attitudes and stereotypes, as
mentioned above, are consciously accessible and deliberative, e.g. when prompted people
can indicate how they feel about snakes or tell you all the characteristics people attribute
to cheerleaders (Oskamp & Schultz, 2005). Conversely, over the past 30 years much
attention has been paid to the idea that there are myriad neural associative networks
active in our brains that are physically impossible to be consciously aware of at any given
time. Such associations, referred to as implicit, automatic, fast, or subconscious, by
definition exert their influence behind the conscious ‘scene’ so to speak.

When primed by relevant stimuli in the environment, implicit associations are
likely to alter the way we feel about or perceive things unbeknownst to us. For instance
if an ophidiophobe sees a snake, it’s likely the implicit attitude that is responsible for his
negative, viscerally aroused feeling. In other words he doesn’t have to think “that’s a
snake and I hate snakes,” he just knows he doesn’t like them and runs the other way
accordingly. A similar process occurs when stereotypic associations are primed. For
instance when someone sees a cheerleader walking down the hall they probably don’t
think “she is probably peppy and athletic,” they just interpret her behaviors in a manner
consistent with the stereotype without thinking about it. The implicit attitude and
stereotypic associations people have can also be quite different from that which they would consciously report, particularly with socially sensitive issues such as those involving race or gender (Devine, 1989; Nosek, Banaji, & Greenwald, 2002b; Cunningham, Nezlek, & Banaji, 2004). Thus examining implicit attitudes and stereotypes can offer insight into factors that influence people in ways unbeknownst to them, and possibly serve as an index for gauging feelings and beliefs that are in contrast to that which people would explicitly report.

Much like explicit attitudes and stereotypes, implicit attitudes and stereotypes are thought to be fundamentally distinct from one another as well. Implicit attitudes represent the basic, engrained evaluative associations of one’s perception towards objects or domains that at times can be activated involuntary and uncontrollably (Greenwald & Banaji, 1995; Fazio & Olson, 2003). Implicit attitudes can be derived via personal experience, classical conditioning (Olson & Fazio, 2001; Olson & Fazio, 2002), or operant conditioning (Kuykendall & Keating, 1990; Cacioppo, Marshall-Goodell, Tassinary, & Petty, 2002), and theoretically serve as the more stable assessment of one’s attitude by which one’s explicit attitude is derived (Wilson, Lindsey, & Schooler 2000; Ajzen, 2001; Gawronski & Bodenhausen, 2006).

Implicit stereotypes on the other hand represent the basic, engrained associations between groups, or any cognitive category, and the attributes associated with them (Greenwald & Banaji, 1995). Implicit stereotypes often bias individuals’ information processing outside of their awareness, including information pertinent to others and the self (Kiefer & Sekaquaptewa, 2007). As products of semantic memory and the
socialization process (Sherman & Bessenoff, 1999; Mitchell, Ames, Jenkins, & Banaji, 2009), stereotypic associations specifically facilitate encoding of stereotype-consistent information while hindering processing of stereotype-inconsistent information (for a review see Fiske, 1998). Thus while implicit attitudes likely help us seek out desired constructs (or avoid undesirable ones) at a basic level, implicit stereotypes facilitate efficient information processing, albeit in a manner prone to bias.

Evidence for the distinction between implicit attitudes and stereotypes also comes from work examining the neuroanatomy of the two types of associations. Amodio and Devine (2006) suggest that whereas implicit attitudes are likely derivatives of brain regions such as the amygdala, which are associated with basic motivational and appetitive behaviors, stereotypes are derivatives of structures involved in semantic processing, including neocortical structures in the prefrontal cortex and associative networks in general. This notion is supported by past research. For instance, the role of the amygdala in the expression of implicit attitudes is abundant as it has been shown to be integral to fear learning (e.g. Phelps & LeDoux, 2005) and has been correlated with implicit, but not explicit racial bias (e.g. Phelps, O'Connor, Cunningham, Funayama, Gatenby, Gore, & Banaji, 2000).

Conversely, stereotype activation has been shown to elicit unique activation in the right prefrontal cortex (Mitchell et al., 2009) and in the right dorsolateral prefrontal cortex (rDLPFC) specifically (Knutson, Mah, Manly, & Grafman, 2007). For example, Mitchell et al. (2009) found that when individuals applied stereotypes to make judgments about other people’s thoughts (e.g. showing men pictures of a woman and asking them if
the woman liked to shop) an extensive region of the right frontal cortex was active that in turn was positively correlated with participants’ gender implicit association test (IAT) scores (i.e. the more gender stereotyping effects participants demonstrated on the IAT, the greater the activity in the right frontal cortex). Interestingly, individuals with lesions specific to their ventromedial prefrontal cortex fail to demonstrate typical IAT stereotype effects altogether, implicating this region as potentially integral to implicit stereotyping as well (Milne & Grafman, 2001).

With some basis for believing that implicit attitudes and implicit stereotypes operate through distinct neurological mechanisms, we suspect that these attitudes and stereotypes can in turn differentially affect behavior. More specifically, we assume that implicit attitudes underlie motivation but implicit stereotypes underlie susceptibility to cognitive impairments resulting from stereotype threat. The rationale for these hypotheses is presented next.

*Implicit Attitudes Predict Motivation*

Implicit attitudes have been shown to uniquely influence a variety of processes to varying degrees, including basic approach and avoidance tendencies (Amodio & Devine, 2006), nonverbal behaviors (Dovidio, Kawakami, & Gaertner, 2002), and neurological responses to stimuli (Phelps et al., 2000). To the extent implicit attitudes predict basic approach and avoidance tendencies we might expect them to play a direct role in motivational processes in general and academic motivation specifically. An evaluation of stereotype and prejudice research, attitude theories, and the role explicit academic attitudes play in motivation provide reason to believe this is the case.
Pertinent to stereotype and prejudice research, Amodio and Devine (2006) had White participants complete an evaluative IAT at time one. Upon returning at time two, participants were led to believe they would be interacting with an African American partner on various tasks that involved assessments of academic and nonacademic knowledge (e.g. knowledge about popular culture and sports). Findings revealed that evaluative IAT scores predicted how far away participants chose to sit from their supposed African American partner’s belongings, such that the more negatively participants implicitly evaluated African Americans, the further away they sat from their belongings. This suggests that the extent to which one implicitly evaluates an attitude object in a positive or negative manner should ultimately predict their basic motivation to approach or avoid that object respectively.

Combining these findings with current attitude theories would also lead us to expect a direct relationship between implicit academic attitudes and academic motivation. If indeed implicit attitudes can underlie the more stable foundation of one’s explicit attitude, then implicit math attitudes should engender basic approach motivated behaviors in the math domain much like positive explicit math attitudes have been shown to do. Research demonstrating this latter effect is quite abundant. For instance, research by Eccles and her colleagues indicates that the extent to which individuals’ explicitly value math and gain enjoyment from math related activities predicts their motivation to choose math courses and participate in extra-curricular math activities (e.g. Simpkins, Davis-Kean, & Eccles, 2006). According to Eccles’ expectancy-value theory (Eccles, Adler, Futterman, Goff, Kaczala, Meece, & Midgley, 1983), such positive attitudes towards the
math domain may ultimately underlie individuals’ intrinsic motivation to engage in math-
relevant activities, and decisions to take future math classes specifically (Eccles et al., 1983; Eccles, Wigfield, Harold, & Blumenfeld, 1993; Klinger & Cox, 2004; Forbes et al., 2008).

In addition to this work showing that explicit attitudes predict motivation, more recent experimental research shows that manipulating a more positive implicit attitude toward a domain can increase motivation in that domain. For instance, Fazio, Chen, McDonel, & Sherman (1982) found that when individuals indirectly strengthened a positive association towards a puzzle they initially rated as interesting, a process that theoretically made the attitude towards the puzzle more chronically accessible, individuals were more likely to select the puzzle and choose to work on more problems from the puzzle during a ‘free play’ session. Of relevance to math motivation specifically, Kawakami et al. (2008) trained initially low math identified women to approach math by having them either pull a joystick towards their body or push it away from their body when they saw a math-related term on a computer screen. Those who were trained to pull math toward them increased their implicit math identification and engendered more positive implicit math attitudes. They also attempted more math problems on a subsequent math test.

Thus, these findings provide evidence that a direct relationship exists between implicit math attitudes and the extent to which women exert effort on math tasks. Unfortunately these findings do not provide insight into how implicit math attitudes predict effort in situations of stereotype threat, nor do they provide definitive proof that
implicit math attitudes per se would lead to increased math effort. In other words, training low math identified women to approach math engendered positive math attitudes, and training them to approach math engendered greater math effort, but whether positive implicit math attitudes would lead to increased math effort specifically, and how this relationship is affected by stereotype threat is still unknown. Nevertheless, we might expect that the more positive an individual’s implicit attitude is in an academic domain, the greater motivation and effort she will exert when she finds herself in situations where her academic merit is on the line – a scenario that stereotype threat theory posits is exactly what happens when stigmatized individuals are placed under stereotype threat.

**Stereotype Activation Undermines Cognitive Capacity**

Situations of stereotype threat necessitate the activation of negative, group-relevant stereotypes and past research supports this notion (Steele & Aronson, 1995; Kiefer & Sekaquaptewa, 2007). While this activation ultimately assists in undermining performance, less is known about the specific mechanisms involved in engendering this outcome. According to Schmader et al. (2008) negative stereotypes represent one of three key associations that are primed in individuals when they find themselves in stereotype threatening environments. When individuals are placed under stereotype threat, associations between one’s group (be it ethnic, gender, etc.) and the stigmatized domain, one’s group and their self-concept, and one’s self-concept and the domain become activated, but these associations are unbalanced. That is, situations of stereotype threat may prime a negative association between one’s group and the domain (the negative stereotype), but it also likely primes positive associations between the domain
and one’s self-concept, and one’s group and their self-concept. It is the tension that arises from this imbalance, and the motivation to resolve the tension specifically, that engenders an increase in physiological stress, performance monitoring processes, and suppression strategies that can work either alone or in concert with negative appraisal processes and have downstream consequences on performance.

Specifically, this cascade of physiological, performance monitoring, and suppression processes are hypothesized to interfere with one’s ability to perform optimally on complex cognitive tasks via compromising working memory capacity, i.e. one’s ability to focus on a specific task and inhibit interference from distracting stimuli (Engle, 2002; Schmader & Johns, 2003; Schmader et al., 2008). In addition to findings directly implicating working memory as a mediator for stereotype threat effects (Schmader & Johns, 2003), a host of research from both the social cognitive and neuroscience domains has found that placing people in situations that activate unwanted stereotypes inherently undermines cognitive processes associated with executive function because the act of suppressing or controlling stereotypes is cognitively taxing (Richeson, Baird, Gordon, Heatherton, Wyland, Trawalter, & Shelton, 2003; Knutson, Mah, Manly, & Grafman, 2007; Payne, 2005).

For example, Richeson et al. (2003) found that after interacting with an African American partner, those individuals who demonstrated greater implicit racial stereotyping in a pre-test measure performed worse on a subsequent stroop task (a task that requires executive control), conceivably because these individuals taxed finite executive resources during the biracial interaction via attempts to control stereotype activation. This
conjecture was supported by the fact that the relationship between racial stereotyping and performance on the Stroop task was mediated by activity in the right DLPFC, serving as evidence that attempts to control stereotype activation taxes prefrontal resources involved in executive functioning and cognitive control. The basic finding that the act of negative stereotype suppression uniquely taxes and necessitates DLPFC and executive resources have been replicated elsewhere as well (Knutson, et al., 2007; Payne, 2005).

Taken together, these findings suggest that stereotype activation, and the subsequent mechanisms initiated to stem the tide of its unwanted effects, tax working memory capacity that is otherwise critical for success on complex tasks. If this is the case, then removing the negative stereotype from the equation should free up working memory resources under stereotype threat by essentially removing the motor that drives the cascade of processes outlined in Schmader et al.’s model. As opposed to implicit attitudes, the effects of stereotypes are expected to manifest at the cognitive level and have little effect on motivation in stereotype threatening contexts.

As such, priming implicit attitudes and stereotypes may have differential effects on one’s behavior and bias their explicit interpretation of events accordingly. Whereas the valence of one’s basic liking for a domain, i.e. their implicit attitudes towards the domain, should influence their motivation in situations that prime them, the valence of the stereotypic associations between one’s group and domain should influence working memory resources. Given that situations of stereotype threat likely prime both stereotypes (e.g. “I know members of my group are not expected to do well in this situation”) and attitudes (e.g. “I like this domain and value doing well in it”), this
suggests that one’s desire to approach or avoid the domain as well as their cognitive capacity is likely going to be differentially affected by their attitude and stereotype respectively, and the valence of their attitude and stereotype specifically. Thus to better understand the psychological underpinnings of these processes and what role they play in stereotype threatening situations, the present studies sought to investigate the role that implicit attitudes and negative stereotypes play in affecting women’s motivation and cognitive performance in the math domain.

**Hypotheses**

Overall, research provides converging evidence that implicit attitudes and stereotypes are likely distinct in the role they play in motivational and cognitive processes. If stereotype threatening situations prime implicit attitudes and stereotypes we might expect women’s negative implicit attitudes and gender stereotypes related to math to have differential effects on performance by undermining motivation and cognitive capacity, respectively.

