RUNNING HEAD: Women STEM Aversions, Math Performance and Memories

Aversive Responses to Stereotypic STEM Images Predicts Women's Long-Term
STEM Memories and Underperformance in Math

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Abstract

31
32 Social identity and stereotype threat (ST) are situational stressors that increase
33 arousal and negative affect and impair performance when women are outnumbered by
34 men. One consequence of these effects could be that women develop learned
35 aversions towards stigmatized STEM domains. Five studies tested whether stereotypic
36 STEM images (STEMIs) prompt aversive responses that predict ST-like outcomes,
37 including underperformance in ST contexts and more negative ST-oriented memories
38 over time. Using a dot-probe paradigm, Studies 1 and 2 found that women perceived
39 STEMIs as more negatively arousing compared to men, but only ST women exhibited
40 greater arousal responses to STEMIs compared to stereotypic non-STEM images
41 (NonSTEMIs) and underperformed; men in this context showed a similar arousal
42 response to STEMIs and NonSTEMIs and performed better. Study 3 replicated this
43 effect among female STEM majors and linked aversive responses to more negative
44 affect laden memories for the STEM lab experience five weeks later. Using EEG,
45 Study 4 found that enhanced processing of STEMIs presented during an attentional
46 blink task (indexed via increased communication between occipital and prefrontal
47 cortical regions) predicted underperformance on a math test among ST women but
48 marginally better performance among men. Study 5 mitigated ST underperformance
49 effects among women utilizing a dot-probe training paradigm that blunted arousal
50 responses to STEMIs; instructing men to attend to STEMIs facilitated their

51 performance. STEM aversions may thus facilitate ST-like effects, possibly defining
52 what the “threat” in ST is, however, blunting aversions can attenuate these effects
53 when women work alongside men in STEM performance situations.

54 Aversive Responses to Stereotypic STEM Images Predicts Women's Long-Term
55 STEM Memories and Underperformance in Math
56 Beginning around middle school, girls initially interested in Science,
57 Technology, Engineering, and Math (STEM) opt out of these fields at disproportionate
58 rates compared to boys (Settles, et al., 2006; Singh, Mishra, & Kim, 1998; Trower &
59 Chait, 2002). Thus, as girls/women proceed in STEM fields, they work in contexts
60 where they are outnumbered by men on a regular basis. Past research indicates that
61 such contexts prime the negative stereotype that girls/women are expected to be worse
62 at math than boys/men (Spencer, Steele, & Quinn, 1999; Inzlicht & Ben-Zeev, 2000).
63 When negative stereotypes are primed in evaluative contexts, women are likely to
64 exhibit a multitude of responses, including physiological stress and decreased working
65 memory capacity. These responses arise out of the fear that either others' perceptions,
66 or their own performance, will be construed in a manner that is consistent with the
67 negative stereotype. These experiences, collectively referred to as social identity and
68 stereotype threat (SIT and ST respectively; Murphy, Steele, & Gross, 2007; Steele &
69 Aronson, 1995), engender situations where women confirm the very stereotype they
70 are motivated to disprove (Schmader et al., 2008).
71 Although the effects of working in male-dominant contexts on women's
72 performance are clear, little research to date has examined how being placed in
73 identity threatening contexts over time, i.e., being continuously exposed to negative

74 stereotypic contexts or STEM *images* that prime the male-dominant nature of these
75 contexts, may prompt psychological and physiological responses that help perpetuate
76 the negative stereotype itself. That is, facilitating performance differences between
77 men and women and engendering anxiety and feelings of inadequacy among women
78 in diagnostic STEM contexts. Such images are both representative of contexts STEM
79 identified women may find themselves in routinely and can be encountered anywhere
80 at any time in a girl/woman's daily life (e.g., posters on walls in school, or recruiting
81 pamphlets for STEM majors). STEMIs may not only convey the notion that one does
82 not belong, they may be aversive to women at a basic biological level, not unlike a
83 snake phobic might elicit an aversive response towards images of snakes. These
84 aversions may have downstream consequences on how memories in these contexts are
85 formed, as well as performance, much like any biological stressor affects these
86 processes in general.

87 The current studies utilized well-established cognitive, clinical and
88 neuroscience methodologies to assess women's aversive responses to STEMIs. We
89 posited that although men and women may both exhibit arousing responses to these
90 images (whereas men may be positively aroused by STEMIs given their positive
91 stereotypic connotations, women would find STEMIs negatively arousing or aversive),
92 this arousal response will result in ST consistent effects--negative performance
93 outcomes and negative affective memories--for women only.

94 *Identity threatening images may be aversive and undermine performance*

95 Past research suggests that subtle situational cues can signal to stigmatized
96 individuals, including women in STEM fields, that they do not belong in a domain in
97 which their group is negatively stereotyped (Inzlicht & Ben-Zeev, 2000; Murphy et
98 al., 2007; Purdie-Vaughns et al., 2008). Exposure to these cues can undermine the
99 extent to which individuals feel their group is valued, and ultimately their sense of
100 belonging in these domains. One situational cue that is a powerful prime for these
101 effects are contexts where men outnumber women. These contexts can elicit
102 physiological arousal responses, anxiety and negative affect among women (e.g.,
103 Blascovich et al., 2001; Schmader et al., 2009; Spencer et al., 1999; Keller &
104 Dauenheimer, 2003; Johns, Inzlicht, & Schmader, 2008; Forbes et al., 2018; O'Brien
105 & Crandall, 2003; Townsend et al., 2011). Given the link between cue exposure and
106 physiological arousal and anxiety, it stands to reason that male dominant STEM
107 contexts are threatening and anxiety provoking in a physiological sense.

