

**Stereotype Threat Promotes Aversive Responses to STEM Domains:  
An Attentional Blink Investigation**

by

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## **ABSTRACT**

Beginning around middle school, women initially interested in Science, Technology, Engineering, and Math (STEM) opt out of these fields at disproportionate levels compared to men. It is unclear why many women choose to leave these domains despite a high level of initial interest, but one possibility is that women develop learned aversions towards STEM fields over time. Two studies assessed the effects of STEM aversions on performance and math identification. Study 1 probed for evidence of STEM aversions via an attentional blink task and examined how these aversions may undermine performance on a difficult math test while continuous EEG activity was recorded. Results revealed that both men and women exhibit evidence of STEM aversions, but only women underperform on a difficult math test to the extent they exhibit a neural perceptual bias towards STEM images. Study 2 successfully utilized a dot-probe training paradigm to mitigate these effects. Overall, findings suggest that, stereotype threat to STEM domains can produce a learned aversion in women however using attentional paradigms this effect can be reversed.

## **Chapter 1**

### **Study 1**

#### **1.1 Introduction:**

Beginning around middle school, women initially interested in Science, Technology, Engineering, and Math (STEM) opt out of these fields at disproportionate levels compared to men. Only 30% of Ph.D.'s awarded in the STEM domains are earned by women and only 25% of the positions in these fields, including principal investigators or lab technicians, are held by women. Further, women who have earned these degrees report higher job dissatisfaction and are more likely to leave their positions than their male counterparts (Robertson & Bean, 1998; Settles, Cortina, Mallei, & Stewart, 2006; Singh, Mishra, & Kim, 1998; Trower & Chait, 2002). Despite these alarming trends it is largely unclear why many women choose to leave these domains despite a high level of initial interest.

#### **1.2 Stereotype Threat and Memory**

One source of fuel for the exodus could be due to repeated exposure to stereotype threatening situations. Stereotype threat is a situational stressor that targets, such as women, experience when they fear their actions may inadvertently confirm the negative group stereotype (Steele & Aronson, 1995; Schmader, Johns, & Forbes, 2008). Stereotype threat can also have a strong impact on how much stigmatized groups (i.e. women and math) identify with these domains personally (e.g., Majors & Billson, 1992; Ogbu, 1997; Steele, 1997). Given this, the current studies focus on the

following question: Do women develop learned aversions towards STEM domains, and if they do what are the consequences of these aversions?

To examine whether women possess learned STEM aversions, it's important to first determine how these aversions may develop. One possibility stems from the fact that the experience of stereotype threat is often associated with negative emotions and physiological arousal. For instance, stereotype threat has been shown to elicit increases in blood pressure (Blascovich, Spencer, Quinn, & Steele, 2001), skin conductance (Osborne, 2006; 2007) and sympathetic activation of the cardiovascular system (Murphy, Steele, & Gross, 2007), as well as neurological indices of emotion regulation (Wraga, Helt, Jacobs, & Sullivan, 2007) and conflict detection (Forbes, Schmader, & Allen, 2008).

Stereotype threatened individuals also report heightened levels of explicit anxiety (Spencer, Steele, & Quinn, 1999), self-doubt (Steele & Aronson, 1995), negative expectations (Stangor, Carr, & Kiang, 1998), feelings of dejection (Keller & Dauenheimer, 2003), and task-related worries (Beilock, Rydell, & McConnell, 2007; Cadinu, Maass, Rosabianca, & Kiesner, 2005). These responses can arise independently, or can occur simultaneously, which forces individuals to utilize cognitive resources that would otherwise be needed for optimal performance; i.e., stigmatized individuals often experience cognitive depletion under stereotype threat (Ståhl et al. 2012). Such symptoms have been seen in girls as early as in kindergarten and continue throughout adulthood (Ambady et al., 2001). More implicit, nonverbal indicators of anxiety have also been observed in both performance and non-performance related domains, including dot probe measures typically used in clinical



settings to detect abnormal anxiety responses to stimuli (Johns, Inzlicht, & Schmader, 2008; Bosson, Haymovitz, & Pinel, 2004).

Negative affect and physiological arousal also happen to be two integral ingredients for emotional memory encoding and mood congruent memory encoding processes. Extant research reveals that when individuals experience negative affect and arousal, negative information associated with the affective experience receives privileged access and is encoded and recalled more efficaciously compared to positive or neutral information (Pratto, Felicia, and John 1991). Research out of our lab provides direct evidence that stereotype threat may facilitate encoding of negative, stereotype confirming information specifically. Forbes et al. (under review) placed women in stereotype threatening contexts and then had them complete a math task that provided them with unique but accurate feedback after each problem. A surprise memory test was then administered to participants where they were asked to indicate whether they had seen the wrong or correct feedback during the math task. Results revealed that stereotype threatened women exhibited greater memory for negative feedback (i.e. wrong compared to correct feedback) received during the math task compared to positive feedback, women not under threat and men in either condition. Furthermore, women exhibited this same pattern up to a week later, particularly for those who were most identified with the math domain. Stereotype threatened women also underperformed on a follow-up difficult math test and reported more post-test anxiety to the extent they encoded negative feedback more efficaciously.

Based on findings from Forbes et al. (under review), a deleterious cycle reveals itself. When a person enters a stereotype threatening situation (e.g., math class), the experience of negative arousal and affect will yield preferential encoding of

information associated with that mood state. This information is then remembered better over time, is spontaneously recalled, and can directly engender general negative affect when individuals find themselves in similar situations (Forbes et al., under review). Thus individuals may associate these general feelings of negative affect with the domain itself in the same manner as basic Hebbian learning. Over time, this could potentially lead to a learned aversion towards STEM domains. This aversion may interfere with strategies people use to remain interested and invested in their domain. Importantly, it's possible to reverse these aversions via reversing the negative learned associations (Bögels & Mansell, 2004). Therefore, another critical element of this study will be to identify methods which may ameliorate learned aversions women may have to the STEM fields.

In this study we utilized an attentional blink paradigm to probe for evidence of learned STEM aversions and assess how these aversions may in turn affect performance in stereotype threatening contexts. We hypothesized that to the extent to which women have developed a learned aversion towards STEM domains, exposure to STEM-relevant stimuli, e.g., pictures of men in lab-coats or male professors teaching STEM topics, would facilitate an attentional blink. The severity of this attentional blink, as indexed by basic neural perceptual responses to STEM stimuli, may in turn predict the severity of stereotype threat consistent responses. That is, if learned aversion plays a role in stereotype threat, women may perform worse on a difficult math test to the extent they exhibit greater neural processing of STEM oriented stimuli.