The present set of studies sought to test these assumptions by retraining women’s implicit attitudes and stereotypes towards the math domain. Learning a valuable lesson from Anthony Burgess’ seminal novel *A Clockwork Orange*, we did not attempt to retrain women via injecting them with noxious chemicals and exposing them to ‘special films.’ Rather, we relied on tenets of Hebbian learning and past research that indicates that pairing two constructs together repeatedly (be they semantic or evaluative in nature) is a simple, yet highly effective way to facilitate basic learning, implicit attitude development, and the reversal of stereotype valence (Hebb, 1949; Olson & Fazio, 2001; Kawakami,
Dovidio, Moll, Hermsen, & Russin, 2000). Retraining the implicit attitude and stereotype, as opposed to taking an individual difference approach, affords us the ability to experimentally manipulate these constructs and directly assess the effects they have on motivation and working memory accordingly. In turn we can also parse the causal role these specific mechanisms play in performance more confidently.

Given this, it is hypothesized that retraining women’s implicit attitudes (i.e., attitude retraining) and stereotypes (i.e., counterstereotype retraining) towards the math domain would differentially undermine or conversely, enhance their motivation and cognitive capacity in stereotype threatening performance situations. Whereas stereotype threatened women retrained to have more positive implicit math attitudes should exert greater math effort, a more positive attitude is not expected to buffer them against cognitive deficits observed due to threat. In contrast, women trained to have more positive stereotypic associations between their group and math should exhibit greater cognitive capacity in situations that cue stereotype threat, although these stereotypes alone might not engender greater motivation. Furthermore, given the nature of the retraining process, these effects should be independent of any predictive contribution made by explicit attitudes and stereotypes.

Predicting the effects of positive implicit math attitudes and stereotypes on math performance is more complex. On the one hand, we might expect the increased effort that results from more positively retrained implicit math attitudes and the increased cognitive capacity that results from stereotype retraining to translate directly into better performance. However, over a decade of research on stereotype threat shows that
stereotype threatened individuals often perform poorly despite being highly identified with math and highly motivated to succeed in hopes of disproving the relevant negative group stereotype (Steele, 1997). Try as they might, these individuals still often underperform. From this analysis, retraining attitudes might increase effort, but might not necessarily affect performance on a cognitively challenging test.

In contrast, based on findings by Schmader and Johns (2003) we know decreased cognitive capacity incurred under stereotype threat translates directly into underperformance. If retraining stereotypes to be more positive reduces the effects of stereotype threat on working memory, then performance should only be improved when stereotypes have been retrained.

OVERVIEW OF STUDIES

Four studies were conducted to assess the differential effects that implicit attitudes and stereotypes have on motivation, cognitive capacity and performance in stereotype threatening situations. We conducted an initial pilot study to determine if the implicit attitude training manipulation would engender implicit attitude change specifically (as opposed to explicit attitudes). With evidence that our training manipulation successfully changed implicit attitudes, Study 1 sought to investigate the role that implicit attitudes play in women’s basic math motivation (i.e. their motivation in a stereotype-neutral environment), and demonstrate that implicit attitudes would have no effect on working memory or performance in a stereotype threatening situation. In Study 2 we included men and manipulated stereotype threat which allowed us to assess whether positive implicit math attitudes would boost women’s math motivation specifically in
stereotype threatening situations. Study 3 examined the differential and/or combinatory effects of implicit attitudes and stereotypes on basic math motivation and then cognitive capacity under stereotype threat by manipulating women’s implicit math attitudes and whether they reinforced a negative or positive association between women and math. Finally, Study 4 assessed whether the effects of positive and negative stereotypic associations on working memory capacity was specific to stereotype threatening situations and whether working memory capacity mediated the effects of stereotype valence on performance on a difficult math test.
Chapter 2

PILOT STUDY

An initial pilot study was conducted to determine if the valence of individuals’ implicit attitudes could be changed in a timely manner. The retraining process consisted of manipulating a personalized implicit association test (pIAT; Olson & Fazio, 2004) such that individuals indirectly associated idiosyncratic things they liked with math related words over the course of 480 trials. By engaging in this indirect association/retraining process, we hypothesized that participants who indirectly associate things they like with math related words would develop a more positive implicit, but not explicit, math attitude towards the math domain compared to participants who indirectly associate things they did not like with math related words. This attitude change would be indexed as a change in the D statistic (Greenwald, Nosek, & Banaji, 2003) derived from participants’ pre and post pIATs towards implicit math liking. Women in the math retraining condition should have a more positive implicit math attitude after the retraining compared to their baseline scores and compared to women in the language retraining condition.

Methods

Participants

Seventy-three female undergraduate students participated in the pilot study for course credit.

Procedure
Initial explicit math attitudes (referred to as pre-math attitudes) were obtained from participants in an earlier mass survey pretest. Upon entering the lab, participants were asked to complete a series of traditional and modified pIATs under the guise that they were pilot testing different versions of a task that would help determine children’s preferences towards different careers. The first pIAT participants completed was of the traditional variety which allowed us to obtain a baseline assessment of their implicit attitudes towards the math and language domain. In this task, participants are presented with both idiosyncratic words that they should either like or dislike on some level and with words related to the math and language domain (see appendix A for the full list of words). The participant’s task is to categorize the words in the manner instructed, e.g. press one key when they see a word they like or a word related to math and another key when they see a word they don’t like or a word related to language. After a critical block of trials, the categories pertaining to each key are reversed, e.g. participants press one key when they see a math related word or an idiosyncratic word they don’t like. Comparing reaction times on blocks where participants pair things they like with math related words to blocks where they pair things they don’t like with math related words provides us with an index of their implicit liking for math.

Participants then completed a modified pIAT that allowed us to manipulate the extent to which participants associate things they like with math related constructs and things they don’t like with language related constructs or vice versa. Specifically, participants saw four categories at the top of the screen: ‘I like’, ‘I don’t like’, ‘Math’, and ‘Language’. The location of the four categories was dependent on what condition
participants were assigned to. Participants assigned to the math retraining condition saw the ‘I like’ and ‘Math’ category labels paired together in the top left-hand corner of the computer screen, and the category labels ‘I don’t’ like’ and ‘Language’ in the top right-hand corner of the computer screen. The location of these category labels were in turn reversed every fourth block to ensure participants remained vigilant and engaged. Words were then presented one a time in the center of the screen and participants were instructed to press a specific key on the keyboard every time they saw a word that was either an idiosyncratic item they liked (e.g., coffee or beer) or something related to the math domain (e.g., subtracting or multiplying), and to press a different key when they saw a word that was either an idiosyncratic item they did not like or related to the language domain (e.g., reading or writing).

Conversely, participants assigned to the language retraining condition saw the ‘I like’ and ‘language’ category labels paired together in the left hand corner of the screen, and the category labels ‘I don’t like’ and ‘math’ paired together in the right hand corner of the screen (the location of these categories reversed every four blocks as well). Participants in this condition were instructed to press a specific key on the keyboard every time they saw a word that was either something they didn’t like or something related to the math domain, and to press a different key when they saw a word that was either something they liked or something related to the language domain. All participants completed 12 blocks of 40 words in each block for a total of 480 trials. Each block consisted of 10 math words, 10 language words, and 20 idiosyncratic items that were randomly selected from the lists in Appendix A and were presented in random order.
After the training was complete, participants completed a final traditional pIAT that allowed us to assess the effects of the retraining on participants’ implicit attitudes. After participants completed this last pIAT they were asked to complete a battery of questionnaires, which included the same assessment of math attitudes that was in the pre-test. Once this was complete, participants were fully debriefed, probed for suspicion, and dismissed.

Pre and Post Assessment of Explicit Math Liking

Participants’ explicit math attitude was obtained via asking them to rate on a scale of 1 (strongly disagree) to 7 (strongly agree) the extent to which they agreed with the statement “I like tasks that involve math or computation.”

Results

Explicit math liking

A 2 (condition: math retraining vs. language retraining) x 2 (time: pre vs. post) mixed factors analysis of variance (ANOVA) with repeated measures on the second variable was conducted on participants explicit math attitude ratings. This analysis yielded no significant main effects or interactions ($p$’s > .24). Women trained to like math and language reported comparable levels of explicit math liking on the pretest measure ($M_{Math\text{ retraining}} = 3.19, SD = 1.87; M_{Language\text{ retraining}} = 3.90, SD = 1.94$) as they did after the retraining was complete ($M_{Math\text{ retraining}} = 3.48, SD = 1.89; M_{Language\text{ retraining}} = 3.74, SD = 1.82$). This suggests that the attitude retraining measure had no effect on participants’ explicit math attitude.

Implicit math liking
Figure 1. Effects of retraining on implicit math and language liking. More negative D scores correspond to more math liking.

Participants’ D statistic was computed as per the guidelines outlined by Greenwald et al. (2003) and coded such that more negative numbers equaled greater implicit math liking. A 2 x 2 mixed factors ANOVA conducted on participants’ pre and post training D statistics yielded no main effects ($p$’s > .30), but there was a significant interaction $F (1, 71) = 8.12, p < .01$ (figure 1). Simple effects analyses revealed that while there were no baseline differences in pre-training IAT scores between women in the two conditions ($M_{\text{Math retraining}} = .24, SD = .55; M_{\text{Language retraining}} = .04, SD = .60$); $F (1, 71) = 2.08, p = .15$, after retraining, women trained to like math ($M = -.06, SD = .48$) yielded a D statistic that suggested they implicitly liked math more than women trained to
not like math ($M = .18, SD = .52$), $F (1, 71) = 4.35, p < .05$. Furthermore, women in the math retraining condition exhibited a significant increase in implicit math liking when their post-training implicit math liking was compared to their baseline levels of implicit math liking, $F (1, 71) = 7.21, p < .01$. Women in the language retraining condition did not appear to significantly increase in their implicit math disliking however ($p = .19$).

An examination of within cell correlations between pre and post implicit math liking and explicit math liking also yielded some interesting findings. For example, pre-implicit math attitudes were significantly correlated with both post-training explicit math attitudes ($r = -.39, p < .02$), and post-training implicit math attitudes ($r = .34, p < .04$). Similarly, pre-training explicit math attitudes were significantly correlated with post-training implicit math attitudes ($r = -.36, p < .05$). In other words, women who started out disliking math at either the implicit or explicit level still disliked math even if they went through the language retraining (which reinforces the default negative association with math). In contrast there were no significant relationships between any of these measures among women trained to like math ($p$'s $>.28$), suggesting that when women were retrained to like math their initial implicit and explicit math attitudes had no bearing on their attitudes post-manipulation.

These results provided solid evidence that modifying the PIAT in the manner we did was an effective means of changing individuals’ implicit attitudes towards the math domain such that pairing a math related word with idiosyncratic things they like 120 times (i.e. participants saw 10 math words per block over the course of 12 blocks) engendered a more positive implicit math attitude. These results also indicate that the
effects of the retraining manipulation were exclusive to implicit attitudes, and implicit math liking specifically. This suggests that the retraining may have worked in a manner outlined by Gawronski and Bodenhausen (2006).

Gawronski and Bodenhausen (2006) argued that implicit attitudes can be altered or conditioned and appear independent of the explicit attitude when individuals are at least partially aware of the continual pairings they are making. When then asked to report an explicit attitude that is pertinent to the implicit attitude, individuals distrust the feelings derived from their implicit attitude, recall other relevant explicit attitudes that contradict the implicit attitude, and report an explicit attitude that appears to be orthogonal to the implicit attitude accordingly. Despite this, the alteration of the implicit attitude is successful. Evidence of such phenomena has been found in research on evaluative conditioning (for a review see De Houwer, Thomas, & Baeyens, 2001). In light of this, in an effort to avoid potential linkages between the retraining and the dependent measures of the studies and to maximize our ability to manipulate implicit attitudes independent of explicit attitudes, retraining in all four studies took place 24-30 hours before participants completed the dependent measures. With this in mind we proceeded to test our initial hypothesis that women with a more positive implicit math attitude will exert greater math effort in general.
Chapter 3

STUDY 1

The purpose of Study 1 was to test the basic assumption that retraining women to have a positive implicit math attitude will motivate them to engage with math related stimuli and spend more time working in the math domain compared to women with a negative implicit math attitude. Furthermore, we wanted to assess what effects, if any, positive implicit math attitudes would have on working memory capacity and math performance in a stereotype threatening situation. To investigate these questions, women were trained to have either a positive or negative implicit math attitude at time one. To gain a basic assessment of the effects of implicit math attitudes on math motivation, participants returned 24-30 hours later to complete an effort task designed to assess math motivation in a stereotype-neutral environment. All participants then completed a working memory task and math test under stereotype threat. We hypothesized that women trained to implicitly like math would spend more time working on math problems on the effort task compared to women trained to like language (or not like math). Conversely, if the effects of implicit math attitudes are unique to motivation then we should not see any differences in working memory capacity or math test performance among women trained to like math or language.

Methods

Participants

Fifty-eight moderately math identified women participated in the experiment for
course credit. We targeted moderately math identified women under the assumption that those at the extreme ends of domain identification might be less malleable in their implicit attitudes. For example, recall that Kawakami et al.’s (2008) findings revealed that high and low math identified women’s math attitudes were differentially affected by approach/avoidance training such that women’s implicit math attitudes increased if they were low in math identification and were trained to approach math but remained unchanged, regardless of training, if they were high in math identification. Thus, to maximize our ability to detect effects, women were selected if they responded within the range of 3.5-5.5 on a seven point scale (1=strongly disagree, 7=strongly agree) for the following three questions: “Being good at math is an important part of who I am,” “I think that I am good at tasks that require the use of math,” and “I like tasks that involve math or computation” (α = .90).

Procedure

Participants came in to the lab on day one and were informed that the researchers were interested in better understanding how people’s ability to categorize things interacts with memory processes over time. In actuality, participants completed the modified pIAT that was outlined above. As in the pilot study, participants in the math retraining condition were instructed to continuously pair idiosyncratic items they liked with math related words and to pair idiosyncratic items they did not like with language related words. Conversely, participants in the language retraining condition paired things they liked with language words and things they didn’t like with math words.