108 To date, it is unclear why identity threatening contexts (or primes
109 representative of them) are physiologically arousing and anxiety provoking. One
110 possibility is that the physiological arousal, stress and anxiety experienced in identity
111 threatening contexts initially alters how memories for these experiences are encoded
112 and then later recalled in similar contexts to evoke congruent affective, domain-
113 specific responses over time. According to research on emotional memory encoding

114 and recall, a given emotional state experienced during time point one facilitates
115 encoding of information that is consistent with that emotional state (for a review see
116 LaBar & Cabeza, 2006). These memories tend to be more vivid and enduring
117 compared to memories devoid of emotion (Canli, Zhao, Brewer, Gabrieli, & Cahill,
118 2000; Hamann, Ely, Grafton, & Klits, 1999). They also can be spontaneously recalled
119 in contexts that evoke similar emotions and can prompt the re-experience of a given
120 emotion, possibly outside the conscious awareness of an individual (Smith, Henson,
121 Rugg, & Dolan, 2005; Smith, Stephan, Rugg, & Dolan, 2006).

122 Importantly, evidence for emotional memory processes have been found in ST
123 contexts. Women placed in ST contexts exhibited dramatic fluctuations in amygdala
124 activity, considered the harbinger for emotional memory encoding processes, in
125 response to stereotype consistent information received throughout a supposed
126 diagnostic math test (Forbes et al., 2018). Importantly, amygdala activity indirectly
127 predicted emotion-memory based encoding of negative (but not positive) information,
128 and ultimately decreased perceptions of ability in the math domain. To the extent
129 women in ST contexts exhibit biased encoding of negative stereotype consistent
130 information, if similar affective states or contextual cues can prime recall of these
131 memories on a continual basis (strengthening them over time in the process; Alberini
132 & LeDoux, 2013; Nadel, Hupback, Gomez, & Newman-Smith, 2012), it's possible

133 that identity threatening contexts (or images or cues of identity-threatening contexts)
134 could ultimately engender ST like symptoms spontaneously and unconsciously.

135 If ST contexts, and possibly images representative of them, trigger negative
136 affect and arousal via spontaneous recall of negative past experiences in stereotyped
137 domains, consistent with basic associative learning processes, negative affect and
138 arousal may become associated with these contexts over time. Thus, when individuals
139 are cued with either identity threatening contexts, or the images representative of
140 them, learned aversive responses may be primed that stem from the recall of domain-
141 congruent negative affective memories, in addition to a learned affective response.

142 These responses could then undermine performance, elicit negative affect, and
143 memories of future experiences much like any biological stressor interferes with
144 performance, executive function, or biases encoding processes (Schmader et al., 2008;
145 Forbes et al., 2018; Shields, Sazma, & Yonelinas, 2016; Beilock, 2008). That is, a
146 possible deleterious cycle is established where initial stress and underperformance in
147 stereotyped domains biases memories for that experience. These biased memories
148 beget negative affect and underperformance in similar contexts in the future, leading
149 to learned aversions over time that compromise performance, affect, and experiences
150 in and of themselves. SIT contexts may render stereotyped images indicative of these
151 contexts aversive to the stigmatized given the likelihood that these contexts facilitate
152 spontaneous retrieval of negative domain memories and learned associations. To test

153 this idea, the primary goal of the current studies was to examine the link between
154 measures utilized to gauge aversive responses to images and negative affective
155 memory recall and performance in ST contexts.

156 *Overview of Studies and Hypotheses*

157 Five studies bridge cognitive, clinical, and neuroscience methodologies to test
158 the primary hypothesis that STEMIs are aversive to women in SIT contexts, and
159 STEM aversions contribute to more general negative affective recall and
160 underperformance in ST contexts. Studies 1 and 2 utilized a well-studied measure in
161 clinical, social and cognitive research, the dot-probe paradigm, to establish that
162 arousal-like responses were unique to STEMIs (images containing only men in
163 stereotypical STEM settings like chemistry labs) and ST contexts. Study 3 sought to
164 establish an initial link between STEM aversion and symptoms typically exhibited by
165 the stigmatized in ST contexts in male and female STEM majors over time. Study 4
166 assessed how STEMIs were processed in brain regions integral for attending to
167 arousing stimuli on the order of milliseconds. Using these methods, we attempted to
168 establish another link between STEM aversion and traditional underperformance
169 effects normally found in ST contexts. Finally, drawing from clinical research that
170 demonstrates how blunting responses to aversive stimuli can curtail anxiety-provoking
171 consequences of exposure to phobic exemplars (Bar-Haim, 2010; Reese et al., 2010),
172 in Study 5, we manipulated the mediator, i.e., arousal responses to STEMIs, and

173 hypothesized that training women to “blunt” their aversive response to STEMIs would
174 attenuate ST effects.

175 Study 1

176 In Study 1, men and women were brought to a lab setting and were randomly
177 assigned to either a “diagnostic math test” (DMT; i.e., a ST context for women) or a
178 “problem solving task” (PST; i.e., a stereotype neutral context for women) condition.
179 Participants were then asked to complete an adaptive math task that varied in difficulty
180 and length followed by a dot probe task containing STEMIs and NonSTEMIs.

181 The dot probe task was used given its well established link to arousal and
182 aversion as indexed via attentional bias towards stimuli of interest. Aversive responses
183 to visual cues (threatening compared to non-threatening) has been widely studied in
184 clinical and social psychology. This work consistently demonstrates that anxiety and
185 fear promote vigilance for threat-relevant stimuli which results in faster reaction times
186 to these stimuli (e.g., Bradley, Mogg, Falla, & Hamilton, 1998; Bradley, Mogg, &
187 Miller, 2000; Maclean, Mathew, & Tata, 1986; Mogg & Bradley, 1999a, 1999b).
188 Similar anxiety-related attentional biases have been found in ST contexts via a dot-
189 probe paradigm (Johns, Inzlicht and Schmader, 2008). Thus, the dot probe task
190 provides an ideal means to measure the extent to which women may find identity-
191 threatening images related to STEM contexts as aversive (i.e., as a function of the
192 attentional bias exhibited towards these images). However, to provide further support

193 that this attentional bias was negative in nature for women but not men, after the dot-
194 probe task, individuals rated STEMI and NonSTEMI pictures with regards to how
195 positively or negatively arousing women or men in general might find the situations
196 depicted in the images.