For the neural analysis the Calcarine Sulcus was chosen as an a priori source for a couple of reasons. First, previous research has suggested that the Calcarine Sulcus is

one of the main neural generators of the P1. The P1 is an event-related positive deflection which appears about 100ms after stimulus onset. It is classically associated with the primary visual processing of the stimulus (Heinze and Mangun, 1995), and studies have supported that it may in fact be associated to the processing of more complex aspects of the stimulus; thus directly connecting the P1 to the basic perceptual process (Debruille et al., 1998; Seeck et al., 1997). Also, given the nature of the experimental design, it is important to examine early perceptual processing components and how they may be interacting with other neural regions and if any differential findings are resultant of these interactions.

### **1.3 Methods**

#### **Study 1**

##### **Participants**

40 White undergraduates were recruited from the university subject pool. Participants were compensated with partial course credit. Of these 31 (15 women) are included in the present analysis, reasons for exclusion were incomplete data (3), excessive motion during EEG recording (4), and less than 10 usable epochs for data analysis in main categories of interest (2).

##### **Materials**

The stimuli were generated using a windows computer. The study was presented using Empirisoft MediaLab 2012 and Direct RT version 2012 software. EEGs were recorded using a 64 channel BioSemi EEG system. We created a difficult math task using math problems from the GRE. The study also utilized an attentional

blink paradigm. The attentional blink paradigm measures the extent to which a given stimulus is emotionally arousing or hijacks attentional resources to undermine detection of goal relevant stimuli. Two components, Rapid Serial Visual Presentation (RSVP) and Stimulus Onset Asynchrony (SOA), are the main factors that allow this analysis to occur. The RSVP paradigm entails participants looking at a continuous presentation of visual items each presented for a very brief period of time before the next image is presented. This rapid presentation allows the attentional blink to occur with subconscious attention. The attentional blink also depends on the SOA, or the time between the T1 and T2 onset. The time should differ between the onset of both the T1 and T2 stimuli so that the participant cannot habituate to a certain time frame of stimulus onset. T1 is the first target stimuli and T2 is the second target stimuli. It is common that for a shorter SOA (120-200ms) that T2 is less visible and for a longer SOA (greater than 500ms) T2 is more visible to participants (Posner, 1980). At very short SOAs (13 to 53 ms), T2 benefits from the prior capture of attention by T1 and will be likely identified (an effect called 'lag-1 sparing').

## Procedure

Participants completed a series of tasks while continuous EEG activity was recorded. Participants were brought into the lab and placed under stereotype threat with instructions stating the participant would be judged on a diagnostic math task (see Forbes et al. 2008 for procedure). Next participants performed the modified attentional blink task. The stimuli for this task were presented at the center of the computer screen using Empirisoft MediaLab 2012. Participants were shown a series of 7 images. The first was a crosshair placed in the center of the screen for a variable

amount of time (516ms vs. 860ms) to create jitter so the participants would not be able to accurately anticipate the start of any single trial. The next image the participants saw was target 1 (T1) which was either a STEM or Non-STEM academically oriented picture. Men were depicted in the STEM pictures while women were depicted in the Non-STEM pictures, in both instances the persons in the picture were shown in academic or laboratory scenes. T1 was immediately followed by a landscape picture. Next, a second crosshair was presented for a variable amount of time providing either a short SOA (258ms) or a long SOA (698ms). T2 followed the second crosshairs and could either be present or not, if present, T2 was shown between four boxes. If T2 was absent a blank screen with the same four boxes in the same position was presented. Two masks of landscapes then appeared following T2. Each stimulus was presented for 43ms with the exception of the crosshairs which were presented for the variable length of times discussed.

Two questions were then presented at the end of each RSVP trial. The first question inquired about how visible T2 was. The participants were able to choose from a scale of 0-99 with nine separate intervals ranging from 0-11 (not visible at all), 12-22, 23-33, 34-44, 45-55, 56-66, 67-77, 78-88, 89-99 (Very visible). The second question inquired about whether or not the picture with a person/people contained a man/men or woman/women. This question served to determine if participants saw T1 and participants picked either male or female on the response box. Next, participants were given 5 minutes to solve 15 difficult math problems taken from the GRE. Participants were allowed to use scrap paper to help them with this task. We implemented two manipulation checks in order to make sure the effect we observed was what we were looking for. The first was to inquire about the participant's

knowledge of the stereotype that men are better than women at math. This was a pre-selection requirement. We also inquired about whether the participant believed that the experimenter thought men were going to perform better than women on the difficult math task. We ran a single variable T-Test to see the significance of the manipulation check.

#### **1.4 EEG Processing**

EEG signals were referenced offline to an average reference. Epochs were stimulus locked to the presentation of the T1 stimulus. Exclusion criteria for epochs were an amplitude exceeding 120  $\mu$ V and a gradient of 75. Brain Electromagnetic Source Analysis (BESA) 5.3 software (MEGIS Software GmbH, Grafelfing, Germany) was utilized for source localization. First we manually planted a source on each eye and our a priori source of the Calcarine Sulcus using Talairach Coordinates provided in Di Russo et al. (2001). We planted a priori sources and then used Classical LORETA Analysis Recursively Applied (CLARA) iterative processing to determine additional sources until less than 5% of the variance that was unaccounted for. The other sources accountable for the variance were the anterior cingulate cortex (ACC) and the inferior frontal gyrus (IFG). Finding these two regions accounting for the rest of the variance was ideal. It has been proposed that the anterior cingulate cortex (ACC), on the medial surface of the frontal lobe, contributes to performance monitoring by activating in anticipation of errors from heightened risk. It has also been proposed as a more active component in which it has been shown to evaluate the degree of error and implement the appropriate action to the motor system (Carter et al. 1998). The IFG is involved in signaled risk aversion. Higher risk aversion often correlated to the IFG (Christopoulos et al. 2009). This application utilized weighted

LORETA images, ultimately reducing the source space with the iterations (Hoechstetter et al. 2010). All sources were modeled at 56-106ms post presentation of the T1 stimulus as this time interval usually contains the P100, and event related potential identified as an integral index of basic sensory processing.