Participants then came back 24-30 hours later and were informed that they would
be completing what were essentially three different experiments. In actuality participants completed three different tasks: a math effort task, a working memory task, and a math test.

To assess the basic effect of attitude retraining on math motivation, participants were first given ten minutes to complete an effort task designed to assess math effort or motivation to engage with math related items in a stereotype neutral environment. Once the allotted time expired, participants were informed that they would be completing a working memory task and then a mathematics test that was designed to be diagnostic of their genuine mathematic ability. All participants then indicated their gender, thus inducing stereotype threat (Schmader & Johns, 2003; Steele & Aronson, 1995). After time expired, participants were asked to complete a series of questionnaires and then they were debriefed and compensated for their time.

Measures

Math effort. The effort task was comprised of 30 simple math and 30 remote associates (RAT) problems. Participants were presented with an initial choice screen that asked them which type of problem they would like to work on. At that point they could choose to work on a math problem (e.g. Solve for x: 20x - 16x + 19 = 7) or on a remote associates problem (e.g. Find a fourth word that somehow relates to the following three words: athlete's, web, rabbit). Once participants selected a problem type, they were taken to a screen with the respective problem on it and the time they spent looking at that screen was recorded (regardless of whether they answered the problem or chose to return to the previous screen to select the other type of problem). Participants had to answer
one of the problem types presented on the choice screen, and once a problem was answered, they were presented with the choice screen again and asked what type of problem they would like to work on next. Participants were informed they could work on any problem they wanted or just sit quietly in the room for the ten minute time period.

To assess participants’ motivation to persist on math and language problems, the time participants spent working on and/or looking at each math and RAT problem was isolated and then summed together, i.e. the time spent working on or looking at any math problem they chose from the choice screen was summed together to create an index of math effort, and the time spent working on or looking at any RAT problem they chose from the choice screen was summed together to create an index of language effort. The total length of time spent working on or looking at math problems over the course of ten minutes constituted our primary assessment of math motivation.

Overall, participants appeared to look at more math problems ($M = 9.10, SD = 5.26$) than RAT problems ($M = 5.59, SD = 6.76$). In addition, if participants looked at a math problem they were likely to answer it ($M = 8.59, SD = 5.17$) and answer it correctly as math accuracy, operationalized as the number of questions answered correctly divided by the number attempted, was high ($M = 81.10\%, SD = 26.87$). Participants also appeared to spend more total time on math problems ($M = 325.84$ seconds, $SD = 101.84$) compared to RAT problems ($M = 81.89$ seconds, $SD = 101.84$) and it took them longer on average to answer math problems ($M = 46.10$, $SD = 20.07$) compared to RAT problems ($M = 17.69$, $SD = 12.61$). These results were anticipated given that the math problems were selected to be objectively easier than the verbal problems, enabling us to
use time spent to index sheer effort or approach motivation as opposed to performance.

*Working memory capacity.* The working memory task that participants completed was a vowel counting version adapted by Schmader and Johns (2003) from the Reading Span Test (Daneman & Carpenter, 1980). In this task, participants are asked to remember a series of target words presented on a computer screen while also counting the number of vowels present in a sentence that follows the presentation of each word in a set. So for instance, participants may first see the word ‘dress’ in the middle of the screen for two seconds which would then be followed by the sentence ‘Don’t give the fish too much food.’ Participants would then be prompted to enter how many vowels were present in the sentence. Once they entered a number the next target word would appear and the process would repeat.

At the end of each set, which consisted of four to six target words/sentence pairings, participants were asked to recall all the words they can from the set. There were four blocks of four target word sets, four blocks of five target word sets, and four blocks of six target word sets for a total of 12 blocks. The 12 blocks were presented in random order so that participants never knew how many words or sentences would be in each set.

Working memory scores were calculated using the absolute span scoring method (Turner & Engle, 1989; Schmader & Johns, 2003). With this method, participants are only given credit for recalling a word when there was 100% correct word recall in a given set, e.g. if participants correctly recalled all four words in a four target word set they were given four points, whereas if they recalled three out of four words they would receive zero points. Past research suggests that this is a more sensitive assessment of working
memory capacity (LaPointe & Engle, 1990).

Math performance. Math performance was assessed with the Necessary Arithmetic Operations Test (NAOT; Ekstrom, French, Harman, & Dermen, 1976). In this test, participants are presented with word problems and asked to identify the correct procedure for solving the given word problem rather than solving the actual problem itself. For example, a participant may see a problem such as “A farmer has his home and barn insured for $152,000. The yearly premium rate is $2.07 per $100. How much does this insurance cost him each year?” and be asked to choose between the following solutions: 1. divide, add; 2. add, multiply; 3. divide, multiply; or 4. subtract, divide. The test consisted of 15 items and participants were given five minutes to work on the test.

Post-experiment Questionnaire

Math Identification: To assess if the retraining had any effect on explicit math identification or attitudes, and to help isolate the unique effect implicit math attitudes had on math motivation, explicit math identification and attitudes were assessed at the end of the experiment. To evaluate math identification, participants were asked to rate on a scale of 1 (strongly disagree) to 7 (strongly agree) the extent to which they agreed with the following statements: “Being good at math is an important part of who I am (Reverse coded),” “It usually doesn't matter to me one way or the other how I do in math classes”, “Doing well on math tasks is very important to me (Reverse coded),” “I care a great deal about performing well on tests of my mathematic ability (Reverse coded),” and “I always feel good about myself when I do well on a standardized math test (Reverse coded).”
coded)” (α = .75). A mean composite was generated such that lower numbers equaled more math identification.

**Math Liking:** To evaluate explicit math attitudes, participants were asked to rate on a scale of 1 (strongly disagree) to 7 (strongly agree) the extent to which they agreed with the statement “I like tasks that involve math or computation.”

**Results**

**Math identification and liking**

An independent samples t-test conducted on post-experiment math identification and liking ratings revealed no main effects for type of training (p’s > .42). Women trained to like math reported comparable levels of explicit math identification and math liking (M_{identification}=3.55; M_{liking}=3.97) compared to women trained to like language (M_{identification}=3.33; M_{liking}=3.61). Thus consistent with the pilot study, the implicit attitude retraining appeared to have no effect on participants’ explicit math identification or explicit attitude towards the math domain.

**Math effort**

Another independent samples t-test was conducted to assess the effects of math retraining on the total amount of time participants spent working on math problems on
the effort task. This analysis revealed the predicted main effect for condition, $t(56) = -2.23$, $p < .03$ (figure 2). Women trained to like math ($M = 357.40$ seconds) spent significantly more time working on math problems on the effort task compared to women trained to like language ($M = 292.03$ seconds). This finding suggests that training women to implicitly like math increased their motivation to engage with math related activities compared to when women were trained to implicitly like language.\(^1\)

\(^1\) Additional independent samples t-tests revealed that participants in the math retraining condition also tended to look at more math problems on the effort task ($p = .06$), answer more math problems ($p = .07$), and answered more problems correctly ($p = .12$) compared to participants in the language retraining condition. These variables were also all highly correlated with total time spent working on math problems on the effort task ($p$’s < .001).
Language effort

An independent samples t-test conducted on the total time spent working on RAT problems on the effort task revealed no differences between the two conditions (\(p = .27\)). Women trained to like language (\(M = 97.20\) seconds) spent comparable amounts of time working on RAT problems compared to women trained to like math (\(M = 67.60\) seconds). This finding wasn’t entirely surprising as we intentionally made the RAT problems seem more difficult compared to the math problems (as determined through initial pilot testing) in hopes of counteracting any general tendency women might have to prefer verbal problems over math problems.

Working memory

To assess whether retraining implicit math attitudes had any effect on participants’ working memory under stereotype threat, an independent samples t-test was conducted on participants’ working memory scores. This analysis revealed no significant effect for working memory (\(p = .33\)). Women trained to like math (\(M = 33.17\)) had working memory scores that were comparable to women trained to like language (\(M = 36.93\)), suggesting that implicit attitudes did not play a role in enhancing or compromising cognitive capacity in a stereotype threatening situation (figure 3).

Math test performance

Math test performance was operationalized as the percent of problems answered correctly divided by the number of problems attempted on the NATO. An independent samples t-test assessing the effect of training on math test performance revealed no
significant effect for condition ($p = .53$). Women trained to like math ($M = 66.13$) performed comparably on the math test to women trained to like language ($M = 63.28$). Consistent with the working memory findings, this finding indicates that implicit attitude retraining had no effect on participants’ performance under stereotype threat.

Effects of implicit vs. explicit attitude on motivation

Evidence from these initial results suggest that positive implicit math attitudes, manipulated through implicit math attitude retraining, increases women’s basic math motivation to persist on basic math problems. The question remains however as to whether this increased motivation is a unique effect of the implicit attitude, explaining variance over and above any effects of explicit attitudes toward the domain.
To address this question a series of regressions were conducted. An initial regression analysis revealed that explicit math attitudes did not violate the homogeneity of regression assumption as there was no interaction between attitude training and explicit math attitudes predicting math effort \((p = .42)\). Establishing this, a simultaneous regression was then conducted. Participants’ implicit math attitude (i.e. the condition they were in: math retraining = 0, language retraining = 1) and explicit math attitude (i.e. their post-experiment math attitude rating) were entered simultaneously in a regression model as predictors of the total time participants spent working on math problems on the effort task. Results from this analysis suggest that implicit math attitudes \((\beta = -.24, p < .05)\) and explicit math attitudes \((\beta = .40, p < .01)\) have unique relationships to math motivation as both were significant predictors of math effort. This serves as the first evidence to our knowledge that retraining one’s implicit math attitude specifically predicts motivation to engage in math related activities, independent of any relationship to explicit attitudes.

**Discussion**

Results from Study 1 provide evidence that implicit math attitudes affect women’s math effort in a stereotype-neutral situation. Women trained to implicitly like math spent more time on math problems compared to women trained to implicitly like language when given the choice to work on either math or language problems, or do nothing at all. Implicit math attitudes had no bearing whatsoever on working memory capacity or math performance, however. This is not surprising given that we did not necessarily expect implicit attitudes to tap into performance, and given that we did
nothing to alter women’s negative associations between their gender and the math domain.

There are two primary issues that were left unaddressed however. First, this study did not address how women’s implicit attitudes towards math affect their motivation under stereotype threat. While this study revealed that at a basic level, positive implicit math attitudes increase math motivation, the question remains as to whether the implicit attitude will do the same, or possibly amplify motivation, when women’s mathematical merit is on the line. In addition, while we argue that implicit attitudes had no affect on working memory or performance, the effects of implicit attitudes on these processes were examined under quite different conditions, i.e. motivation was assessed in a stereotype-neutral environment while working memory and performance were assessed under stereotype threat. It’s possible that the effects implicit attitudes have on motivation are amplified in stereotype threatening situations and only then would we see effects of motivation on performance. Conversely, stereotype threatening situations could override the influence implicit attitudes have on motivation all together, thus producing little increase in effort compared to that which was found in stereotype-neutral environments.

It’s also imperative to examine whether the effects of implicit attitudes on motivation are specific to women. For instance, if positive implicit attitudes resulted in increased math effort in a stereotype-neutral environment then we would expect men to show this basic effect as well. Situations of stereotype threat are unique to the stigmatized however, and as such implicit attitudes may uniquely effect women’s math motivation under stereotype threat. Thus it is important to use men as a comparison
group to both examine the basic effects of implicit attitudes on motivation and to examine whether or not positive implicit math attitudes uniquely effect women under stereotype threat.
Chapter 4

STUDY 2

A second study was conducted that focused on the questions of how positive implicit attitudes affect women under stereotype threat and whether this process is unique to women. To address how positive implicit math attitudes affect women’s motivation and performance under stereotype threat, women were once again retrained to either implicitly like math or language in session 1, and then completed the effort task and a difficult math test either under stereotype threat or in a neutral control condition in session 2. To assess whether these processes were unique to women, men were also included in the design. Thus Study 2 employed a 2 (gender: men vs. women) x 3 (task description: diagnostic math test + math retraining; problem solving task + math retraining; problem solving task + language retraining) between subjects design.

We expected to replicate our main effect from Study 1, such that math retrained women in a stereotype neutral environment should demonstrate greater math effort compared to language retrained women under neutral conditions. We expected a similar effect for men in this neutral task frame.

However, when the situation included cues to gender-based math stereotypes, we expected attitude retraining to have a different effect on men and women. Specifically, we hypothesized that women trained to have a positive implicit math attitude would exhibit even greater math effort under stereotype threat compared to retrained women in the problem solving task condition or men in either the problem solving task or
diagnostic math test condition. This increased effort should be greater than that which men exhibit because situations of stereotype threat likely motivates a general desire among women to disconfirm the primed negative stereotype, and the positive math attitude intensifies that desire at a personal level, i.e. the implicit attitude boosts motivation more so because success is now personally important or relevant to the individual. We didn’t expect the task description to affect men’s motivation as they should not experience this same motivation to disconfirm a math-related stereotype about their group. If anything, a reminder that men have greater inherent math ability might decrease the sense that they need to try hard at math.

Finally, we might expect a basic gender difference in math effort between men and women in the stereotype-neutral environment who are trained to like language if by default, women’s implicit math attitudes tend to be more negative than men’s (Nosek et al., 2002a). However retraining both groups to not like math may counter these baseline differences. As such we did not expect any overt differences between men and women in this condition.

Although we did not observe effects of attitude retraining on math performance in Study 1, we wanted to include a different measure of performance in this study in case the NOAT was simply an insensitive measure. Recall that Kawakami et al. (2008) found that training low math identified women to approach math resulted in these women demonstrating more positive implicit math attitudes (Study 1) and trying more math problems on a math test (Study 2), but it did not lead these individuals to perform any better on the math test. Based on this past research and the results of Study 1, we did not
expect attitude retraining to increase performance on a difficult math test for either men or women. Thus in Study 2 it is hypothesized that when women retrained to like math are placed under stereotype threat they may attempt more math problems on the math test compared to non-threatened women, women under normal circumstances, and men in any condition, but this won’t necessarily translate into success on the math test.