197 Study 1 sought to address two key questions: 1) whether STEMIs evoke an
198 arousal response that is unique to diagnostic math test (ST) contexts and gender (i.e.,
199 stereotyped threatened women). 2) If the arousal response is evident in both men and
200 women in diagnostic math contexts (which are conceivably threatening for women but
201 positively arousing for men), does this arousal response differ as a function of gender,
202 i.e., is it positive for men and negative for women? We hypothesized that STEMI
203 primes would be more arousing to women in DMT contexts (elicit faster reaction
204 times on the dot probe task) compared to NonSTEMIs and women in PST contexts,
205 but men in DMT contexts may find these primes arousing as well. However, women
206 should explicitly perceive STEMIs as more negatively arousing than men in general.

207 Study 1 Methods

208 All studies reported in this paper focused largely on Caucasian men and women
209 who have knowledge of a specific math stereotype (that men are better at math than
210 women). The reason for this is twofold. 1) Individuals may not be influenced by the
211 stereotype if they have no knowledge of it (McKown & Weinstein, 2003; Muzzatti &
212 Agnoli, 2007; Schmader, Johns, & Barquissau, 2004; Keifer & Sekaqueptewa, 2007).

213 2) Past research suggests that stigmatized minorities are susceptible to both math and
214 intelligence-based stereotypes (Steele & Aronson, 1995; Beasley & Fischer, 2012;
215 Gonzales, Blanton, & Williams, 2002). Given that ST and SIT can be primed in
216 situations where minority individuals are outnumbered by ethnic majority members
217 (aka “solo status” situations; Inzlicht & Ben-Zeev, 2000; Marx & Goff, 2005;
218 Sekaquaptewa & Thompson, 2003), or possibly by the STEMIs and NonSTEMIs used
219 across studies (which also controlled for gender and ethnicity of targets), and the vast
220 majority of students at the university where studies were conducted were Caucasian,
221 there was a concern that confounds could arise in multiple conditions. This would be
222 particularly likely in conditions that place men in contexts where women normally
223 experience stereotype threat and women in stereotype-neutral contexts. That is, if
224 stigmatized minority men or women are placed in the “stereotype threat” or
225 “stereotype neutral/control” condition respectively, they may also underperform given
226 ethnic oriented primes present (either in the images or in the number of majority group
227 members present) whereas Caucasian men and women typically do not underperform
228 in these situations. Asian individuals also exhibit interesting and potentially
229 confounding patterns, including actually performing better in stereotype threat
230 situations if their ethnicity is primed (as would be possible if they found themselves in
231 a solo status situation or in response to STEMI primes, which was likely in these
232 studies; Shih, Pitinsky, & Ambady, 1999).

233 Given these issues, in addition to finite resources available to conduct studies,
234 the decision was made to account for these potential confounds in hopes of studying
235 the hypothesized mechanisms in as controlled a manner as possible. While this would
236 suggest that the generalizability of findings from these studies would be limited to
237 Caucasian men and women, it's important to note that a number of ST and SIT-
238 oriented mechanisms have been identified across stigmatized groups (for a review, see
239 Schmader et al., 2008). This suggests that findings among women in this study could
240 possibly be generalized to an extent to other stigmatized groups, particularly those
241 pursuing careers in STEM. Nevertheless, future research would be necessary to
242 validate that assumption in a large, diverse sample of stigmatized individuals.

243 In addition, all studies reported in this paper implemented a number of tactics to
244 maximize power and validate all measures across studies via conducting sensitivity
245 analyses, using validated stimuli and methods, and presenting stimuli and questions in
246 random order. Specifically, all studies were subject to a sensitivity analysis to ensure
247 each had the necessary number of participants to be able to detect the hypothesized
248 effect size with an alpha of .05 and power of .80. Great care was also taken to pilot-
249 test and validate all stimuli used in the tasks. First, the STEMIs and NonSTEMIs used
250 in the dot-probe and attentional blink tasks were vetted in Studies 1 and 2 for construct
251 validity (participants rated each image for valence, arousal, stress, perceived worry
252 and concern, and dominance) and were pilot tested extensively prior to conducting all

253 studies. All math feedback task problems utilized in studies 1-3 had been previously
254 pilot tested for difficulty and have been used in multiple studies (Forbes et al., 2015;
255 2018). Likewise, the problems utilized in the difficult math test used in studies 4 and 5
256 were explicitly taken from standardized GRE questions and have been utilized in
257 numerous stereotype threat studies in the past (e.g., Schmader et al., 2009; Forbes &
258 Schmader, 2010; Forbes et al., 2015). These GRE problems have been shown to
259 produce reliable stereotype threat consistent effects over time. Finally, all
260 questionnaires, problems within the math tasks, and stimuli presented during the dot-
261 probe and attentional blink tasks were selected at random. All together, we are
262 confident that the presentation order of questions, problems, or images had no effects
263 on the present results and that great efforts were taken to maximize power across
264 studies. Materials for all studies are located on the Open Science Framework:
265 <https://osf.io/54pum/>.

266 *Participants.* With this in mind, 113 Caucasian individuals participated in Study
267 1 in exchange for \$10/hour. Fifty-eight participants (37 women, 21 men) were
268 randomly assigned to the diagnostic math test (DMT) condition while 55 participants
269 (31 women, 24 men) were assigned to the problem solving task (PST) condition. All
270 participants had knowledge of the stereotype that men are better than women at math,
271 as indexed by responses of 3 or lower on a 7-point likert scale question: “Regardless
272 of what you think, what is the stereotype that people have about women and men’s

273 math ability, *in general?*” (1:men are much better than women; 2:men are somewhat
274 better; 3:men are slightly better; 4:men and women are the same; 5:women are slightly
275 better; 6:women are somewhat better; 7:women are much better than men). We aimed
276 for comparable numbers of participants in each cell and numbers consistent with past
277 research utilizing dot probe procedures (e.g., Reese et al., 2010). Our stopping rule
278 was to reach between 110-120 participants. A sensitivity analysis on G* Power
279 revealed that 113 participants would be enough to capture a medium to large size
280 effect (Cohen’s $f = .32$) with an alpha of .05 and power of .80 using four groups.