Time-frequency analysis comprises many methods and measures that capture different aspects of EEG magnitude and phase relationships. We examined both power and phase locking in our time frequency analysis. Phase locking refers to an event related phase consistency with respect to an event's onset. Phase locking specifically measures the collections of neurons that fire in synchrony with other regions; therefore, it is representative of the communication between the two regions observed. Power refers to the average magnitude of oscillations for individual collections of neurons at specific points in time thus representative of the intensity in which the collections of neurons fire together. When these components are analyzed one can assess changes in power and synchronization of EEG signals on a higher order within or between spatial locations across trials with respect to the onset of stimuli or the task (Roach & Mathalon, 2008). For our time frequency analyses all comparisons were locked to the Calcarine Sulcus as it was the source that predicted the greatest amount of variance and has previously been identified as a major neural generator of P1 (Di Russo et al. 2001).

## **1.5 Results**

This study was a 2(gender) x 2(T1 type: STEM/NonSTEM) x 2 (SOA length: Short/Long SOA) mixed factors design with repeated measures on the latter 2 variables. As per the standard in attentional blink paradigms, only trials in which participants correctly identified T1 were included in the analysis (Sergent et al

2005). We ran a mixed-model ANOVA with the number of incorrect T2 responses following correct identification of T1 for both STEM and Non-STEM pictures at T1. Consistent with past attentional blink studies, results revealed that participants were more likely to miss T2 stimuli after a short SOA compared to the long SOA ( $F=146.78, p<.001, \eta_p^2=.835$ ). Participants also missed more T2's following T1 STEM pictures compared to T1 non-STEM pictures following the short SOA ( $F=9.23, p=.005, \eta_p^2=.845$ ; Figures 1 and 2). However, there were no differences between STEM and Non-STEM at long SOA ( $F=.141, p=.2$ ). Thus, findings suggest that STEM images capture more of both men and women's attention under stereotype threat.

Next, to investigate participants' performance on the difficult math task, a one way ANOVA was conducted. Contrary to expectations, no differences in performance were found between men (mean = 32.85 SD= 22.79) and women (mean = 32.66 SD= 28.125) ( $F=0, p=.98$ ). In our manipulation check however an independent samples T-test was conducted to test any potential differences between gender on our manipulation check, results revealed a marginal difference ( $t=1.89, p=.068$ ; women  $M=4.33, SD=2.35$ ; men  $M= 2.88, SD= 1.928, d=0.675, r=0.319$ ) such that, women tended to be more concerned with the researcher thinking they had less ability dependent on their task performance.

Specific to EEG findings, in line with a priori hypotheses, our analyses focused on Calcarine Sulcus, IFG, and ACC sources (Figures 3 and 4). Basic findings are the following for phase locking and power: Differences in gender were examined with an independent T-Test during phase locking between the Calcarine and IFG in the beta band when subjects viewed STEM stimuli. In response to STEM stimuli a marginally



significant difference was found between gender ( $t= 1.933$   $p=.063$ ; women  $M=.197$ ,  $SD=.013$ , men  $M=.166$ ,  $SD=.009$   $d=2.78$   $r=.811$ ) In response to STEM stimuli no differences were found between gender in phase locking between the Calcarine and ACC in the alpha band ( $t=.536$   $p=.596$ ; women  $M=.228$   $SD=.015$ , men  $M=.216$ ,  $SD=.0157$   $d= .78$   $r=0.364$ ). Similarly in response to Non-STEM stimuli no differences were found between gender in power between the Calcarine and IFG in the Beta band ( $t=.360$   $p=.721$ , women  $M= 1188.235$ ,  $SD=640.575$ , men  $M=1117.634$ ,  $SD=438.942$   $d=0.35$   $r=.173$ ). In response to Non-STEM stimuli no significance between gender in power between the ACC and Calcarine in the alpha band ( $t=.592$   $p= .558$ , women  $M=1182.0135$ ,  $SD= 210.151$ , Men  $M=1014.592$ ,  $SD= 190.154$   $d=0.835$   $r=.385$ ). Though no overt differences in power and phase locking were found between men and women, it is still possible that women could exhibit signs of an exacerbated threat response, i.e., stereotype threat consistent performance effects, to the extent they exhibit power and phase locking responses consistent with an aversive response towards STEM images. This possibility was investigated with a series of moderated regression analyses.

We observed the phase locking between the two sources in response to the given stimuli (50-135ms after T1). Increased phase locking between Calcarine and ACC after T1 was shown predicted worse performance on the difficult math task for women who were shown STEM stimuli during T1. Likewise, increased phase locking between Calcarine and IFG after T1 predicted worse performance on the difficult math task for women shown STEM stimuli during T1 as well. Calcarine-ACC Phase Locking in alpha band at T1 STEM showed a significant interaction with ( $B=1.52$ ,  $p<.03$ ). The women's slope was found to be significant ( $t=-3.06$   $p<.01$ ) in this

analysis while the men's slope was not significant ( $t=0.01$   $p=.98$ ). To test if the differences in performance were observed at both high and low phase locking regression analyses for one SD above/below mean for phase locking of ACC. Results indicated that the gender findings hold below the mean ( $t=-2.290$ ,  $p=.030$ ) and above the mean ( $t=-2.225$ ,  $p=.035$ ). See figure 7. Calcarine-IFG Phase Locking in beta Band at the T1 STEM showed a marginal significant interaction ( $B=1.44$   $p=.051$ ). The women's slope was significant ( $t= -2.04$ ,  $p<.05$ ). The men's slope was not significant ( $t=.9$ ,  $p=.4$ ). To test if the differences in performance were observed at both high and low phase locking regression analyses for 1SD above/below mean for phase locking of ACC. Results indicated that the gender findings hold below the mean ( $t=-2.10$ ,  $p=.045$ ) and above the mean ( $t=-2.09$ ,  $p=.046$ ) (See figure 8).

Interestingly, women exhibited different patterns of performance to the extent they exhibited local neural activity in response to Non-STEM images. Specifically looking at power between the brain regions we found that increased ACC power in the alpha band and IFG power in the beta band predicted better performance on the difficult math task for women who saw non STEM stimuli during T1. A moderated regression analysis for ACC power in the alpha band at T1 Non-STEM (shown in Figure 5) had a significant ACC power X Gender interaction predicting performance ( $B=.039$  and a  $p=<.029$ ) Simple slope analysis from these analyses revealed that the women's slope was significant ( $t=8.1$ ,  $p<.001$ ) in the graph, and that the men's slope was not significant ( $t= .001$   $P=.99$ ). To test if the differences in performance were observed at both high and low power, moderated regression analyses for one SD above/below mean of ACC power were performed. Results indicated that the gender findings hold below the mean ( $t=2.247$ ,  $p=.033$ ) and continuously trend above the

mean ( $t=1.858$ ,  $p=0.074$ ). Observing the power in the IFG we found that the power for the IFG in beta band at T1 Non-STEM was also found to have a significant interaction ( $B=.029$ ,  $p<.001$ ). The women's slope was found as significant in this analysis ( $t=10.4$ ,  $p<.001$ ) while the men's slope was not found as significant ( $t=0.0$ ,  $p=1$ ). To test if the differences in performance were observed at both high and low power regression analyses for 1SD above/below mean for power of IFG. Results indicated that the gender findings hold below the mean ( $t=2.670$ ,  $p=.013$ ) and are no longer significant above the mean ( $t=1.291$ ,  $p=0.208$ ) (See figure 6).