Furthermore, because our sample once again will be derived from moderately math identified men and women, and thus excluding those who typically are most susceptible to stereotype threat effects (i.e. the highly math identified), we might not expect pronounced stereotype threat effects on women’s math performance either. However, consistent with past research, we would expect to find evidence of stereotype threat effects among stereotype threatened women who demonstrated more explicit knowledge of the negative stereotype that pertains to women and math (Schmader & Johns, 2003). Thus, exploratory analyses will be conducted to examine these moderated effects.

Methods

Participants

Participants were 149 moderately math identified men and women, recruited via the same guidelines outlined in Study 1. Three female participants were excluded for correctly identifying the purpose of the study and three female participants were excluded for not following directions during the training task. Thus the final sample consisted of 63 females and 80 males.

Procedure
Participants came in to the lab on day one and completed the same attitude retraining measure described in the pilot study. Participants returned 24-30 hours later and were randomly assigned to a diagnostic math test condition (1/3 of the sample) or problem solving task (2/3 of the sample) condition. Specifically, participants in the diagnostic math test condition were informed that the researchers developed diagnostic measures of math and verbal intelligence and that the goal of the experiment was to have participants complete standardized math and verbal tests. Participants were led to believe that they would complete the diagnostic math test first. Conversely, participants in the problem solving task condition were told that the researchers developed problem solving tasks to assess the problem solving strategies people prefer and that the goal of the experiment was to have participants complete different problem solving exercises. Participants were led to believe they would complete the quantitative portion of the problem solving task first.

One concern with placing individuals under stereotype threat and then trying to assess their motivation via our effort task was that the unique motivation that implicit attitudes contribute would be convolved with the motivation that we would normally expect among everyone taking a more traditional, SAT-like math test. Thus we framed the effort task as a separate pilot study, in hopes that it would allow us to uniquely assess the effects of attitude retraining on math effort in a stereotype threatening context, but without having it be the central threat-inducing task. To do this, after participants heard the manipulation and completed demographic information (including indicating their gender in the diagnostic math test condition) a computer failure was staged. The
experimenter informed participants that we had been having this problem recently and she needed time to fix the program. Participants were told that in the meantime, they could choose to complete an experimental math and verbal problem solving exercise as part of an unrelated pilot study. They then received instructions that they could choose to work on whichever type of problem they wished or do nothing at all, much like the instructions participants received for the effort task in Study 1. In actuality this separate ‘pilot study’ was the same effort task that was used in Study 1. Consistent with Study 1, the total time spent working on math problems on the effort task, regardless of whether they answered the problem or not, comprised our primary assessment of math effort.

Once the allotted time (10 minutes) for the effort task expired, participants were informed that the initial technical difficulties with the diagnostic math test/problem solving task program had been resolved. At that point participants were given 20 minutes to complete a math test that consisted of 30 moderately difficult math problems from a GRE practice test (Schmader & Johns, 2003; Study 3). Performance on the math test was assessed via how accurate participants were on the math test, operationalized as the percent of problems answered correctly divided by the number of problems attempted.

Pre & Post-experiment Questionnaire

Stereotype knowledge: To assess participants’ explicit stereotype knowledge they were asked the following question during a mass survey session administered earlier in the semester: “Regardless of what you think, what is the stereotype that people have about women and men’s math ability, in general?” Participants indicated the nature of their stereotype knowledge by circling a number on a scale from 1 to 7 (1=’Men are
much better than women’, 2=’Men are somewhat better’, 3=’Men are only slightly better’, 4=’Men and women are the same’, 5=’Women are only slightly better’; 6=’Women are somewhat better’, 7=’Women are much better than men’).

Stereotype endorsement: Participants endorsement of the negative math-women stereotype was assessed during a mass survey session administered earlier in the semester. Participants were asked to rate the extent to which they agreed or disagreed (on a 7 point scale; 1=strongly disagree, 7=strongly agree) with the statement “It is possible that men have more math ability than women.”

Math identification and liking: After the math test, participants completed the same assessments of explicit math attitudes and math identification that were used in Study 1.

Assessment of conscious contextual interpretations: To assess whether the stereotype threat manipulation engendered a conscious, stereotype threat-consistent contextual interpretation, participants were asked to rate the extent to which they agreed or disagreed (on a 7 point scale; 1=strongly disagree, 7=strongly agree) with the statements “I am concerned that the researcher will think I have less ability if I did not do well on this task” and “I am concerned that the researcher will judge me based on my performance on the task” \( (r = .89) \). A mean composite was calculated and coded such that higher numbers were associated with more stereotype threat-based concerns.

Results

Assessment of conscious contextual interpretations
A 2 (gender: male, female) x 3 (task description: diagnostic math test + math retraining; problem solving task + math retraining; problem solving task + language retraining) analysis of variance (ANOVA) was conducted on participants’ assessment of their situation. While there was no main effect for condition ($p = .85$), there was a main effect for gender, $F(1, 137) = 7.15$, $p < .01$. Women ($M = 3.59$) reported more concern that their ability and performance would be negatively evaluated by the researcher than did men ($M = 2.89$). The interaction was not significant ($p = .69$). This suggests that unexpectedly our environment might have been more explicitly threatening for women overall, at least insofar as they self-reported post-experiment.

Past research has revealed that stereotype threat effects are most pronounced, and possibly only evident, in individuals who possess knowledge of the negative stereotype pertinent to their group (Schmader & Johns, 2003). Given that we did not select individuals based on such factors, we conducted more detailed analyses to examine whether women in the diagnostic math test condition reported more stereotype threat-consistent concerns to the extent that they actually report being cognizant of the negative stereotype pertaining to their group. Within cell correlations confirmed this hypothesis. The more women reported society perceiving men to be better at math than women, the more women in the diagnostic math test condition (where conceivably these negative stereotypes are activated) reported having stereotype threat-consistent contextual interpretations ($r = -.45$, $p < .05$). The relationship between these variables was largely non-existent or reversed and was significantly different from this correlation in the other conditions, including women trained to like math ($r = .17$, $p = .46$; $z=-1.96$, $p < .03$) or
language \((r = .27, p = .24; z = -2.25, p < .02)\) in the problem solving conditions, or men trained to like math in the diagnostic math test condition \((r = .02, p = .93; z = -1.55, p = .06)\).

**Math identification and liking**

A 2 x 3 ANOVA was conducted on post-experiment math identification and math liking ratings. These analyses yielded no main effects or interactions \((p’s > .11)\). Men \((M_{\text{identification}} = 3.46; M_{\text{liking}} = 4.12)\) and women \((M_{\text{identification}} = 3.86; M_{\text{liking}} = 3.76)\) trained to like math and taking a supposed diagnostic math test reported similar levels of math identification and liking as men \((M_{\text{identification}} = 3.54; M_{\text{liking}} = 4.38)\) and women \((M_{\text{identification}} = 3.64; M_{\text{liking}} = 3.73)\) trained to like math or men \((M_{\text{identification}} = 4.10; M_{\text{liking}} = 4.37)\) and women \((M_{\text{identification}} = 3.55; M_{\text{liking}} = 4.20)\) trained to like language taking supposed problems solving tasks. Thus similar to Study 1, the training manipulations appeared to have little effect on men’s or women’s explicit perceptions towards the math domain.

**Math effort**

To test our critical hypothesis, a 2 x 3 ANOVA was conducted on the total time participants spent working on math problems on the math effort task. While no main effects were found \((p’s > .09)\), we did find a significant interaction, \(F(1, 137) = 3.89, p < .03\) (figure 4). Simple effects analyses revealed that, as predicted, women trained to have a positive implicit math attitude and taking a ‘diagnostic math test’ \((M = 669.90)\) spent significantly more time on math problems on the effort task compared to their male counterparts \((M = 499.95)\), and women with either a positive \((M = 539.53)\) or negative
Figure 4. Total time spent working on math problems in the effort task as a function of attitude training and condition. Math retrain DMT=participants trained to like math in the diagnostic math test condition, Math retrain PST=participants trained to like math in the problem solving task condition, Language retrain PST= participants trained to like language in the problem solving task condition.

\( M = 455.49 \) implicit math attitude completing a ‘problem solving task’ \( (p' < .05) \).\(^2\)

A test for the replication of the pattern demonstrated in Study 1, where women trained to like math exerted greater math effort compared to those trained to not like math under neutral conditions, was consistent with Study 1 but did not reach significance \( (p = .22) \). Interestingly, comparisons among men yielded no significant differences between

\(^2\) Contrary to findings from Study 1, there were no trends or significant main effects or interactions found between the six conditions with regards to the number of math problems looked at, answered, or answered correctly on the math effort task \( (p' > .20) \). Interestingly, these variables were all highly correlated with total time spent working on math problems on the effort task \( (p' < .01) \) in every condition except for women trained to like math in the problem solving task condition. Here the correlations were marginal between total time and the number of problems looked at and answered \( (p' = .08) \) and non-significant between total time and the number of problems answered correctly on the math effort task \( (p = .21) \).
the three conditions \((p’ s > .26)\). Contrary to our predictions, there appeared to be no basic effect of math retraining on men’s math effort as men trained to like math in the diagnostic math test and problem solving task conditions \((M = 467.90)\) spent similar amounts of time working on math effort problems compared to men trained to like language \((M = 534.79)\). Furthermore, aside from women exerting significantly more math effort than men in the diagnostic math test condition, there were no differences between men and women in the problem solving task conditions \((p’ s > .21)\).

Post-hoc analyses were conducted to determine if there was any relationship between participants’ prior stereotype knowledge and math effort. Within cell correlations indicated there were no significant relationship between these variables in any of the conditions \((p’ s > .29)\).

Overall, findings suggest that among women trained to have positive implicit math attitudes, priming the negative math stereotype pertinent to their gender elicits an enhanced motivational response that surpasses that which they would exhibit in stereotype neutral environments, and that which men exhibit when they believe they are taking a test that is diagnostic of their math ability.

Language effort

An additional 2 x 3 ANOVA was then performed on the total time participants spent working on RAT problems on the effort task. Consistent with Study 1, this analysis produced no significant main effects or interaction \((p’ s > .12)\). Regardless of whether individuals were trained to like math and thought they would be taking a diagnostic math test \((M_{men}=180.76; M_{women}=143.68)\), or if they were trained to like math \((M_{men}=265.90; \)
women = 187.65) or not like math (M_{men} = 182.58; M_{women} = 199.41) and thought they would
be completing a problem solving task, participants exhibited comparable amounts of
language effort. This suggests that retraining implicit attitudes has the most pronounced
effects on women’s motivation when the implicit attitude is in direct contrast to a clear,
salient negative stereotype. In other words, effort seems to only increase when
individuals have a positive implicit attitude towards a domain and a negative expectation
about their ability in that domain is primed. If the positive implicit attitude is congruent
with the expectations about one’s ability, motivation is not influenced.

Math test performance

A 2 x 3 ANOVA conducted on participants’ math test accuracy yielded no
significant main effects or interaction (p’s > .20). Individuals trained to like math taking
a ‘diagnostic math test’ (M_{men} = 47.01; M_{women} = 47.30) performed comparable to those
trained to like math (M_{men} = 48.03; M_{women} = 43.60) or not like math (M_{men} = 55.34;
M_{women} = 51.45) completing a ‘problem solving task.’ Thus implicit attitude retraining
appeared to have no discernible effect on overall math performance. However, given that
one would expect stereotype threatened women to perform worse than everyone else, the
question remains as to whether the attitude retraining actually helped reverse this effect
or whether moderately math identified women would be prone to exhibit stereotype threat
effects in the first place.

Post-hoc analyses were again conducted to probe for any relationship between
math test performance and participants’ prior stereotype knowledge. There were no other
significant relationships found in the other conditions (p’s > .05).
Effects of implicit vs. explicit attitude on motivation and performance

To assess differential effects of implicit and explicit attitudes on motivation, a series of regression analyses were conducted. An initial regression analysis was conducted to examine whether or not explicit math attitudes violated the homogeneity of regression assumption. Participants’ explicit math attitude, gender and the condition they were in were entered in step one, all possibly 2-way interactions were entered in step two, and the 3-way interaction was entered in step three predicting math effort. While there were no interactions between math test description and explicit math attitudes ($p=.58$) and the three way interaction between test description, gender, and explicit math attitudes was not significant ($p=.58$), there was a significant interaction between gender and explicit math attitudes ($\beta = .66, p < .02$). Simple slope analyses revealed that this effect was specific to men however as the slope for men was significantly different from zero ($\beta = .30, p < .01$) while the slope for women was not ($\beta = -.14, p = .28$). Given that we were only interested in the effects that implicit and explicit attitudes had on math effort in stereotype threatened women, which was also the only group that exhibited an enhanced motivational effect, we proceeded with analyses accordingly.

Thus a second regression analysis was performed on participants’ math motivation, accounting for the variance associated with participants’ explicit math attitudes assessed post-experiment. Participants’ gender, condition, and explicit math attitude were entered in to step one of the model, and the interaction term for condition and gender was entered in to step two predicting total time spent working on math problems on the effort task. Consistent with Study 1, the explicit math attitude was a
marginal predictor of math motivation ($\beta = .16, p = .056$). In addition, the interaction was significant ($\beta = .46, p < .01$), suggesting implicit attitudes once again played a unique role in math motivation.