281 *Procedure.* As part of a larger study, participants were seated in their own sound-
282 dampened chamber in front of a computer screen (they were also prepped for EEG
283 recording, however, only behavioral findings are reported here in light of the primary
284 research question for this study). This study directly manipulated stereotype threat via
285 instructions and gender composition of research assistants as utilized in previous
286 laboratory studies (e.g., Forbes et al. 2015; Forbes et al., 2018). To manipulate
287 stereotype threat, participants in the DMT condition were told that they would be
288 completing an experimental math task that was diagnostic of their math intelligence.
289 After the instructions, in order to prime ST, participants were asked to indicate their
290 gender within the demographic questionnaire. Participants in the PST condition were
291 told that they would be completing an experimental problem solving task that was
292 diagnostic of the type of problem solving strategies they prefer. In addition, only

293 female research assistants were present when women completed tasks in the PST
 294 condition. Conversely, there was always a male research assistant present when
 295 women completed tasks in the DMT condition. Participants then completed an
 296 adaptive math task, a dot-probe task that measured STEM aversion/affinity, and a
 297 manipulation check. Participants were invited for a second session of the study (that
 298 took place one week after the first visit) to complete ratings on the images they were
 299 exposed to during the initial visit.

300 *Math Feedback Task.* Participants completed a 15-minute math task consisting of
 301 standard multiplication and division problems (e.g., $10 \times 20 =$) that initial pilot tests
 302 confirmed varied in degree of difficulty (easy, medium and hard, ensuring all
 303 participants would solve problems correctly and incorrectly; Forbes et al.,
 304 2018)¹. During each trial, participants were given three answer choices below each
 305 problem (A, B or C), with the answer to each problem randomly presented in one of
 306 the three answer positions on each trial. Participants had up to 16 seconds to solve

¹ It is important to note that participant performance was not of central interest in studies 1-3. Indeed, a different math task than one traditionally used to assess standard ST effects was used to satisfy requirements for a larger goal of the studies (described below). Specifically, the math task used in Studies 1-3 was much longer than typical studies used to document ST effects (e.g., Forbes et al., 2015), provided veridical feedback on a trial-by-trial basis, and contained problems that ranged in degree of difficulty (to ensure that all participants solved approximately comparable numbers of problems correctly). This is in contrast to typical math tests used in ST studies that are much shorter, do not provide feedback, and consist of homogenous levels of difficult math problems. Given that performance can actually be facilitated for easier math problems in ST contexts, and that threat effects are most pronounced on difficult math problems, hypotheses for performance were more tenuous in these studies (O'Brien & Crandall, 2003). Nevertheless, we would expect women experiencing ST to underperform in general. For reference, all correlations between performance and dot probe reaction times for all studies can be found in the supplementary results.

307 each problem, made all answer selections via a keyboard, and did not have scratch
308 paper. After each response participants received feedback for 2 seconds that indicated
309 whether their answer was wrong or correct. If participants were unable to answer a
310 problem within that time frame, they would receive negative feedback. On average
311 participants solved 53.19 problems (SD=2.90).

312 *Dot Probe Task:* The dot-probe task (e.g., Trawalter, Todd, Baird, & Richeson,
313 2008) consisted of a brief practice phase followed by a testing phase. The testing
314 phase consisted of 128 trials (64 critical trials and 64 filler trials). In each trial, a
315 crosshair was presented in the middle of the screen as a fixation point (1000ms). On
316 the critical trials, the fixation point was then replaced by one STEMI and one non-
317 STEMI presented on either side of the crosshair for 500ms. In the filler trials, two
318 STEM or two non-STEM images were presented on either side of the crosshair for
319 500ms. After 500ms a small dot appeared where one of the images was previously
320 located. The dot remained on the screen until participants responded by pressing
321 either the “9” key on the keypad when the dot was located on the right side of the
322 screen or the “1” key on the keypad when the dot was located on the left side of the
323 screen. Reaction times to identifying the location of the dot were used as our primary
324 dependent variable. The degree to which a given image type (e.g., STEMIs) is more
325 arousing is indexed by shorter reaction times elicited in response to the image that was
326 presented in the screen area prior to the dot’s appearance in comparison to the other

327 image type (e.g., NonSTEMIs). That is, more arousing images prime an attentional
328 bias that yields faster reaction times when the dot replaces that image in comparison to
329 the other image (e.g. Trawalter, Todd, Baird, & Richeson, 2008).

330 All STEMIs contained only men in STEM settings (e.g., men standing around a
331 laboratory bench wearing laboratory coats). All non-STEMIs depicted only women as
332 the focal point in stereotypic academic settings (e.g., a female professor teaching a
333 class of students). We held stereotypicality of gender in academic settings constant
334 across the sets of images. As such, we were able to rule out the possibility that images
335 that highlight where women do belong in academic settings (according to role-based
336 gender stereotypes) might also be aversive to women because they inadvertently
337 highlight their lack-of-fit in STEM settings (Eagly & Karau, 2002; Heilman, 1983;
338 2001).

339 *Manipulation Check:* Participants were asked to rate the extent to which “I am
340 concerned the researcher will judge me based on my performance on the task” via a
341 seven point Likert scale (1= “Strongly Disagree” and 7 = “Strongly Agree”;
342 Schmader, Forbes, Zhang, & Mendes, 2009).