## **1.6 Discussion**

Participants showed the expected attentional blink effects, that is, they were more likely to miss the T2 stimulus, during a short SOA as opposed to a long one. Our hypothesis was partially supported with the main effect of more "blinks" of T2 stimulus following the T1 STEM pictures versus the T1 Non-STEM pictures, suggesting that STEM stimuli hold the participant's attention longer, causing the "blink" effect. Women who demonstrated greater phase locking between the V1 in Calcarine Sulcus and ACC and Calcarine and IFG in response to STEM stimuli performed worse on the difficult math task. This is unsurprising given the roles that these neural areas play in focusing attention and responding to threatening stimuli. Those women who have a greater amount of resources allocated to attending to threatening stimuli are potentially suffering from cognitive depletion and the associated stereotype threat effects, leading to a poorer performance on the math task. Communication between these two areas could be the product from the learned aversion. This indicates that STEM stimuli create an aversion that limits women's

performance on STEM based tasks. These findings support our hypothesis, women under stereotype threat may develop a learned aversion to STEM domains, shown by the larger amount of attention directed to the STEM images. This is also shown when their performance decreases on the difficult math task following the initiation of stereotype threat. Interestingly, women performed better on the difficult math task to the extent in which they exhibit greater IFG of ACC power in response to the Non-STEM stimuli. The increased attention to the Non-STEM stimuli has a direct effect on the performance on the subsequent math task.

Here we demonstrated the increased attention towards STEM stimuli predicted decreased math performance on a difficult math task, while increased attention towards Non-STEM stimuli had the opposite effect. This invites the possibility that if one could train participants away from the threatening stimuli (i.e. STEM related images), it may be possible to increase their performance outcomes. One potential way of doing this would be by using dot-probe training (Pratto, Felicia, and John. (1991). By directing the participant's attention away from the STEM stimuli, stereotype threat effects could potentially be mitigated and performance may increase on subsequent math tasks.

## **Chapter 2**

### **Study 2**

#### **2.1 Introduction**

Study 1 demonstrated that in a stereotype threatening context individuals attend more to STEM domain related images depending on whether they elicited enhanced phase locking between different neural regions. This brings about the question of whether the performance outcomes related to stereotype threat can be attenuated by blunting the arousal response elicited by STEM stimuli. One way to achieve this is by directing individuals' attention either towards (exacerbate) or away (mitigate) from STEM stimuli. We hypothesized that if the participant's attention is directed towards threatening content (STEM stimuli) then this could exacerbate stereotype threat based performance decrements on a difficult math test. Conversely, if attention is directed away from STEM stimuli it might be possible to attenuate stereotype threat effects on the difficult math test.

#### **2.2 Methods**

##### **Participants**

126 Participants were selected for study 2 from the same pool as Study 1. In the exacerbate condition 64 subjects were used (34 women, 30 men). In the mitigate condition 58 participants were used (28 women, 30 men). All subjects were white

students who reported awareness of the stereotype that men are predicted to do better at math than women.

### Materials

The same materials were used as in study 1. The stimuli were generated using a windows computer. Empirisoft MediaLab 2012 and Direct RT version 2012. A 64 channel BioSemi EEG system was also used. We created a difficult math task using difficult math problems from the GRE. The same attentional blink paradigm was also used. In study 2 however we also implemented a Dot-Probe task (Trawalter et al., 2008). The Dot-Probe manipulation works to eliminate attentional bias by prompting the participant to avert their gaze away from threatening stimuli. When a threatening situation is presented, (i.e. STEM stimuli), the threat is attenuated by an averted eye gaze. Previous work has found that after using a Dot-Probe manipulation the stimuli no longer captures the perceiver's attention to the same degree (Trawalter et al., 2008).

The dot-probe task consisted of the following: The first part consisted of practice trials in which a cross hair was presented in the middle of the screen as a fixation point (1000ms). Two faces soon replaced this presentation (500ms). After the faces were presented they were replaced with masks before a small gray dot appeared on the left or right side of the screen. This dot is what would orient the participant's eye gaze either towards or away from the STEM stimuli. The dot would appear on the screen until the participant indicated that they in fact saw the small dot.

The real task had a similar procedure in which a cross hair was presented in the middle of the screen as a fixation point (1000ms). We then used STEM and Non-STEM academic stimuli which consisted of either men or women. These stimuli were presented very quickly so that they were perceived as close to subliminal within a

mask. A small gray dot appeared and the participants would then press a corresponding button to indicate whether the dot was on the left (f button) or right (j button) side of the screen.

### Procedure

Study 2 was identical to that of Study 1 with a couple of notable exceptions. The first being the addition of the dot-probe training task prior to stereotype threat induction. The second major deviation from the design of Study 1 is that no electrophysiological recordings were taken, this study utilized behavioral measures only. Participants were brought into the lab and immediately took part in a dot-probe task either directing the participant's attention towards (exacerbate condition) or away (mitigate condition) from the STEM threats.

After completing the dot-probe task the participant was given the same threat induction and attentional blink task as in Study 1, followed by the same difficult math task. The only difference was that during the attentional blink task participants were able to manually enter how visible T2 was using the keyboard on a scale from 0-100.

## 2.3 Results

The design of this study was 2(gender) x 2(condition) x 2(T1 type: STEM/NonSTEM) x 2 (Short/Long SOA) mixed factors design with repeated measures on the latter 2 variables. To test whether there was a difference between STEM and Non-STEM pictures we performed a mixed model ANOVA. Basic findings from Study 2 replicated those from study 1: Participants missed more T2 images following T1 STEM pictures compared to T2 Non-STEM pictures ( $F = 22.354$ , with a  $p < .001$ ,  $\eta_p^2 = .155$ ) and missed more T2 images during short SOA trials compared to long SOA ( $F = 373.697$ ,  $p < .001$ ,  $\eta_p^2 = .745$ ).