**Post-hoc analyses**

To better understand the nature of stereotype threatened women’s enhanced motivational response, post-hoc analyses were conducted on the relationship between participants’ endorsement of the stereotype, the extent to which participants reported stereotype threat-related concerns, and math effort. One might expect that the more women endorsed the negative stereotype about women’s math performance, the more susceptible they would have been to our stereotype threat manipulation, and this is what we found. When women were placed under stereotype threat, the extent to which they endorsed the negative math stereotype predicted their reported levels of concern over the researcher negatively evaluating their math ability based on their performance ($\beta = .49, p < .03$). This suggests that stereotype threat-related concerns were more salient to women to the extent that their negative math-women stereotypic associations were stronger.

These stereotype threat-related concerns in turn predicted math effort, such that the more concern stereotype threatened women reported, the more math effort they exerted under stereotype threat ($\beta = -.45, p < .04$). Stereotype endorsement itself did not predict math effort however ($\beta = -.26, p = .26$), suggesting a possible indirect relationship where strength of stereotype activation only affects math effort to the extent the negative stereotype activation engenders conscious concerns. The sobel statistic for this indirect pathway was only marginally significant however (sobel statistic=-1.64, $p = .10$).
Conversely, in the other conditions the relationship between stereotype endorsement and reported stereotype threat-related concerns was reversed and significantly different from stereotype threatened women with positive implicit math attitudes, including women trained to like math \( (r = -.27, p = .23; z=2.44, p < .01) \) or language \( (r = -.29, p = .21; z=2.47, p < .01) \) in the problem solving conditions, or men trained to like math in the diagnostic math test condition \( (r = -.41, p = .05; z=3.24, p < .01) \). These analyses provide some evidence that it was the interaction between positive implicit attitudes and negative stereotype activation specifically that may have been fueling math motivation.

**Discussion**

In sum, results from this second study provide converging evidence that implicit attitudes predict increased math motivation, particularly under stereotype threat. Once again, a positive implicit math attitude did not correspond to any noticeable performance benefits however. There were some limitations to this study however. For instance, the degree to which women in the diagnostic math test condition experienced stereotype threat is an open question as overall, women in this condition did not report significantly more stereotype threat-related concerns, and did not underperform on the math test.

As mentioned above, the lack of an overt threat effect could have been due in part to our selection criteria. For instance, we did not select women and men based on whether they were aware of the negative math-women stereotype in our society. Such selection criteria has proven necessary for engendering over threat effects in the past (Schmader & Johns, 2003), and indeed when we examined individuals based on this criteria we found that only women in the diagnostic math test condition expressed
increased stereotype threat-related concerns to the extent they indicated being aware of the negative math-women stereotype.

Furthermore, the criteria that we did select individuals on, moderate math identification, may have set the stage for our participants to be less likely to experience stereotype threat in the first place. Indeed, past research has revealed that it is those who are the most identified with math that are often the most susceptible to stereotype threat (Spencer et al., 1999). Selecting individuals based on high levels of identification could have helped exacerbate stereotype threat effects in this study. Nevertheless, in an effort to better understand how exactly implicit attitudes affect motivation under stereotype threat we felt it was important to first investigate these processes in more subtle stereotype threatening situations.

It was also surprising that men did not show the basic increase in math motivation when they were trained to have positive implicit math attitudes, as men in both math retraining conditions exerted math effort that was comparable to those trained to like language. While perplexing on the surface, the answer could lie in the nature of the stereotypes attributed to men. Based on our findings, if an enhanced motivational response is elicited in situations where individuals have a positive attitude towards the domain but negative stereotypes about their group are primed, then placing individuals in a situation where their implicit attitude is congruent with primed expectations about their group may undermine, or have little effect on motivation. In essence these situations could instill individuals with the feeling that they simply don’t need to try as hard. If this
is the true then we may be able to model this effect by training women to have positive implicit math attitudes and positive math stereotypes attributed to their gender.

Finally, while the findings from this study provided evidence that priming negative stereotypes enhances individuals’ motivation, possibly due to the interaction between positive, domain-specific implicit attitudes and the primed negative stereotype, this enhanced motivation did not translate into enhanced performance. This indicates that other possible factors such as cognitive capacity may be critical for optimal performance. As argued above, it may be possible to test this conjecture by directly altering both women’s implicit attitudes and the nature of the negative stereotype that pertains to their gender. Doing such should allow us to assess the possible differential and combined effects that attitude and stereotype retraining have on motivation and cognitive resources normally taxed by stereotype threat.
Chapter 5

STUDY 3

Study 3 sought to add to the effort findings from Studies 1 and 2, while also assessing the role that stereotype activation plays in math effort and cognitive capacity in stereotype threatened individuals. Furthermore, we wanted to investigate what relationship, if any, exists between attitudes and stereotypes in predicting effort and cognitive capacity under stereotype threat. In light of the findings from Study 2, we hypothesized that retraining women to like math should once again translate into greater math effort, particularly if they strengthen the negative stereotypic associations between women and math, but have little effect on cognitive resources under stereotype threat. Conversely, retraining women to associate their group with being good at math should have little effect on their motivation, especially if they have a positive implicit math attitude, but it should directly increase their working memory capacity.

Methods

Participants

Participants were 129 women who reported being moderately identified with math on a questionnaire administered at the beginning of the semester. Women were selected if they reported within the range of 3.5-5.5 on the same math identification scale used in Study 1 (α = .86). Five participants were excluded for not following directions in either the training or working memory task, two participants were excluded for correctly
identifying the purpose of the study, and two participants’ data were lost due to computer failure. Thus a total of 120 participants were included in the analyses.

Procedure & Measures

The study was a 2 (stereotype retraining: counterstereotype retraining vs. stereotype reinforcement) x 2 (attitude training: math retraining vs. language retraining) factorial design. The procedure for Study 3 was identical to Study 1 with two notable exceptions. First, we excluded the math test in session 2 due to time constraints and the lack of significant effects on the prior two studies. More importantly, we also introduced a second training task on day 1 designed to retrain women’s stereotypes about math and language. Thus, day one consisted of participants completing the two training tasks, which were counterbalanced for the order in which participants completed them.

The stereotype retraining task was developed for the purposes of the study. A traditional IAT was manipulated in a manner similar to what was done for the implicit attitude retraining in Study 1. Participants saw four categories at the top of the screen: ‘Women are good at’, ‘Men are good at’, ‘Math’, and ‘Language’. The location of the four categories was dependent on what condition participants were assigned to. Participants assigned to counterstereotype retraining saw the ‘Women are good at’ and ‘Math’ labels paired together in the top left-hand corner of the computer screen, and the labels ‘Men are good at’ and ‘Language’ in the top right-hand corner of the computer screen (again the location was reversed every four blocks). Participants were then exposed to words that were either idiosyncratic actions, math related, or language related, and they were told to press one button on the keyboard if they saw a word that they think
society perceives women to be good at (see appendix A for the complete list of words) or a math related word (the same math and language words used in Study 1), and to press another button every time they saw a word they think society perceives men to be good at or a language related word. The idiosyncratic words themselves were chosen if they both represented a basic, neutral action and were as gender neutral as possible. The motivation behind these selection criteria was that we didn’t want individuals pairing math or language related words with actions that were convolved with pre-existing gender stereotypes as it could interfere with counterstereotype retraining specifically.

Conversely, participants assigned to the stereotype reinforcement training condition saw the labels ‘women are good at’ and ‘language’ in the right hand corner of the screen and the labels ‘men are good at’ and ‘math’ in the left hand corner of the screen (reversed every four blocks). These participants were told to press one button when they saw an idiosyncratic action that society perceives women to be good at or a language related word, and to press another button when they saw an idiosyncratic action that society perceives men to be good at or a math related word. Once again there were 12 blocks of 40 trials each with 10 math and language related words randomly presented per block.

After completing the attitude and stereotype retraining tasks on Day 1, participants returned 24-30 hours later and first completed the math effort task under the guise that it was a separate experiment. This was done to assess the basic interaction between positive implicit attitudes and reinforced negative stereotypic associations on motivation before stereotype threat was introduced. Participants were then placed under
stereotype threat and asked to complete a working memory task with the belief that they would be taking a math test that was diagnostic of their genuine math ability after the working memory task (Schmader & Johns, 2003). Participants were informed after the working memory task that due to time constraints they would not be completing the math test. At that point they completed the math liking and identification questionnaires, were debriefed, and thanked.

*Post-experiment Questionnaire*

**Stereotype knowledge:** To assess what unique effects, if any, implicit stereotype retraining has on working memory capacity in comparison to explicit knowledge of the gender/math stereotype, participants were asked the following question in a mass survey session administered earlier in the semester: “Regardless of what you think, what is the stereotype that people have about women and men’s math ability, in general?” Participants indicated the nature of their stereotype knowledge by circling a number on a scale from 1 to 7 (1=’Men are much better than women’, 2=’Men are somewhat better’, 3=’Men are only slightly better’, 4=’Men and women are the same’, 5=’Women are only slightly better’, 6=’Women are somewhat better’, 7=’Women are much better than men’).

**Math identification and liking:** Math identification and liking were assessed once again after the experiment was complete using the questions described in Study 1.

*Results*

**Math identification and liking**

Initial 2 (attitude retraining) x 2 (stereotype retraining) ANOVAs were conducted on post-experiment math identification and liking ratings. Results revealed no significant
main effects or interactions for either math identification or liking ($p$’s > .28). Women trained to like math and associate women with being good at math reported comparable levels of math identification and math liking ($M_{\text{identification}}=3.32; M_{\text{liking}}=4.13$) compared to women trained to like math and associate women with being good at language ($M_{\text{identification}}=3.35; M_{\text{liking}}=4.04$), women trained to like language and associate women with being good at math ($M_{\text{identification}}=3.21; M_{\text{liking}}=3.81$), and women trained to like language and associate women with being good at language ($M_{\text{identification}}=3.48; M_{\text{liking}}=3.72$). These findings provide further evidence that the retraining of attitudes and stereotypes does not affect participants’ explicit perceptions towards the math domain.

**Math effort**

A 2 x 2 ANOVA was conducted on the total time spent on math problems on the math effort task. This analysis revealed no main effect for attitude training ($p = .34$), but there was a main effect for stereotype training, $F(1, 116) = 6.98, p < .02$, that was in turn qualified by a significant attitude training by stereotype training interaction, $F(1, 116) = 3.90, p = .05$ (figure 5). Simple effects analyses revealed that women trained to reinforce the stereotype spent significantly more time on math problems if they had also been trained to like math ($M = 362.64$) compared to women trained to like language ($M = 289.52$), $F(1, 116) = 4.35, p < .04$. When women were counterstereotypically retrained however, implicit attitude training seemed to have no effect on time spent working on math problems ($p = .47$).
Furthermore, among those trained to like math, women who were also trained to reinforce the stereotype spent more time working on math problems compared to women who were trained to reinforce the counterstereotype ($M = 252.24$), $F(1, 116) = 9.63, p < .01$. None of the other pairwise comparisons were significant ($p$’s > .44), including those involving women trained to like language and associate women with being good at math ($M = 277.73$). These findings provide further evidence that it is the unique combination

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3 Once again the retraining appeared to have the most pronounced effects on total time spent working on math problems on the effort task. There were no significant main effects or interactions found for the number of math problems participants looked at, answered, or answered correctly on the math effort task ($p$’s > .31). These variables were all significantly correlated with total time spent working on math problems on the effort task however ($p$’s < .01).
of positive implicit attitudes and strong negative stereotypic associations that engender the greatest motivational response.

**Language effort**

An additional 2 x 2 ANOVA was performed on the total time participants spent working on RAT problems on the effort task. This analysis yielded no main effects or significant interaction ($p$’s > .22). Women who were trained to reinforce the counterstereotype and trained to like math ($M = 107.55$) or language ($M = 95.98$) spent comparable amounts of time working on RAT problems compared to women who were trained to reinforce the stereotype and trained to like math ($M = 74.62$) or language ($M = 113.90$).

**Working memory**

An additional 2 x 2 ANOVA was conducted on participants’ working memory scores. Although there was no main effect found for attitude training ($p = .28$), there was the predicted main effect found for stereotype training, $F (1, 116) = 4.62, p < .04$ (figure 6). Women trained to associate women with being good at math ($M = 33.22$) had higher working memory scores under stereotype threat than women trained to associate men with being good at math ($M = 27.34$). The interaction for this analysis was not significant ($p = .88$). This finding provides evidence that it is the negative stereotype specifically that compromises women’s working memory resources under stereotype threat as opposed to their implicit attitude towards the domain, or some combination of the two.

**Effects of implicit vs. explicit attitude on motivation**
A regression analysis was conducted to determine if implicit and explicit attitudes had unique effects on math motivation. There was no evidence that explicit attitudes violated the homogeneity of regression assumption as there were no significant interactions between attitude training and explicit math attitude ($p=.73$), stereotype training and explicit math attitude ($p=.29$), or attitude training, stereotype training, and explicit math attitude ($p=.60$). Thus a second regression analysis was conducted where attitude retraining, stereotype retraining, and participants’ explicit math attitude was entered on step one of the model, and the attitude by stereotype training interaction term was entered in to the second step of the model predicting total time spent working on math problems on the effort task. Results revealed again that implicit and explicit math

![Figure 6](image)

*Figure 6.* Working memory scores as a function of attitude and stereotype training type. Math Retrain = women trained to like math, Language Retrain = women trained to like language.
attitudes appeared to play a unique role in math motivation as the interaction term ($\beta = -.34, p < .03$) and explicit math attitude ($\beta = .29, p < .01$) were both significant predictors of math effort.