343 *Image Rating Task:* In the second session of this study, participants rated how
344 they believed men and women would feel in the situations portrayed in the images
345 used in the dot-probe task on three separate items (‘how worried would a man/woman
346 feel about fitting in here?’, ‘do you think a man/woman would fear being perceived as

less capable in this situation?', and 'How comfortable would a man/woman feel in this situation?'). Participants answered these questions on a 1 to 7 scale, 1 indicating that a man or woman would be 'not at all worried' or 'not at all fearful', and 7 indicating that a man or woman would be 'very worried' or 'completely fearful'. For the last question, 'How comfortable would a man/woman feel in this situation', 1 indicated that a target would feel 'completely uncomfortable' and 7 indicated a target would feel 'completely comfortable' in a given situation. This item was reverse coded. Due to high inter-item reliability among the three items (female-target STEMIs $\alpha=.97$; female-target NonSTEMIs $\alpha=.94$; male-target STEMIs $\alpha=.90$; male-target NonSTEMIs $\alpha=.93$), a mean composite was calculated to index the perceived valance of arousal each participant expected men or women to experience in STEM and non-STEM settings. Higher numbers indicate perceived increased negative arousal among male or female targets in STEMIs or NonSTEMIs.

Study 1 Results

Manipulation check: This analysis did not include three participants who were unable to finish the study due to time constraints (1 PST woman, 2 PST men). To test the effects of our manipulation, a 2 (Gender: Men or Women) x 2 (Condition: DMT or PST) ANOVA was conducted on the manipulation check question. The results yielded a main effect for gender, $F(1, 106)=5.70$, $p<.02$, $\eta^2=.05$. Women in the DMT ($M=3.49$, $SD=1.81$) and PST ($M=4.10$, $SD=1.79$) conditions reported greater concern

367 that the researcher would judge them based on their performance compared to men in
368 the DMT (M=2.67, SD=1.35) and PST (M=3.23, SD=2.20) conditions. No other
369 effects were significant ($p's > .10$). This suggests evaluative concerns associated with
370 the negative math stereotype in typical ST contexts were primed in women in both
371 conditions, which perhaps is not surprising given both conditions were exposed to
372 STEMI primes immediately prior to answering this question.

373 *Math Feedback Task:* One participant was excluded from this analysis due to
374 incompleteness of the math task (1 PST woman). Because of the repeated measures
375 nature of the math feedback task, and to account for the within subject variability,
376 performance data was analyzed using Generalized Estimating Equations (GEE;
377 Ballinger, 2004; Liang & Zeger, 1986). We specified a logit model given that the
378 outcome variable is binary (correct coded 1; wrong coded 0) and an unstructured
379 working correlation matrix (Fitzmaurice, Laird, & Rotnitzky, 1993). We included the
380 main effects of condition, gender, and the two-way condition by gender interaction as
381 predictors. Analyses yielded a main effect of gender, $B = .19$ ($SE = .04$); $Wald\chi^2(1) =$
382 $23.77, p < .001$ (95% Wald LL CI = .112; UL CI = .264), indicating that for every one
383 unit increase in gender (from women, coded -1, to men, coded 1), the log odds of
384 getting the question correct increased by .19 units. In other words, men were more
385 likely to get a question correct than women in the math feedback task. No other effects
386 were significant ($p's > .97$). Consistent with the manipulation check, these findings

387 suggest that women in both conditions were exhibiting ST-consistent effects, at least
 388 with respect to overt, traditional assessments of ST.

389 *Image Rating Task:* Twenty-two participants did not complete the image rating
 390 task and thus were excluded from these analyses (8 DMT women, 6 PST women, 3
 391 DMT men, 5 PST men; one other DMT male had no male oriented STEMI ratings but
 392 was considered in the analysis as they had all other image ratings).² To determine
 393 whether there were gender differences in the perceived valence of the STEMI and
 394 NonSTEMI dot probe images a 2 (Gender: Men, Women) x 2 (Condition: DMT=0 or
 395 PST=1) x 2 (Image Type: STEMI, NonSTEMI) x 2 (Question Orientation: Male
 396 targets, Female targets) mixed factors ANOVA was conducted on participants' image
 397 arousal composite ratings. A three-way interaction between gender, image type, and
 398 question orientation ($F(1,86)=6.00$, $p<.02$, $\eta^2=.07$; Figure 1) revealed that women
 399 rated female STEMI targets as more negatively aroused than men ($p=.002$). This
 400 difference was not statistically significant in nonSTEMI images or for male targets in
 401 either image type ($p's>.53$). Both women and men rated female STEMI targets as
 402 more negatively aroused than female nonSTEMI targets ($p's<.001$) and male
 403 nonSTEMI targets as more negatively aroused than female nonSTEMI targets
 404 ($p's<.001$).

² The reduction in responses in this analysis was due to this measure being collected during a second visit where a number of participants from the first visit either did not return or did not have time to complete the rating task.

405 Overall, men and women rated STEMIs as more negatively arousing for
406 female targets compared to all other image-target combinations and male targets as
407 more positively aroused. Thus, these findings provide initial evidence that STEMIs
408 were perceived as more negatively arousing among women but more positively
409 arousing among men. Full analyses are reported in the supplementary materials.