To investigate differences between men and women on our manipulation check a univariate ANOVA was conducted with gender and condition as fixed factors. Results indicated that there was no differences between ratings for condition ( $F = .629$ ,  $p = .429$ ; mitigate  $M = 3.78$ ,  $SD = 2.202$ ; exacerbate  $M = 3.58$ ,  $SD = 2.098$ ,  $d = 0.093$   $r = 0.0464$ ). However, there was a significant difference between ratings for women and men ( $F = 9.135$ ,  $p = .003$ ; women  $M = 4.22$ ,  $SD = 2.149$ ; men  $M = 3.11$ ,  $SD = 2.00$ ,  $\eta_p^2 = 0.070$ ) indicating that women were more concerned that the researcher would perceive them as having less ability if they did not perform well on the task.

We then ran a univariate ANOVA that showed no significant difference between conditions in overall performance (mitigate mean = 54.14,  $SD = 30.08$ ; exacerbate mean = 46.67,  $SD = 28.84$ ;  $F = 1.614$   $p = .2$   $d = 0.25$   $r = 0.126$ ). However there was a significant difference for gender on performance (women mean = 43.27,  $SD = 29.67$ ; men mean = 57.15,  $SD = 27.97$ ;  $F = 6.353$   $p = .013$ ,  $\eta_p^2 = 0.051$ ). Due to the gender difference between the two conditions, independent sample T-Tests were performed for each condition. This showed that in the mitigate threat condition there was no significant difference between men and women ( $t = -.925$   $p = .359$ ; women  $M = 50.22$ ,  $SD = 31.6323$ , men  $M = 57.55$ ,  $SD = 28.747$   $d = -0.24$   $r = -0.12$ ). In the exacerbate threat condition we found women ( $M = 37.763$   $SD = 27.24$ ) performed worse than men ( $M = 56.75$   $SD = 27.6388$ ),  $t = -2.764$   $p = .008$   $d = -0.691$   $r = -0.327$ ). These findings indicate that the gender differences are being driven by performance of women in the exacerbate condition, whereas in the mitigate condition women's performance is equal to that of men.



## **2.4 Discussion**

In Study 2 we found the negative performance outcomes associated with stereotype threat could be mitigated. After taking part in our training task in which the participant's attention is directed away from threatening stimuli the performance deficient normally encountered in stereotype threatening contexts is ameliorated.

## **Chapter 3**

### **Conclusions**

#### **3.1 General Discussion**

Findings across two studies provided some support for our hypotheses. In study one we predicted that stereotype threat can promote learned aversions that would impact how women perform on a difficult math test. The typical attentional blink paradigm effects were replicated, but findings also revealed that both men and women exhibited increased attentional allocation to STEM stimuli. However, women exhibited a much different pattern neurally in response to STEM stimuli compared to men that in turn was associated with their performance on a subsequent difficult math test. Specifically, women performed worse on the difficult math test to the extent STEM stimuli appeared to receive privileged access perceptually (i.e., enhanced communication between neural regions integral for bottom-up perceptual processes). Surprisingly, we also found evidence that increased attention towards non-STEM stimuli was also a significant predictor of performance on a subsequent math task, but such that, performance was better increased in those women with more ACC or IFG activation in reaction to non-STEM stimuli.

From these data we hypothesized in study two that we could counteract these aversion responses to ameliorate stereotype threat effects on performance. Using dot-probe training we successfully accomplished this. Women trained to attenuate the initial threat response associated with STEM stimuli performed comparably to their

male counterparts and better than women trained to exacerbate the threat response towards STEM stimuli.

There are a few Limitations to consider for these experiments, such as the lack of a control group in Study 1. However, we specifically chose to conduct this experiment in this way. Earlier studies suggest that there is a large performance difference between men and women in stereotype threatening contexts that is largely absent when the tasks are framed in a non-threatening manner (i.e. not diagnostic or evaluative) (Schmader, 2002). Being as we were testing specifically if women compared to men had developed a learned aversion under threatening contexts a control condition was deemed redundant in light of previous work (Spencer et al. . 1999). Although we had reason to exclude a control group in the future a control effect would be helpful to compare our individual data to, our analysis of the manipulation check was trending and this could have been avoided if a control group was present.

Another limitation may be the stimuli we chose for T1 across the studies. The pictures used for T1 arguably could be construed as representative of the negative math stereotype in a sense. That is, the stereotype holds that men are more likely to be in STEM fields and women are more likely to be in the humanities. However, this could mean simply that we controlled for negative stereotypicality of the images which still allowed us to differentiate between men and women's responses to STEM compared to non-STEM images. Although women may have been shown non-stem images we still found differences between the two sets of images. This suggests that there is more to the images than just stereotypicality. In study 1 we found results that were highly consistent to our original hypothesis providing support for the previous

statement. Because we were testing stereotype threat on a math related performance only the STEM pictures would be threatening. Negative stereotypicality was controlled for.

The combination of Study 1 and 2 demonstrated a full effect of stereotype threat with significance. We observed in Study 1 that using the attentional blink paradigm learned aversion can play a significant role in the performance of women under threat and that this performance can be predicted by phase locking and power statistics from the Calcarine Sulcus, ACC, and IFG. We then predicted that this aversion can be reversed. To test this we used a dot-probe training task to direct the participant's attention away from the threatening stimuli. This training resulted in a significant increase in performance showing how aversion can be mitigated.