Affects of implicit stereotype vs. explicit stereotype knowledge on working memory

A simultaneous regression was then conducted to assess what roles implicit stereotypes, as indexed by our stereotype retraining, and explicit stereotype knowledge played in working memory. Given that attitude retraining appeared to have no effect on working memory, and the main effect for stereotype retraining on working memory, we only examined the effects of stereotype retraining and prior stereotype knowledge on working memory scores. Thus participants’ stereotype training condition (0=counterstereotype training, 1=stereotype reinforcement) and stereotype knowledge scores from the pre-test were entered simultaneously into the model predicting working memory scores. Results revealed that the implicit stereotype was the only significant predictor of working memory scores ($\beta = -.19, p < .05$). Participants’ explicit stereotype knowledge did not predict women’s working memory capacity under stereotype threat ($\beta = -.12, p = .20$). Thus stereotype retraining appeared to have a unique effect on working memory capacity, and suggests that the stereotype engendered by our manipulation was possibly unique from that which participants possessed before the experiment.

Discussion

Results from Study 3 indicate that once again a positive implicit math attitude can facilitate increased math effort, but only when negative stereotypic associations between gender and math had been strengthened. This could be a direct result of stereotype
reactance (Kray et al., 2001) and could provide insight into the motivational mechanisms discussed in stereotype threat theory (Steele, 1997) and demonstrated empirically (Jamieson & Harkins, 2007). In other words, women who highly identify with the math domain likely find themselves in situations where the negative stereotype is primed and strengthened continually, e.g. they find themselves greatly outnumbered by men in their math classes every day, which would subsequently strengthen the negative association between their gender and the math domain. To the extent then that these women have positive implicit math attitudes, this suggests that when these women find themselves in performance situations where their mathematic merit is on the line (situations that likely prime negative stereotypes), their motivation to persist may be enhanced in part because the motivation engendered by their positive implicit math attitude and the motivation engendered by stereotype reactance interact. Conversely, demonstrating the opposite effect, where women trained to like math and associate their gender with being good at math exerted the least effort, also sheds light on why men in Study 2 did not show the effects of attitude retraining. Having a positive implicit attitude in a domain where a positive stereotype is attributed to one’s group seems to lessen the need to exert effort in situations where these associations are primed.

The other important finding from this study might demonstrate exactly why women who try hard and want to do well in the math domain may still underperform. Namely, while these women may be motivated to persist on math related activities because of their primed positive implicit math attitude and negative math stereotype, ironically the negative stereotype might be cuing processes that tax the cognitive
resources they would need to perform optimally (Schmader et al., 2008). As results from this study indicate, stereotype threatened women who reinforced the negative stereotype pertaining to their gender and math, regardless of attitude valence, exhibited less working memory capacity than women who were trained to associate their gender with being good at math. Thus it may not matter how much one implicitly likes the domain, if they have knowledge of the negative stereotype that pertains to their group, and it is a strong association, they may be likely to exhibit stereotype threat effects when those stereotypes are activated.

The results from this study are informative, but there are still several open questions about the effects of stereotype retraining specifically. First, it must be determined whether women trained to reinforce the counterstereotype are actually exhibiting better working memory capacity under stereotype threat as compared to a control condition, la a stereotype lift effect (Walton & Cohen, 2003), or whether women trained to reinforce the negative stereotype are exhibiting a decrease in working memory capacity. Second, as all participants were placed under stereotype threat in this study, it is necessary to demonstrate that the retraining effect is specific to stereotype threatening situations, i.e. we should not see an increase or decrease in working memory resources among women in stereotype-neutral environments. Third, if retraining the stereotype translates into increased working memory under stereotype threat, what effects will retraining ultimately have on math performance? Finally, if stereotype retraining does translate into increased performance on a difficult math test, does working memory mediate this process?
Chapter 6

STUDY 4

To examine these questions, an additional study was conducted where women were retrained to either reinforce the negative stereotype pertinent to their gender and math, or reinforce the counterstereotype, i.e. that their gender is good at math. Participants were then either placed under stereotype threat or not, and completed a working memory task and a moderately difficult math test. Thus, Study 4 employed a 2 (Training type: counterstereotype retraining vs. stereotype reinforcement) x 2 (Task description: diagnostic math test vs. problem solving task) between subjects design. As our focus in this study was on stereotype retraining, we did not manipulate attitude retraining in this design.

Given that decreased working memory capacity has been shown to directly result in worse math performance when individuals are under stereotype threat (Schmader & Johns, 2003), it was hypothesized that stereotype threatened women trained to strengthen the negative math-gender stereotype would demonstrate typical stereotype threat consistent patterns and perform worse than women in the problem solving condition, (perhaps particularly among those who are most identified with math). Conversely, women retrained to associate their gender with being good at math should show enhanced working memory capacity and perform better on a math test under stereotype threat compared to stereotype threatened women who reinforced the stereotype. In fact counterstereotype retrained women might exhibit greater working memory capacity and
increased performance compared to all others in accordance with a stereotype lift effect (Walton & Cohen, 2003). Importantly, the increase in working memory capacity that counterstereotype retrained women exhibit when under stereotype threat should mediate the relationship between stereotype retraining and math performance.

Methods

Participants

One hundred and ninety women participated in the study for course credit. Because attitudes were not being retrained in this experiment, we did not select individuals on any predetermined characteristics like math identification. Of the 190 participants, nine were excluded for not following directions in either the training or working memory task and four were excluded for correctly identifying the purpose of the study. Thus 177 participants were included in the analyses.

Procedure

Participants came in to the lab on day one and completed the same counterstereotype retraining or stereotype reinforcement training that was described in Study 3. Participants returned 24-30 hours later and were informed that they would be participating in what were essentially two separate experiments. The first ‘experiment’ consisted of completing the working memory task outlined above, and the absolute span score once again constituted our assessment of working memory capacity.

The second ‘experiment’ consisted of completing a math test composed of 30 moderately difficult math problems taken from the GRE (Schmader & Johns, 2003; Study 3). Performance on the math test was assessed via participants’ accuracy on the
math test, i.e. the percent of problems answered correctly divided by the number of problems attempted.

The manipulation was administered immediately upon participants’ arrival on day 2. Specifically, participants in the stereotype threat condition were told that they would be completing an experimental measure that was designed to be a diagnostic measure of their natural mathematical ability after the working memory task. In contrast, participants in the control condition were informed that they would be completing an experimental measure that was designed to assess the type of problem solving strategies they tend to use on problem solving tasks.

Before starting the working memory task participants answered demographic questions and participants in the stereotype threat condition were asked to indicate their gender as well. All participants were then presented with a paper consisting of four moderately difficult math problems taken from the GRE that served as an example of the type of problems they will see on the diagnostic math test. This was intended to serve as an additional means of making stereotype threat more salient that has been proven to be successful in the past (e.g., Schmader & Johns, 2003).

Pre and Post-Experiment Questionnaire

Pre-test math identification: As we did not select on math identification in this study, chronic levels of math identification were obtained from a mass survey session conducted at the beginning of the semester via the questions described above. These pre-experiment math identification scores provided us with a more sensitive assessment of stereotype threat effects, such that stereotype threatened women who are both most
identified with math and trained to reinforce the negative stereotype should show the greatest decrements in working memory and performance on the math test.

*Stereotype knowledge:* To assess the differential affects of implicit and explicit stereotypes on working memory and math performance, participants were asked in an earlier mass survey session the same stereotype knowledge question that was asked in Study 3.

*Post-test math identification:* After the task was complete, participants completed the same assessments of explicit math identification that were used in the previous studies.

*Assessment of conscious contextual interpretations:* To assess whether the stereotype threat manipulation manifested at conscious levels, participants were asked to rate the extent to which they agree or disagree with the statements (on a 7 point scale; 1=strongly disagree, 7=strongly agree) “I am concerned that the researcher will think I have less ability if I did not do well on this task” and “I am concerned that the researcher will judge me based on my performance on the task.” A mean composite was calculated and coded such that higher numbers were associated with more stereotype threat-based concerns.

**Results**

*Assessment of conscious contextual interpretations*

A 2 (Training type: counterstereotype retraining vs. stereotype reinforcement) x 2 (Task description: diagnostic math test vs. problem solving task) ANOVA was conducted on the mean composite of participants’ responses to their conscious assessment of the
context. Results yielded no main effects or interaction ($p$’s > .33). Women who thought they were taking a diagnostic math test ($M_{\text{counterstereotype train}}$=3.36; $M_{\text{stereotype train}}$=3.63) reported levels of stereotype-threat related conscious concerns that were comparable to women who thought they were taking a problem solving task ($M_{\text{counterstereotype train}}$=3.33; $M_{\text{stereotype train}}$=3.56) regardless of stereotype retraining. This suggests that, unexpectedly, framing the math test as diagnostic of math ability compared to a problem solving task wasn’t strong enough to engender conscious, stereotype-threat related concerns and possibly manifested only at more implicit levels of processing.

Post-test math identification

A 2 x 2 ANOVA was then conducted on post-experiment math identification composites. This analysis yielded no significant main effects or interaction ($p$’s > .10). Thus retraining appeared to have no effect on women’s identification with math as a function of whether they thought they were taking a diagnostic math test ($M_{\text{counterstereotype train}}$=3.54; $M_{\text{stereotype train}}$=3.87) or a problem solving task ($M_{\text{counterstereotype train}}$=3.78; $M_{\text{stereotype train}}$=3.53).

Working memory

To test our first primary hypothesis, a 2 x 2 ANOVA was conducted on participants’ working memory scores. This analysis revealed no main effect for task description ($p = .42$), but there was a marginal main effect for training type ($p = .06$) suggesting that women who received counterstereotype retraining exhibited marginally greater working memory capacity than women who received stereotype reinforcement training ($M_{\text{counterstereotype train}}$=29.19; $M_{\text{stereotype train}}$=25.23). More importantly, the predicted
interaction between training type and task description was significant, $F(1, 173) = 6.50$, $p < .02$ (figure 7). Simple effects analyses revealed a pattern in the diagnostic condition that replicated the result from Study 3. Specifically, women who received counterstereotype retraining ($M=33.17$) exhibited significantly greater working memory capacity when taking a ‘diagnostic math test’ compared to women who received stereotype reinforcement training ($M=23.07$), $F(1, 173) = 9.20$, $p < .01$. However, when the situation was stereotype neutral, stereotype retraining had no effect on working memory capacity ($p = .62$).
Furthermore, among women who received counterstereotype retraining, working memory was higher in the diagnostic math test condition compared to the problem solving task condition ($M=25.48$), $F (1, 173) = 5.46, p < .03$. Surprisingly, this task frame manipulation had no effect on working memory for women trained to reinforce the stereotype taking a ‘diagnostic math test’ compared to those taking a ‘problem solving task’ ($M=27.04; p = .21$). These findings suggest that retraining women to associate their gender with being good at math actually engendered enhanced working memory capacity when these individuals thought they were taking a math test that was diagnostic of their math ability and in a situation that primed the stereotype.

While we also expected women trained to reinforce the negative stereotype associated with their gender to exhibit significantly less working memory capacity compared to all other conditions, it is important to stress that our sample was comprised of women of all levels of math identification. Given that stereotype threat effects are often found among those most identified with math (Spencer et al., 1999), this suggests that it’s quite possible some participants in our sample were less likely to exhibit typical stereotype threat effects than others. When within cell correlations were conducted between participants’ pre-test math identification and working memory, we found evidence of the predicted stereotype threat effect.

Specifically, among women taking the ‘diagnostic math test’, while those who received counterstereotype retraining actually demonstrated a significant positive relationship between math identification and working memory ($r = .34, p < .04$), this pattern was significantly reversed among those trained to reinforce the negative
stereotype ($r = -.32, p < .05$). These correlations were significantly different from one another as well ($z = -2.92, p < .01$), suggesting that women who received stereotype reinforcement training exhibited significantly less working memory capacity compared to women who received counterstereotype training to the extent that they identified with math and would be taking a ‘diagnostic math test’. Conversely, there was no relationship among these variables for women ‘taking a problem solving task’ when they were trained to reinforce the negative stereotype ($r = -.01, p = .96$) or reinforce the counterstereotype ($r = .00, p < .98$). These correlations were in turn marginally different from the correlation for women under stereotype threat who reinforced the stereotype ($z’s = -1.44, p’s = .07$).

A follow-up regression analysis was then conducted to test the 3-way interaction between training type, task description and math identification. Thus these three variables were entered in step one of the model, followed by all 2-way interactions in step two, and the 3-way interaction in step three predicting working memory. This analysis yielded no main effects or significant 2-way interactions ($p’s > .10$) except for the interaction between task description and training type ($\beta = -.18, p < .03$). In addition, there was a marginal 3-way interaction between training type, task description, and math identification ($\beta = -.13, p = .09$).

Math test performance

To test our second primary hypothesis, another 2 x 2 ANOVA was conducted on participants’ math test accuracy. Results yielded only the predicted interaction $F (1, 173) = 3.96, p < .05$ (figure 8). The main effects were not significant, ($p’s > .11$). Consistent
with the working memory findings, simple effects analyses indicated that women who received counterstereotype retraining performed significantly better on the math test when they thought they were taking a diagnostic math test ($M=48.15$) compared to their counterparts who received stereotype reinforcement training ($M=37.20$), $F(1, 173) = 6.06, p < .02$, and compared to those who received counterstereotype training but thought they were taking a problem solving task ($M=37.48$), $F(1, 173) = 5.88, p < .02$. No other comparisons were significant once again ($p$’s > .72), including the comparison between women trained to reinforce the negative stereotype in the diagnostic math test and problem solving conditions ($M=38.69; p = .72$). These findings compliment the working memory findings by suggesting that having women repeatedly associate their gender with being good at math engendered enhanced performance on a math test specifically when these individuals thought the test was diagnostic of their math ability.