410 *Dot Probe Task.* To assess whether self-reported arousal manifested as a
411 potential aversion for women in ST contexts, analyses were then conducted on STEMI
412 and nonSTEMI reaction times on the dot probe task. Four participants (3 women and 1
413 man in the DMT condition; $n=109$) were excluded from the following analyses due to
414 their reaction times being identified as outliers on the Grubbs test (also known as the
415 extreme studentized deviate method; Grubbs, 1969). To examine any differences in
416 the reaction times to STEMIs and NonSTEMIs, we conducted a 2 (Gender:
417 Women=0, Men=1) x 2 (Condition: DMN = 0, PST=1) x 2 (Image Type: STEM=0,
418 NonSTEM=1) mixed model analysis with repeated measures on the last variable. We
419 used multilevel modeling to account for within subject variability as participants
420 provided multiple responses for each image type. The full factorial model tested
421 participants' reaction times for STEMIs and NonSTEMIs as the level 1 predictors
422 while condition and gender were entered as level 2 predictors. Results revealed a
423 main effect for Gender, $F(1,102)=10.35$, $p<.01$, indicating that women had slower
424 reaction times to the images overall compared to men. An interaction between

425 condition and image type also emerged, $F(1,102)=5.42$, $p<.03$ (Figure 2). This
426 interaction indicated that in relation to individuals in the PST condition, those in the
427 DMT condition were faster to attend to STEMIs compared to NonSTEMIs. The three-
428 way interaction between gender, condition, and image type was not significant
429 ($p=.436$).

430 Given the main effect for gender, the interaction for condition, and our a priori
431 hypotheses, additional exploratory comparisons were conducted. Importantly, these
432 analyses revealed that for women in the DMT condition, reaction times to STEMIs
433 were faster compared to NonSTEMIs, $p<.01$. This difference was not apparent in
434 women in the PST condition or men in either condition, $p's>.14$. Differences between
435 men and women were apparent in the PST condition such that men were faster than
436 women to both STEMIs and NonSTEMIs ($p's<.01$). A marginal difference was found
437 between men and women in the DMT condition to NonSTEMIs such that men were
438 faster than women in responding to NonSTEMIs, $p=.058$, however, men in the DMT
439 condition were not faster to respond to STEMIs compared to women in the DMT
440 condition. No differences were apparent within gender for any group ($p's>.10$),
441 although women in the DMT condition were marginally faster to STEMIs compared
442 to women in the PST group $p=.10$.

443 These results suggest that compared to stereotype neutral problem-solving
444 contexts, diagnostic math test contexts that prime ability oriented math stereotypes

445 among men and women exacerbate arousal responses to stereotypic STEM primes.
446 Based on image ratings these arousal responses are likely more inherently positive for
447 men but inherently negative for women. The attentional bias women (but not men) in
448 the DMT condition elicited in response to STEMIs compared to NonSTEMIs (and
449 marginally more so than women in PST contexts) also suggests STEMI-based
450 aversion is unique among women in stereotype threatening contexts.

451 Study 1 Discussion

452 Study 1 provided initial evidence that only women in DMT contexts exhibit
453 arousal responses to STEMIs over and above NonSTEMIs, while also
454 underperforming on a difficult math test compared to men. Men performed better
455 overall compared to women but also exhibited an arousal response to STEMIs on the
456 dot probe task; this effect was not unique to STEMIs in relation to NonSTEMIs and
457 was only significant in the PST condition, however. In addition, everyone rated
458 STEMIs as more negatively arousing for women compared to men (though this effect
459 was more pronounced in women) and positively arousing for men compared to
460 women, suggesting the arousal response exhibited on the dot-probe task was more
461 likely to represent an aversive response for ST women and potentially an affinity-like
462 response for men. These findings provide initial evidence for the possibility that when
463 placed in ST contexts, the negative affect and potential spontaneous retrieval of ST
464 consistent memories and learned associations may render negative stereotypic primes

465 such as STEMIs more aversive compared to when these images are presented in
466 contexts that may prompt other, less affectively charged memories or learned
467 associations (i.e., the PST condition). Study 2 sought to identify boundary conditions
468 for results found in Study 1, specifically by examining whether negative (or positive)
469 arousal responses were specific to women (or men) viewing STEMIs or whether the
470 converse pattern would be observed when men and women viewed targets in
471 counterstereotypical STEM contexts as well.

472 Study 2

473 In addition to replicating Study 1, Study 2 sought to examine whether potential
474 STEM aversions primed by SIT contexts were specific to gender primes,
475 stereotypicality of the STEM primes, or the interaction of the two dimensions. To test
476 this, women and men were placed in DMT or PST conditions. Half of these
477 individuals completed a dot probe task consisting of stereotypical STEMIs while the
478 other half completed a dot probe task consisting of counterstereotypical STEMIs, i.e.,
479 individuals were exposed to counterstereotypic images of women in STEM contexts
480 (e.g., women in lab coats pipetting, working on math problems, etc.) and men in non-
481 STEM contexts (e.g., men teaching kindergarten children or English classes). This
482 provided a means to examine whether congruency of context prime (stereotypical vs
483 counterstereotypical STEMIs and nonSTEMIs), and the subsequent activation of
484 memories, associations and affect primed by ST contexts was necessary to engender

485 aversive responses in ST contexts. We reasoned that ST contexts prime the necessary
486 negative memories, affect, and learned associations to render STEMIs, i.e., potentially
487 threatening images congruent with these contexts, aversive (or positively arousing for
488 men). Conversely, to the extent counterstereotypic STEMIs are not perceived as
489 threatening to women (i.e., men are perceived as threatening in SIT contexts whereas
490 other women typically are not, and may in fact even be a positively arousing buffer to
491 an extent; Inzlicht & Ben-Zeev, 2000; Marx and Roman, 2002), the affective
492 memories/states experienced in SIT contexts would not be congruent with the
493 affective states evoked by these images. Thus, women should not exhibit aversive like
494 responses to counterstereotypic STEMIs in DMT contexts, however it is possible that
495 they exhibit more positively arousing responses to these images in SIT contexts
496 specifically. These patterns were not expected in stereotype neutral contexts given that
497 these contexts do not prime the necessary memories, affect and learned associations
498 that render STEMIs aversive.

499 In addition, we replaced the image ratings used in Study 1 (which measured
500 participants' perceptions of how a man or woman would typically feel in those
501 contexts) with more direct ratings of perceivers' own perceptions of image valence,
502 stressfulness and dominance. Replicating the effects of Study 1 with these more direct
503 queries would provide stronger support for our hypothesis that stereotypic STEMIs are

504 negatively arousing for women in SIT contexts whereas they might be positively
505 arousing for men.