### 3.2 Figures

Figure 1 T2 “blinked” after STEM Images at T1

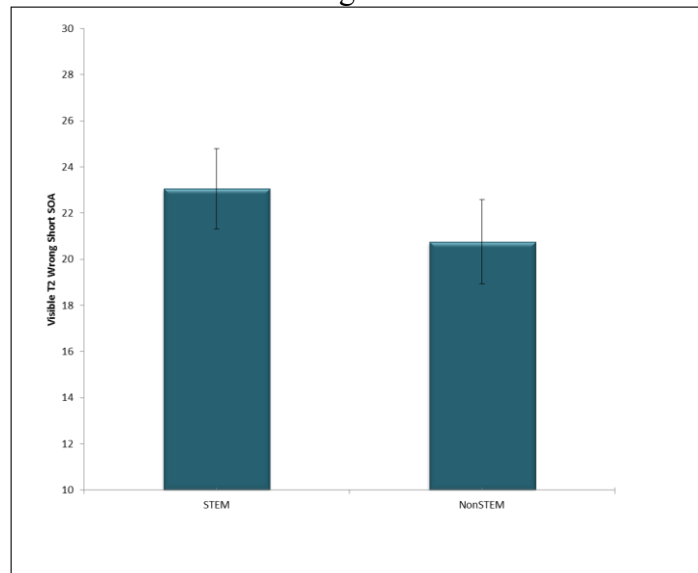


Figure 2 Short SOA produces more “blinks” for Visible T2

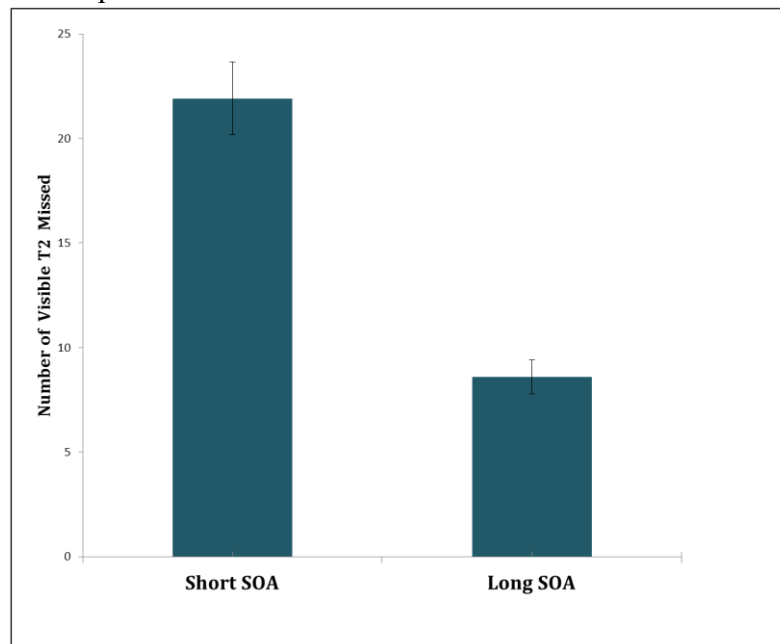


Figure 3 Source Localizations

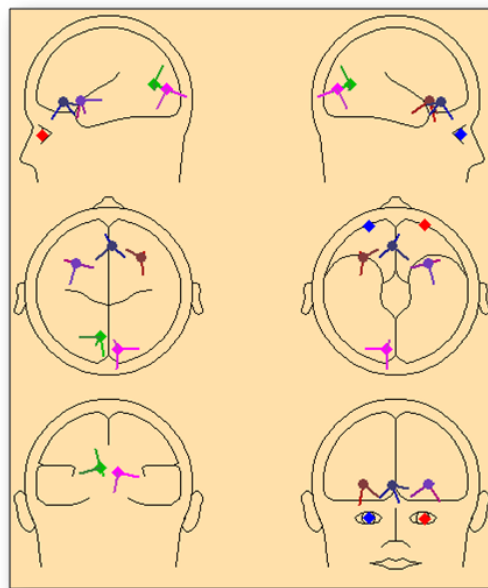


Figure 4 Neurological Perspective on Source Localizations

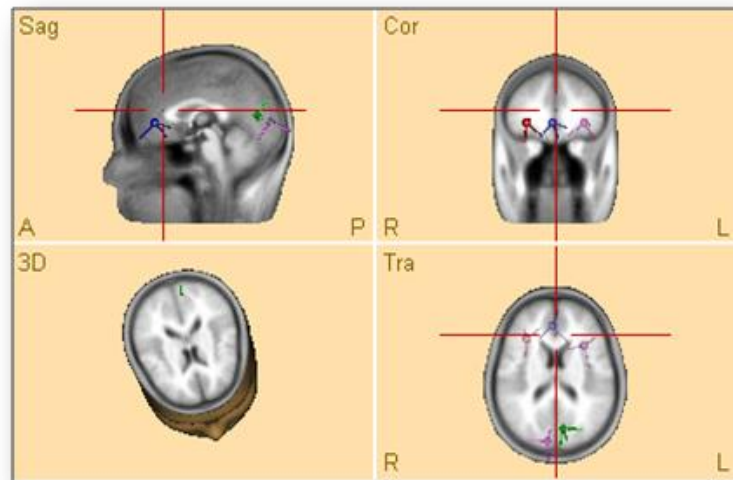