Our threat manipulation did not lower women’s math performance if they had reinforced the stereotype however. An assessment of whether math identification had any relationship with math performance that would be indicative of a stereotype threat effect yielded some unexpected findings. Namely, whereas pre-test math identification was positively correlated with math performance among stereotype threatened women trained to reinforce the counterstereotype ($r = .44, p < .01$), and among those in stereotype neutral environments regardless of training type ($r_{counterstereotype \ train} = .34, p < .04; r_{stereotype \ train} = .31, p < .04$), there was no relationship between these two variables among stereotype threatened women trained to reinforce the stereotype ($r = .20, p = .22$). Thus inconsistent with the effects found for working memory, math identification was
associated with enhanced performance on the math test among everyone except for women who thought they were taking a diagnostic math test and had been trained to reinforce the negative stereotype.

A follow-up regression analysis was then conducted to assess the relationship between task description, training type and math identification predicting math performance. This analysis revealed a main effect for math identification ($\beta = .33, p < .001$). There were no other significant effects however, including the 3-way interaction ($p$’s > .14).

**Mediation analyses**
To test our third primary hypothesis that working memory will mediate the relationship between stereotype training type and math accuracy, mediation analyses were carried out as per the guidelines of Baron and Kenney (1986). Specifically, a series of regression analyses were conducted between condition, working memory scores, and math accuracy where training type (counterstereotype retraining=0, stereotype reinforcement=1) and task diagnosticity (‘diagnostic math test’=0, ‘problem solving task’=1) were entered on step one of the model and the interaction term was entered in step two predicting working memory. Consistent with the ANOVA results described above, only the interaction was significant ($\beta = .34, p < .02$). A parallel analysis on math test accuracy yielded the same interaction pattern, ($\beta = .27, p < .05$).

A final regression analysis revealed that when working memory was entered in to step one of this second model, it was a significant predictor of math test accuracy ($\beta = .21, p < .01$), and the interaction predicting test performance became non-significant ($\beta = .20, p = .14$). A sobel test (Sobel, 1990) testing for the indirect pathway was significant (test statistic=1.90, $p=.05$). Together, the results of these analyses suggest that the increase in working memory capacity that counterstereotype retrained, stereotype threatened women exhibited mediated the relationship between the training type by task description interaction and accuracy on the math test.

**Effects of implicit stereotypes vs. explicit stereotype knowledge on working memory and math test accuracy**

A final set of regression analyses were conducted to assess the unique effects of stereotype training and stereotype knowledge on working memory and math test
accuracy. An initial regression analysis was conducted by entering training type (counterstereotype retraining=0, stereotype reinforcement=1), task diagnosticity (‘diagnostic math test’=0, ‘problem solving task’=1), and participants’ pre-test indication of stereotype knowledge on step one of the model, and the training type by task diagnosticity interaction term on step two of the model predicting working memory scores. This analysis indicated that explicit stereotype knowledge was not a significant predictor of working memory ($\beta = .03, p = .66$). The interaction term remained significant however ($\beta = .36, p < .01$). An identical analysis was conducted on participants’ math test accuracy and yielded similar findings for stereotype knowledge ($\beta = -.05, p = .52$) and the training type by task diagnosticity interaction ($\beta = .26, p = .07$), although the interaction was somewhat reduced.

These results suggest that the stereotype training manipulation elicited an effect on working memory scores and math test accuracy that was unique from participants’ explicit stereotype knowledge. In fact, consistent with Study 3, this effect was unique to the implicit training entirely, indicating that the manipulation had an exclusive effect on working memory and math test performance in stereotype threatening contexts.

Discussion

Results from Study 4 indicate that retraining women to have positive implicit associations between their gender and math can actually enhance their working memory capacity and performance on a difficult math test when they are put in situations that normally induce stereotype threat. This enhancement in working memory capacity in turn fully mediated the relationship between counterstereotype retraining and math test
performance. Furthermore, the new positive stereotypic association engendered by retraining was a unique predictor of working memory and performance compared to individuals’ prior explicit stereotypic knowledge.

The primary issue that remains unclear is the extent to which working memory is compromised by negative stereotypic associations and the situations that prime them. Women trained to reinforce the negative stereotype did not show overall decrements in working memory capacity or performance when they believed they were taking a diagnostic math test compared to women, regardless of training type, who believed they were taking a problem solving task. Given the nature of our sample, which was comprised of women who exhibited various levels of math identification and stereotype knowledge, this was not entirely surprising. More detailed analyses revealed that women who had reinforced the negative stereotype did exhibit less working memory capacity to the extent they were identified with math and that this relationship was significantly different from their counterstereotype retrained counterparts, and marginally different from women in stereotype-neutral environments regardless of training. While these relationships did not hold for math test performance, stereotype threatened women who reinforced the stereotype were the only individuals who did not demonstrate enhanced performance to the extent they were identified with math, suggesting that the stereotype threatening situation disrupted a relationship that otherwise should exist (and that the counterstereotype retraining seemingly counteracted).
Chapter 7

GENERAL DISCUSSION

The role of implicit attitudes and stereotypes in stereotype threat

Results from the four studies indicate that implicit attitudes and stereotypes play a unique role in motivation and performance in stereotype threatening contexts. Positive implicit math attitudes were found to increase math motivation in general (Study 1), and math motivation among stereotype threatened women specifically when negative stereotypes had either been primed subtly (Study 2) or implicitly reinforced (Study 3). While these positive implicit math attitudes enhanced motivation to work on basic math problems, they appeared to contribute little in terms of motivating individuals to persist or perform optimally on difficult math tests.

Conversely, implicit math stereotypes appeared to play a more prominent role in performance on a math test, as mediated by working memory resources. After being retrained to associate their gender with being good at math, women exhibited increased working memory capacity (Studies 3 and 4) and increased math performance (Study 4) in a situation that typically would lead to threat-induced performance impairments. Mediational analyses confirmed that the enhanced performance that resulted from the positive stereotype reinforcement was mediated by the increased working memory capacity that counterstereotype reinforcement fostered for women.

Implicit math stereotypes also appeared to play some role in math motivation, but in an ironic sense compared to that of implicit math attitudes. While positive implicit
math attitudes alone predicted increased math motivation in stereotype neutral environments, it was the interaction between the negative math stereotype (primed subtly or via implicit strengthening) and positive implicit math attitude that caused women to exert even greater math effort overall. This could serve as evidence, and perhaps point to a mechanism for stereotype reactance (Kray et al., 2001).

According to Kray and her colleagues, consistent with psychological reactance theory (Brehm, 1966), priming negative stereotypes may engender perceptions of restriction on one’s ability to perform. This in turn motivates individuals to restore their sense of freedom by working harder in the face of explicit negative stereotypes specifically. Applying results from our studies, this could mean that the motivation engendered by a positive implicit attitude interacts with the motivation engendered by stereotype reactance to produce a synergistic effect that magnifies motivation in stereotype threatening situations specifically.

This conjecture is supported by the findings from Study 3 where there was a main effect for stereotype training on math motivation indicative of a stereotype reactance effect (women trained to reinforce the negative stereotype exerted greater math effort) that was qualified by the attitude by stereotype training interaction. Contrary to Kray et al. (2001) enhanced motivation was evident in our studies regardless of whether or not the stereotype was overtly salient to women (this topic will be discussed in greater detail below). Ironically when this same negative stereotype was primed in stereotype threatening situations it may have intensified math motivation, but it also compromised working memory capacity (Study 3), particularly among those most identified with the
math domain (Study 4). These patterns point to an interesting relationship between attitudes and stereotypes and highlight the importance of their role in motivation, cognitive capacity, and ultimately performance in stereotype threatening situations.

These findings are also important for furthering our understanding of the basic mechanisms involved in stereotype threat effects. For instance, enhanced motivation under stereotype threat has been an integral theoretical conjecture (Steele, 1997), and has been demonstrated empirically (Jamieson & Harkins, 2007), but different explanations have been rendered to explain why threatened individuals exhibit this effect. For instance, Steele (1997) argues that stigmatized individuals are likely motivated out of a desire to disconfirm the negative stereotype (or fear confirming it). Taking a more parsimonious approach and relying on research rooted in basic arousal and social facilitation effects (Zajonc, 1965), Jamieson and Harkins (2007) argue that the mere potential for evaluation is enough to enhance motivation under stereotype threat, and that this enhanced motivation may lead to enhanced performance as well.

While both accounts appear distinct on the surface they both imply that evaluation apprehension is integral to engendering motivation in stereotype threatening situations. At the same time, neither account has demonstrated a causal role for evaluation apprehension in motivation effects, nor have they outlined when and why an individual would be more or less likely to exert more motivation under stereotype threat. The present findings address these issues and also allude to a potential role that evaluation apprehension plays in motivation effects. Specifically, our findings suggest that the valence of individuals’ engrained perceptions towards a domain (i.e. their implicit
attitude) predicts their basic motivation to approach domain-relevant constructs, and when individuals with positive implicit attitudes are placed in situations that induce stereotype reactance (i.e. stereotype threat), the motivation engendered by these two processes interact to magnify motivation.

Pointing to a possible role for evaluation apprehension, as the post-hoc analyses from Study 2 revealed, the more stereotype threatened women with positive implicit math attitudes endorsed the negative stereotypic associations between their gender and math, the greater evaluation apprehension they reported (i.e. they agreed more with the statements “I am concerned that the researcher will think I have less ability if I did not do well on this task” and “I am concerned that the researcher will judge me based on my performance on the task”). This evaluation apprehension in turn predicted greater math effort. Thus evaluation apprehension may play a role in motivating stereotype threatened individuals to the extent that individuals have positive implicit attitudes in the domain, and stronger negative stereotypic associations between their group and the domain that subsequently become salient to them under stereotype threat.

In addition to highlighting the difference between motivation and capacity effects, these findings also outline how and why the activation of negative stereotypes is critical to engendering stereotype threat effects. Specifically, it is the implicit effects of stereotype activation, rather than attitudes, which set the stage for poorer performance as mediated by reduced working memory capacity. Schmader et al.’s (2008) process model of stereotype threat suggests that the activation of negative self-relevant stereotypes can prime a cognitive imbalance that engenders a cascade of psychological processes and
taxes working memory resources that are otherwise critical for optimal performance on complex cognitive tasks. However, this chain reaction of processes will only be set in motion to the extent that one possesses the stereotypic association linking their group to poor performance in the domain. By retraining this link, we can circumvent the processes that would normally reduce cognitive capacity when one is taking a test that is diagnostic of ability.

These results also point to a relationship between negative stereotypes and domain identification. In support of Schmader et al.'s (2008) balance model, results from Study 4 suggested that working memory capacity was only compromised in highly math identified women trained to reinforce the negative stereotype and who then had that stereotype activated by the stereotype threat manipulation. This finding is consistent with the idea that when individuals had a stronger, more negative association between gender and math and a stronger, more positive association between the self and math, they experienced the greatest cognitive imbalance and taxation of working memory resources.

In contrast, among women who were retrained to associate women as being good at math, when stereotypes were subsequently activated via the stereotype threat manipulation, they had significantly greater working memory capacity to the extent they were positively identified with math. In this situation, the cognitive associations between self and domain and gender and domain should be more consonant, and as a result, working memory resources were enhanced.

_The role of implicit and explicit processes in stereotype threat and motivation_
Inherent in these findings is the importance of implicit and explicit processes in stereotype threatening situations. Results from all four studies provided consistent evidence that implicit associations are unique in the effects they engender in stereotype threatening situations compared to the possible effects due to explicit attitudes and stereotypes. For instance, results from Studies 1, 2, and 3 indicated that both implicit (manipulated) and explicit (measured after the fact) math attitudes were related to increased math effort. One important distinction appeared to arise from these analyses. Namely, while significant main effects for explicit math attitudes predicting math effort were found across the 3 studies, the effects of implicit math attitudes appeared to be predicated on the situation, and when the attitude was in opposition to activated stereotypes specifically.4

These results could provide interesting insight into conditions under which individuals are most motivated to interact with domain relevant stimuli. For instance, it’s not surprising that the valence of one’s explicit attitude towards math related to math motivation among everyone, regardless of the situation, as this effect has been well established elsewhere (e.g. Eccles et al., 1983). However, it was only when individuals held both a positive implicit math attitude and they were in situations where negative beliefs pertinent to one’s group were activated, that motivation was even greater (i.e. stereotype threatened women with positive implicit math attitudes exhibited more math effort than everyone else). If individuals had negative implicit math attitudes, or were in

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4 As indicated throughout, regressions probing for interaction effects between explicit math attitudes and any of the conditions across the studies predicting math effort were all non-significant except for the interaction between gender and explicit math attitudes in Study 2 that was driven by men.
situations where they had positive implicit math attitudes and a positive stereotype was primed, they exhibited less motivation. Thus while explicit attitudes towards the domain may engender motivation in both stereotype threatening and stereotype-neutral contexts, implicit attitudes may play an important role in stereotype threat by adding fuel to the motivational fire when they are in opposition to primed negative stereotypes.

At the same time, one could question whether the explicit math attitude, which was obtained from participants after the experiment was complete, was not a product of the implicit attitude retraining and the situation itself. For instance, analyses of participants’ explicit math attitudes obtained in an earlier mass survey session revealed no relationship between participants’ chronic explicit math attitudes and math motivation measured in the experimental session ($p’s > .30$ across Studies 1, 2, and 3). So what did the explicit math attitude assessed post-experiment represent?

Given that all individuals, regardless of training, appeared to spend more time on math problems on the effort task compared to RAT problems on the effort task, it’s quite possible that individuals’ implicit math attitude motivated them to work on math problems in general, and via self-perception processes (Bem, 1967) they derived their reported post-experiment explicit math attitude. In other words, when prompted at the end of the experiment, participants may have paused to reflect on whether or not they liked math and to the extent that they realized that they spent more time on math problems than RAT problems, were more likely to conclude that they liked math. While this conjecture is speculative, in light of the current attitude theories described earlier (e.g. Wilson et al., 2000; Gawronski & Bodenhausen, 2006), which hypothesize that
implicit attitudes may serve as the platform by which explicit attitudes are derived, this possibility seems plausible. Regardless, these findings point to interesting possibilities about the way in which implicit associations can affect behavior that might over time affect more explicit attitudes.