506 Study 2 Methods

507 *Participants.* 238 individuals participated in Study 2 in exchange for partial
508 course credit. One hundred and twenty participants (stereotypical images: 33 women,
509 29 men; counterstereotypical images: 30 women, 28 men) were randomly assigned to
510 the problem solving task (PST) condition while one hundred and eighteen participants
511 (stereotypical images: 30 women, 26 men; counterstereotypical images: 34 women, 28
512 men) were assigned to the diagnostic math test (DMT) condition. All participants had
513 knowledge of the stereotype that men are better than women at math, identified via the
514 same means described in Study 1. We aimed for comparable numbers of participants
515 in each cell and numbers consistent with past research utilizing dot probe procedures
516 (e.g., Reese et al., 2010). Our stopping rule was to reach between 220-240
517 participants. A sensitivity analysis on G* Power revealed that 223 participants would
518 be sufficient to capture a medium size effect (Cohen's $f = .26$) with an alpha of .05,
519 power of .80 using eight groups.

520 *Procedure.* Participants were seated in front of a desktop computer screen.
521 This study directly manipulated stereotype threat via instructions and gender
522 composition of research assistants as utilized in previous laboratory studies (e.g.,
523 Forbes et al. 2015). DMT and PST condition instructions were identical to Study 1.

524 Different from Study 1, this study directly manipulated image stereotypicality (as a
 525 function of gender) such that participants were randomly assigned to either view
 526 stereotypical STEMIs and NonSTEMIs (i.e., men in lab coats, women in libraries) or
 527 counterstereotypical STEMIs and NonSTEMIs (i.e., women in lab coats, men in
 528 libraries). If participants were randomly selected for the stereotypical image condition
 529 they would *only* see stereotypical STEMIs and NonSTEMIs. Likewise if randomly
 530 selected for the counterstereotypical image condition participants would *only* see
 531 counterstereotypical STEMIs and NonSTEMIs. After priming ST (or not), participants
 532 completed one of these dot-probe tasks to assess stereotypical STEM aversion/affinity,
 533 followed by a math feedback task for 34 minutes. Finally, participants rated the
 534 images presented during the dot probe task for valence, arousal, and dominance and
 535 completed a manipulation check.

536 *Dot Probe Task:* The dot-probe task was identical to the one used for Study 1,
 537 with the exception being the types of images included in this study (either
 538 counterstereotypic STEMIs or stereotypic STEMIs).

539 *Math Feedback Task.* Participants completed a math feedback task that was an
 540 extended version of the task used in Study 1³. This task was 34-minutes in length and

³ In this study, participants also completed the dot probe task before completing a longer version of the math feedback task described in Study 1. Therefore, it was unclear how performance might be affected by women exposed to STEMIs in both the DMT and PST conditions. Given that subtle negative stereotypic primes have been shown to elicit stereotype threat effects in the past (Davies, Spencer, & Quinn, 2002; Oswald & Harvey, 2000), STEMI exposure could prime an identity threat (or lift)-like effect on performance, even in the absence of an overtly threatening manipulation that primes

541 consisted of the same types of problems described in Study 1. Again, math score
 542 accuracy was calculated by dividing the total number of correct responses by the total
 543 number of attempted problems.

544 *Image Ratings for Perceived Stressfulness of the Situation.* Participants rated each
 545 image for how stressful it was using the Self-Assessment Manikin (SAM) with a 9
 546 point Likert scale (Bradley & Lang, 1994; ‘If you find the presented image as being
 547 very stressful or anxiety provoking press 9, if you find the presented image as being
 548 very calm or relaxing press 1.’). Higher numbers indicated participants experienced
 549 more negative arousal towards the different types of STEMIs.

550 *Image Ratings Valence.* Participants rated how positive or negative they viewed
 551 the situations portrayed in the images used in the dot-probe task via the SAM and a 9
 552 point Likert scale (‘If you find the presented image as being very positive press 9, if
 553 you find the presented image as being very negative press 1’). Higher numbers
 554 indicate more positive valence towards the presented images.

555 *Manipulation Check:* Participants were asked to rate the extent to which “I am
 556 concerned the researcher will judge me based on my performance on the task” via a

contextually congruent memories, affective states, and learned associations. Thus, consistent with Study 1 it is possible participants in PST contexts may also exhibit evidence of stereotype threat or lift responses.

557 seven point Likert scale (1= “Strongly Disagree” and 7 = “Strongly Agree”;
 558 Schmader, Forbes, Zhang, & Mendes, 2009).

559 Study 2 Results

560 *Manipulation Check:* A 2 (Gender: Men, Women) x 2 (Task Description:
 561 DMT, PST) x 2 (Image Stereotypicality: Stereotypical, Counterstereotypical)
 562 univariate ANOVA was conducted on participants’ ratings on the manipulation check
 563 question. A main effect of gender was found, $F(1, 210) = 30.012, p < .001$, indicating
 564 that women ($M = 3.80, SD = 1.86$) were more concerned about the researcher judging
 565 them based on their task performance compared to men ($M = 2.46, SD = 1.60; p < .001$)
 566 regardless of whether they were explicitly placed in a DMT or PST context.

567 *Math Feedback Task:* Consistent with Study 1, performance data was again
 568 analyzed using Generalized Estimating Equations (GEE; Ballinger, 2004; Liang &
 569 Zeger, 1986), specifying a logit model given that the outcome variable is binary
 570 (correct coded 1; wrong coded 0) and an unstructured working correlation matrix
 571 (Fitzmaurice, Laird, & Rotnitzky, 1993). We included the main effects of condition,
 572 gender, and stereotypicality in a full factorial model. Analyses yielded an interaction
 573 between gender and stereotypicality, $B = -.083 (SE = .04); Wald_{\chi^2}(1) = 5.42, p = .02$
 574 (95% Wald LL CI = $-.152$; UL CI = $-.013$). When exposed to counterstereotypical
 575 STEMIs, women underperformed in comparison to men ($p < .01$). Men on the other

576 hand underperformed when exposed to stereotypical STEMIs in comparison to when
577 they were exposed to counterstereotypical STEMIs ($p < .01$).