Figure 5 Power for the ACC in the alpha band at T1 Non-STEM stimuli

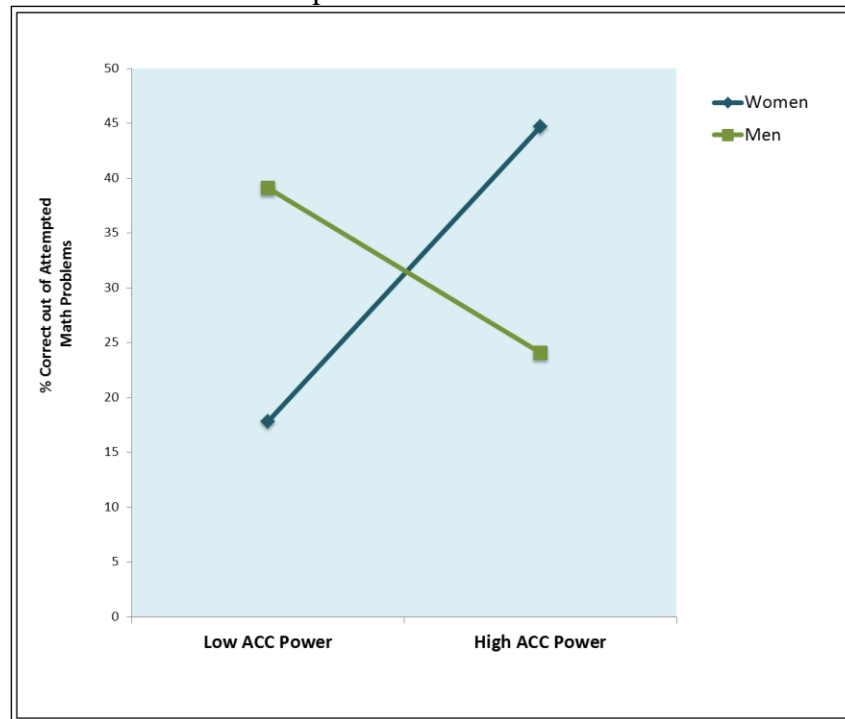


Figure 6 Power for the IFG in the Beta Band at T1 Non-STEM

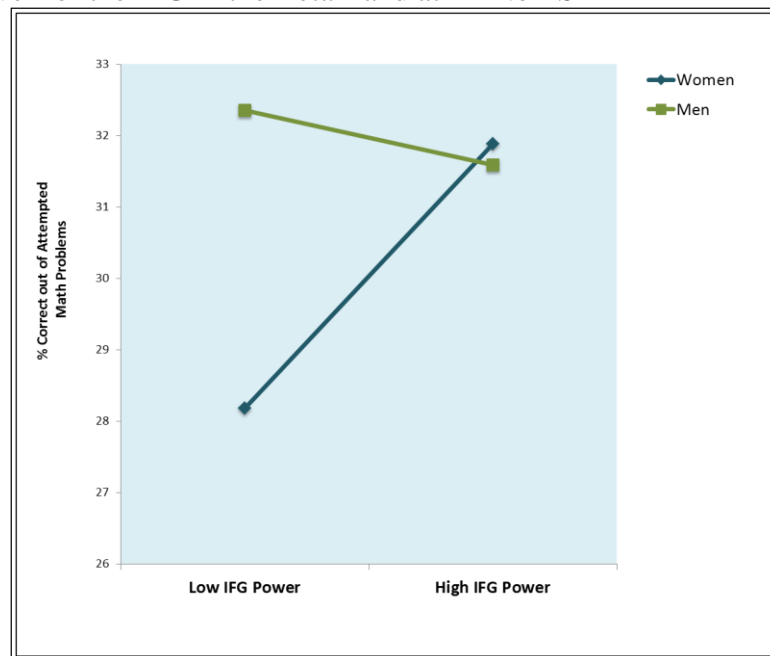


Figure 7 Calcarine-ACC Phase Locking in Alpha Band at T1 STEM

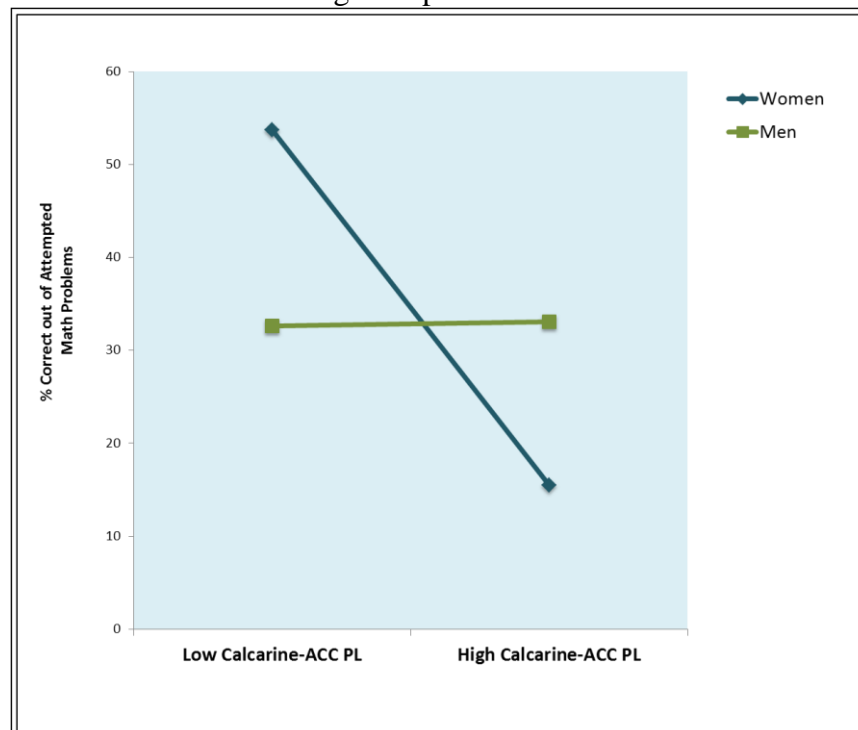
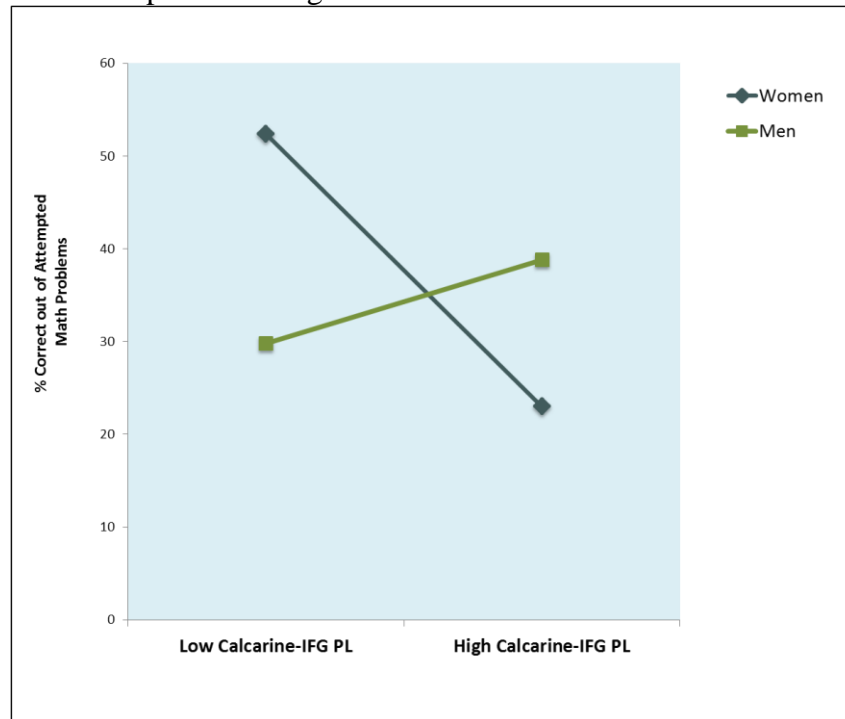