For instance, it is important to speculate what implications these findings have for research on implicit and explicit attitudes and stigmatized individuals’ involvement in stigmatized domains in general. As has been well documented to this point, positive implicit attitudes increased motivation while negative implicit attitudes appeared to decrease motivation. If implicit attitudes do in fact form the basis through which explicit attitudes are derived, this points to a potential linear mechanism through which this relationship is established. Namely, if positive implicit attitudes motivate one to engage with a domain then this relationship must play a role, possibly via self-perception, in formulating explicit attitudes towards the domain. Thus one may establish an implicit liking for the domain, spend more time in it accordingly, and then over time formulate the explicit attitude that they must like the domain because they spend so much time in it. In other words, increased motivation could be one potential mediator between implicit attitudes and explicit attitudes.

If this is the case however it sets the stage for a disturbing realization. Recall that women overall, even women math and science majors, tend to have more negative implicit math attitudes compared to men (Nosek et al., 2002a). Based on our findings this would suggest that when women are in stereotype threatening situations, their math motivation, at least that facet of motivation that implicit attitudes index, may be
decreased to an extent. Following the logic outlined above this could ultimately lead to a more negative explicit attitude towards the domain and facilitate devaluing of the domain accordingly in hopes of reducing threats to the self. How long this process would take, or how often one needs to experience aversive events in a stigmatized domain, is an important issue for future research. For instance, we demonstrated that having individuals pair things they likes with math related words 120 times was enough to influence their motivation over the course of one day. This probably isn’t comparable to the feelings of dejection a girl might feel upon continually underperforming in the math domain, but nevertheless our training could have provided a microcosm of what happens to girls in the math domain from the times of junior high in to college.

These results also provide important theoretical advancements on the roles that implicit attitudes play in motivational processes in general. Among other things these findings suggest that the valence of implicit academic attitudes can directly influence individuals’ basic approach/avoidance tendencies towards academically relevant stimuli. To our knowledge, evidence of this direct relationship has not been demonstrated in the literature until now. In addition, these findings could also speak to such questions as why people persist in the face of naysayers. If someone say has a strong positive implicit attitude towards basketball but others expect her to do poorly (i.e. others have a negative performance stereotype about her), it may be the interaction between these dichotomous evaluations and expectancies that motivates her to put in extra time at the gym.

*The role of implicit and explicit knowledge of the stereotype in stereotype threat*
While both implicit and explicit attitudes appeared to play a role in motivating individuals in stereotype threatening situations, the same could not be said for explicit knowledge of the stereotype compared to implicit stereotypic associations. Results from Studies 3 and 4 suggested that the implicit stereotypes derived via our training manipulation played a unique role in altering cognitive resources under stereotype threat while explicit knowledge of the stereotype, at least that which was reported in the mass survey pre-test, did not. So how is it then that a negative stereotype can have deleterious consequences on working memory and performance implicitly while that which individuals explicitly acknowledge does not?

In line with a politically correct answer, our sample consisted of people who reported minimal differences in math ability between men and women. For example, in Studies 3 and 4, there were no differences in explicit stereotype knowledge between the conditions ($p$’s > .34), and in general women in the samples reported that society thought men were only slightly better at math than women ($GM = 2.87, SD = 1.34$; 36% of the samples provided a knowledge score that was at or above the midpoint of 4 and 65% reported a score of 3 or above). Given this, one wouldn’t necessarily expect explicit stereotype knowledge to engender decrements in working memory and performance. After all, if individuals don’t expect much difference between groups, then why would there be any? This suggests that it is likely the activation of the engrained, implicit knowledge of the stereotype specifically, derived through the socialization process outside of the awareness of the individual, that undermines performance in stereotype threatening situations. Thus, assuming our retraining was affecting people at implicit
levels, these findings provide evidence that the working memory and performance decrements engendered by stereotype threat likely stem from activation of the implicit stereotype as opposed to explicit stereotype knowledge. With that said future research would be necessary to demonstrate that a direct manipulation of explicit stereotype knowledge would not have an effect on working memory or performance and a direct manipulation of implicit stereotype knowledge would.

Conceivably, the finding that implicit stereotypic associations had differential effects on behavior compared to that of explicit self-reported stereotype knowledge is comparable to those found in the stereotype and prejudice literature, where IAT scores and explicit self-reports have effects on different kinds of perceptions and behaviors (e.g. Dovidio et al., 2002). Just like people can report liking members of the out-group but unbeknownst to them act to the contrary when they encounter a member of that out-group, individuals may report minimal differences between groups but unbeknownst to them underperform when they find themselves in a situation that activates an implicit stereotype about their group’s inability in a stigmatized domain. The present results suggest that the implicit stereotype, or that knowledge which is engrained outside of awareness, drives the behavioral effects in these situations.

This is not to say that explicit knowledge of the stereotype couldn’t play a role in stereotype threat, as ultimately it is unclear what effects our stereotype retraining had on participants’ explicit interpretations of the context. For instance, one certainly needs to possess the knowledge of the stereotype on some level in order to feel threatened by confirming it, and our stereotype retraining manipulation may have simply served as a
means of making the stereotype more chronically accessible to participants. This is certainly plausible and it could help explain why other explicit variables such as domain identification and stigma consciousness (Brown & Pinel, 2003) moderate stereotype threat effects. Being prone to think more about negative stereotypes attributed to one’s group, or being continuously exposed to stereotype consistent stimuli, likely strengthens the negative stereotyped association between one’s group and the domain which in turn facilitates stereotype activation in stereotype threatening situations and makes it more chronically accessible. At the same time, our results demonstrate that implicit stereotype activation also can play a prominent role in engendering threat effects and undermining performance. Whether this distinction could help differentiate or identify conditions under which people explicitly report threat effects and when they don’t would be an important question for future research.

Findings from these studies also provide further support for the role that stereotype activation plays in taxing executive resources in situations where the thoughts associated with the stereotype are undesirable and unwanted. Conversely, findings also indicate that priming positive stereotypes may actually enhance cognitive capacity. The mechanisms for this process aren’t well defined but answers could lie in Schmader et al.’s integrative model of stereotype threat. For instance, it’s possible that in the same way priming negative stereotypes can engender physiological threat responses, performance monitoring for signs of stereotype confirming evidence, and suppression processes that can all tax working memory resources, priming positive stereotypes could reduce the likelihood that these mechanisms are activated. Instead, in these situations,
individuals may experience an increase in physiological challenge responses, performance that is unencumbered by explicit monitoring, and positive appraisals of ambiguous cues. These processes could lead directly to increased working memory capacity and enhance performance accordingly.

*Study limitations*

Overall, results from the four studies revealed an interesting and unique role for implicit attitudes and stereotypes, and implicit processes overall in stereotype threatening situations. With that said it is important to acknowledge and discuss some of the limitations in these studies. One seemingly disconcerting pattern in Studies 2 and 4 is the lack of an expected stereotype threat effect on working memory and performance. For instance, in Study 2 women under stereotype threat performed similarly on the math test compared to their male counterparts and to women in the control conditions. Women in this condition also reported levels of stereotype threat related concerns that were comparable to everyone else which makes one question the degree to which women experienced stereotype threat due to our manipulation. Similarly in Study 4, women who had reinforced the negative stereotype in the diagnostic math test condition overall failed to demonstrate the expected stereotype threat effects on working memory and math performance.

While these are valid concerns, it should be stressed again that to better understand the nature of how implicit attitudes affected motivation under stereotype threat, in Study 2 we purposefully selected women who were moderately identified with the domain – we did not recruit women who were very low in math identification, and we
did not recruit those who are most strongly identified with the domain, and in Study 4 we didn’t select on this criterion at all. Unfortunately doing such came with the likelihood that these individuals would be less susceptible to experiencing stereotype threat, as it is usually those who value the domain most who show the strongest effects (Stone, Lynch, Sjomeling, & Darley, 1999; Aronson, Lustina, Good, Keough, Steele, & Brown, 1999; Spencer et al., 1999). It should also be noted that in both studies individuals were not selected on the basis of whether they were cognizant of the negative stereotype pertinent to women in the math domain, which is a selection criterion that has been employed in prior studies sampling from this same population (Schmader & Johns, 2003).

Not surprisingly, when we conducted more fine grained analyses on the data from Study 2 we found some suggestion that the more women reported having knowledge of the negative math stereotype, the more stereotype threat related concerns they reported. Likewise more detailed analyses from Study 4 suggested that women in the diagnostic math test condition who reinforced the negative stereotype had lower working memory to the extent they were identified with math. This suggests that our manipulation probably did activate stereotypes as intended, but that the resultant effects on capacity and performance might have been muted by the relatively weaker levels of identification or lack of stereotype knowledge in these samples. Future research is needed to test the viability of these retraining manipulations on a sample that is highly identified with the domain.

One final perplexity in our findings with some particularly interesting implications arose in Study 2. Namely, it was curious that men didn’t show any added
math motivation despite being trained to implicitly like math. If you recall, like women in stereotype neutral contexts, we expected men trained to like math to show a basic increase in math motivation compared to men trained to like language. No differences in math motivation were found between men in the three conditions however, which is inconsistent with what we would expect based on findings from Kawakami et al. (2008) as well. Given that men in this situation had both a positive implicit math attitude and positive math stereotypes attributed to them in society, it could be that when individuals like the domain and believe that their group is expected to succeed in it, it instills a confidence in them that nullifies or dampens the motivation to engage with the domain. For instance, much like women exerted the most math effort when they had positive implicit math attitudes and they were in situations where the negative stereotype was activated, men exerted less math effort when they had positive implicit math attitudes and they were in a situation where positive stereotypes may have been more salient.

Interestingly, women showed a similar pattern in Study 3. Here we found that while women trained to like math and reinforce the negative stereotype exerted the most math effort, women trained to like math and reinforce a positive stereotype about their group and math exerted significantly less effort. In essence, it’s the antithesis of stereotype reactance, a stereotype acceptance or embrace if you will, that may actually undermine motivation in situations that prime positive stereotypes and positive implicit attitudes. To our knowledge these represent theoretically novel findings. Future research would be needed to better understand this potential process.

*Future directions & implications*
One interesting caveat to the potential link between Nosek et al.’s (2002a) findings and ours discussed above is the distinction between implicitly identifying things with the self and implicitly liking something. In other words, what’s the difference between pairing math related constructs with the term ‘I like’ compared to ‘I’ or ‘me’?

As Olson and Fazio (2004) highlight the difference could be substantial. In essence, it could come down to a distinction between knowing and feeling. For instance, there can be a big difference between knowing about a negative, socially derived stereotype, e.g. ‘African Americans are hostile’ and how you feel about African Americans in general, e.g. ‘I like African Americans’. Thus what the IAT assesses (‘African American’ and ‘good’ or ‘bad’) and what the pIAT assesses (‘I like’ and ‘African American’) are probably quite different. In this manner, assessing constructs that one self identifies with can be quite different from what one possibly likes, and this distinction ultimately distinguishes between what we were manipulating.

So what differential effects might these constructs engender? According to Schmader et al. (2008), the extent to which one identifies with a stigmatized domain is one of the three associative constructs that are primed in stereotype threatening situations and subsequently creates a cognitive imbalance. Following the logic of manipulating negative stereotypic associations, this suggests that manipulating domain identification (e.g. having someone continually pair terms such as ‘I’ or ‘me’ with math related words) should have effects on working memory capacity and performance similar to that which we found when we manipulated stereotypic associations. This would be in stark contrast to that which we found for implicit attitudes, suggesting a meaningful distinction between
the two constructs and the psychological processes they underlie. Thus it will be critical for future research to examine the role that implicit attitudes and stereotypes play in those highly identified with a stigmatized domain, in part because we might expect identification, attitudes, and stereotype knowledge to all play differential roles in motivation and performance. In light of this, caution should be exhibited when applying IAT findings, such as those from Nosek et al. (2002a) with the findings from our study.

Finally, these results also provide a novel methodological advancement for investigating implicit processes. The retraining methods incorporated here outline a convenient, effective, and subtle means of both manipulating implicit processes and understanding the effects of implicit processes on behavior. Indeed, it’s almost shocking to think that having someone pair the most basic of activities such as walking with a math word would be sufficient to both alter the nature of a stereotype and free up subsequent working memory resources when the new stereotype is theoretically primed. Future research will be needed to investigate how long-lasting and stable these effects are but evidence suggests that simple training manipulations such as these intensifies over the course of multiple days (Kawakami et al., 2000).

In sum, by directly manipulating implicit processes, our results highlight how priming implicit attitudes and stereotypes can undermine, or conversely enhance, motivation and performance. These findings also help illuminate the role that implicit processes play in stereotype threatening situations and in motivation and cognitive processing in general. Thus, contrary to the ineffectiveness of cognitive retraining in alleviating Alex’s innate evil ways in *A Clockwork Orange*, we found that retraining implicit attitudes and
stereotypes was a highly effective means of altering motivation and performance respectively, thus furthering our understanding of these mechanisms in the stereotype threat process accordingly.
APPENDIX A

List of words representing math, language, idiosyncratic items and idiosyncratic actions presented in the retraining tasks

<table>
<thead>
<tr>
<th>Math items</th>
<th>Language items</th>
<th>Idiosyncratic items</th>
<th>Idiosyncratic actions</th>
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<td>airplanes</td>
<td>acting</td>
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<td>beer</td>
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REFERENCES