Figure 8 Calcarine-IFG phase locking in the Beta Band at T1 STEM





## REFERENCES

- Aronson, J., Quinn, D. M., & Spencer, S. J. (1998). Stereotype threat and the academic underperformance of minorities and women. In J. K. Swim C. Stangor (Ed.), (pp. 83-103). San Diego, CA, US: Academic Press.
- Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M., & van IJzendoorn, M. H. (2007). Threat-related attentional bias in anxious and nonanxious individuals: A meta-analytic study. *Psychological Bulletin*, 133(1), 1-24.
- Beilock, S. L., Rydell, R. J., & McConnell, A. R. (2007). Stereotype threat and working memory: Mechanisms, alleviation, and spillover. *Journal of Experimental Psychology: General*, 136(2), 256.
- Blascovich, J., Spencer, S. J., Quinn, D., & Steele, C. (2001). African americans and high blood pressure: The role of stereotype threat. *Psychological Science*, 12(3), 225-229.
- Bögels, S. M., & Mansell, W. (2004). Attention processes in the maintenance and treatment of social phobia: Hypervigilance, avoidance and self-focused attention. *Clinical Psychology Review*, 24(7), 827-856.
- Bosson, J. K., Haymovitz, E. L., & Pinel, E. C. (2004). When saying and doing diverge: The effects of stereotype threat on self-reported versus non-verbal anxiety. *Journal of Experimental Social Psychology*, 40(2), 247-255.
- Cadinu, M., Maass, A., Rosabianca, A., & Kiesner, J. (2005). Why do women underperform under stereotype threat? Evidence for the role of negative thinking. *Psychological Science*, 16(7), 572-578. doi:10.1111/j.0956-7976.2005.01577.x
- Christopoulos, GI.; Tobler, PN.; Bossaerts, P.; Dolan, RJ.; Schultz, W. (Oct 2009). "Neural correlates of value, risk, and risk aversion contributing to decision making under risk.". *J Neurosci* 29 (40): 12574–83
- Debruille JB, Guillem F, Renault B. ERPs and chronometry of face recognition: following-up Seeck et al. and George et al. *Neuroreport* 1998;9:3349–53.
- Di Russo, F., Martínez, A., Sereno, M. I., Pitzalis, S., & Hillyard, S. A. (2002). Cortical sources of the early components of the visual evoked potential. *Human Brain Mapping*, 15(2), 95-111.

- Eich, E. (1995). Searching for mood dependent memory. *Psychological Science*, 6(2), 67-75.
- Forbes, C. E., Schmader, T., & Allen, J. J. (2008). The role of devaluing and discounting in performance monitoring: A neurophysiological study of minorities under threat. *Social Cognitive and Affective Neuroscience*, 3(3), 253-261. doi:10.1093/scan/nsn012; 10.1093/scan/nsn012
- Forbes, C. E., Duran-Jordan, K., Magerman, A., Leitner, J. & Schmader, T. (Under Review). Unforgettable: Stereotype threatening contexts enhance encoding of negative feedback to engender underperformance and anxiety. *Journal of Personality and Social Psychology*.
- Heinze HJ, Mangun GR. Electrophysiological signs of sustained and transient attention to spatial locations. *Neuropsychologia* 1995;33:889–908.
- Hochstetter, K., Berg, P., & Scherg, M. (2010). BESA research tutorial 4: Distributed source imaging.
- Hommel, Bernhard, and Elkan G. Akyürek. (2005) "Lag-1 Sparing in the Attentional Blink: Benefits and Costs of Integrating Two Events into a Single Episode." *The Quarterly Journal of Experimental Psychology Section A* 58.8 1415-433. Print.
- Johns, M., Inzlicht, M., & Schmader, T. (2008). Stereotype threat and executive resource depletion: Examining the influence of emotion regulation. *Journal of Experimental Psychology: General*, 137(4), 691.
- Keller, J., & Dauenheimer, D. (2003). Stereotype threat in the classroom: Dejection mediates the disrupting threat effect on women's math performance. *Personality & Social Psychology Bulletin*, 29(3), 371-381. doi:10.1177/0146167202250218
- Kray, L. J., Galinsky, A. D., & Thompson, L. (2002). Reversing the gender gap in negotiations: An exploration of stereotype regeneration. *Organizational Behavior and Human Decision Processes*, 87(2), 386-410.
- Murphy, M. C., Steele, C. M., & Gross, J. J. (2007). Signaling threat: How situational cues affect women in math, science, and engineering settings. *Psychological Science*, 18(10), 879-885. doi:10.1111/j.1467-9280.2007.01995.x
- Neff, K. D. (2003). Development and validation of a scale to measure self-compassion. *Self and Identity*, 2, 223-250.

- Osborne, J. W. (2006). Gender, stereotype threat, and anxiety: Psychophysiological and cognitive evidence. *Electronic Journal of Research in Educational Psychology*, 4(1), 109-138.
- Osborne, J. W. (2007). Linking stereotype threat and anxiety. *Educational Psychology*, 27(1), 135-154.
- Pratto, Felicia, and Oliver P. John. (1991) "Automatic Vigilance: The Attention-grabbing Power of Negative Social Information." *Journal of Personality and Social Psychology* 61.3, 380-91.
- Posner M. I. (1980) Orienting of attention. *Quarterly Journal of Experimental Psychology*, 32:3–25.
- Sadaghiani, S., R. Scheeringa, K. Lehongre, B. Morillon, A.-L. Giraud, and A. (2010) Kleinschmidt. "Intrinsic Connectivity Networks, Alpha Oscillations, and Tonic Alertness: A Simultaneous Electroencephalography/Functional Magnetic Resonance Imaging Study." *Journal of Neuroscience* 30.30: 10243-0250.
- Schmader, T. (2002). Gender identification moderates stereotype threat effects on women's math performance. *Journal of Experimental Social Psychology*, 38(2), 194-201.
- Sergent, C., Baillet, S., Dehaene, S. (2005). Timing of the brain events underlying access to consciousness during the attentional blink. *Nature Neuroscience*, 2/15/13-1-10. doi:10.1038/nn1549
- Shapiro, K. L., Raymond, J. E., & Arnell, K. M. (1997). The attentional blink. *Trends in Cognitive Sciences*, 1(8), 291-296.
- Spencer, S. J., Steele, C. M., & Quinn, D. M. (1999). Stereotype threat and women's math performance. *Journal of Experimental Social Psychology*, 35(1), 4-28.
- Ståhl, Tomas, Colette Van Laar, and Naomi Ellemers. "The Role of Prevention Focus under Stereotype Threat: Initial Cognitive Mobilization Is Followed by Depletion." *Journal of Personality and Social Psychology* 102.6 (2012): 1239-251. Print.
- Stangor, C., Carr, C., & Kiang, L. (1998). Activating stereotypes undermines task performance expectations. *Journal of Personality and Social Psychology*, 75(5), 1191.

- Steele, C. M., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African Americans. *Journal of Personality and Social Psychology*, 69(5), 797.
- Trawalter, Sophie, Andrew R. Todd, Abigail A. Baird, and Jennifer A. Richeson. "Attending to Threat: Race-based Patterns of Selective Attention." *Journal of Experimental Social Psychology* 44.5 (2008): 1322-327. Print.
- Wraga, M., Helt, M., Jacobs, E., & Sullivan, K. (2007). Neural basis of stereotype-induced shifts in women's mental rotation performance. *Social Cognitive and Affective Neuroscience*, 2(1), 12-19. doi:10.1093/scan/nsl041; 10.1093/scan/nsl041