578 *Image Rating Analyses.* The following analyses excluded 17 individuals (3 PS
579 men and 2 PS women viewing stereotypical STEMIs, 3 PS men and 3 PS women
580 viewing counterstereotypical STEMIs, 4 DM men viewing stereotypical STEMIs, 1
581 DM man and 1 DM woman viewing counterstereotypical STEMIs) who did not
582 complete the image rating task at the end of the study due to time constraints.
583 Participants rated each image presented during the dot-probe task on arousal and
584 valence. For each measure a 2 (Gender: Men, Women) x 2 (Task Description: DMT,
585 PST) x 2 (Image Stereotypicality: Stereotypical, Counterstereotypical) x 2 (Image
586 Type: STEMI, nonSTEMI) mixed factors ANOVA with repeated measures on the last
587 variable was conducted. Key findings are reported below. Full analyses are reported in
588 the supplementary methods and results.

589 *Perceived Stressfulness of the Situation Ratings.* Analyses revealed a main
590 effect for image type, $F(1, 211) = 8.886, p < .01, d = .40$, indicating that participants
591 rated STEMIs as more stressful than nonSTEMIs. An interaction between image type
592 and image stereotypicality was also evident, $F(1, 211) = 3.928, p < .05, d = .27$,
593 indicating that stereotypical STEMIs were rated as more stressful than stereotypical
594 nonSTEMIs ($p = .001$). No other effects were observed, including those specific to
595 counterstereotypical STEMIs (p 's $> .15$; Figure 3).

596 *Valence Ratings.* As hypothesized, results revealed a significant interaction
 597 between image type, image stereotypicality, and gender, $F(1, 211) = 15.330, p < .001,$
 598 $d = .53$. Simple effect contrasts using a bonferroni adjustment to control for multiple
 599 comparisons revealed that women found stereotypical STEMIs more negatively
 600 arousing than stereotypical nonSTEMIs ($p < .01$), consistent with Study 1. The opposite
 601 pattern was observed for women with respect to counterstereotypical images; women
 602 rated counterstereotypical STEMIs as being more positive than counterstereotypical
 603 nonSTEMIs ($p < .001$). In addition, both men and women rated stereotypical
 604 nonSTEMIs as more positive than counterstereotypical nonSTEMIs ($p's < .03$). Cross-
 605 gender differences in ratings were also observed in two conditions; women rated
 606 stereotypical nonSTEMIs and counterstereotypical STEMIs (i.e., pictures including
 607 women in STEM or non-STEM contexts) as more positive than men ($p's < .03$; Figure
 608 4).

609 *Dot Probe Task.* 15 participants were identified as outliers via Grubbs test
 610 conducted on dot-probe reaction times and were excluded from these analyses (i.e.,
 611 these individuals had Z scores greater than 3.5 SDs from the grand mean ($p < .05$) of all
 612 dot-probe reaction times; 2 PST men and 2 women viewing stereotypical STEMIs, 2
 613 PST men and 1 woman viewing counterstereotypical STEMIs, 1 DMT man and 2
 614 women viewing stereotypical STEMIs, 2 DMT men and 3 women viewing
 615 counterstereotypical STEMIs). A 2 (Gender: Men, Women) x 2 (Task Description:

DMT, PST) x 2 (Image Stereotypicality: Stereotypical, Counterstereotypical) x 2 (Image Type: STEMI, nonSTEMI) mixed factors ANOVA with repeated measures on the last variable was conducted on participants' dot-probe reaction times. These analyses revealed a main effect for task description, $F(1, 202) = 14.117, p < .001, d = .52$, indicating that those in the DMT condition had faster reaction times compared to those in the PST condition. Similar to Study 1, a main effect was also found for gender, $F(1, 202) = 8.870, p < .01, d = .41$, indicating that men were faster overall on the dot probe task compared to women. A marginal interaction was found for image type and task description, $F(1, 202) = 3.61, p = .059, d = .31$). The pattern of this interaction demonstrated that participants were faster to respond to STEMIs ($M = 419.33$) compared to nonSTEMIs ($M = 427.32$) in the DMT condition, $p = .069$, whereas in the PST condition participants responded to STEMIs at similar speeds compared to nonSTEMIs, $p = .40$.

A final marginal interaction was found between image type, task description, and gender, $p < .1, d = .29$. Similar to Study 1, simple effects revealed that DMT women were the only group to have faster reaction times to both stereotypical and counterstereotypical STEMIs compared to nonSTEMIs. Considering women rated stereotypic STEMIs as more negatively arousing than counterstereotypic STEMIs, these findings suggest that while both image types may have been arousing to women, only STEMIs were likely to be perceived as aversive among women in SIT contexts

636 ($p < .05$, Figure 5). Additionally, simple effect contrasts using a bonferroni adjustment
637 to control for multiple comparisons showed that in the PST condition, men were faster
638 than women in responding to stereotypical and counterstereotypical STEMIs ($p < .02$),
639 while in the DMT condition men were faster than women in responding to
640 stereotypical and counterstereotypical nonSTEMIs ($p < .04$). No other effects were
641 significant (p 's $> .35$).

642 Study 2 Discussion

643 Study 2 yielded results consistent with Study 1, showing that only women in
644 an identity-threatening context (DMT condition) exhibited an attentional bias towards
645 STEMIs compared to NonSTEMIs. Study 2 also showed that this was true regardless
646 of the stereotypicality of the image (i.e., whether the image contained a man or woman
647 in a STEM context). Men, once again, exhibited faster reaction times to images
648 regardless of their content. While attentional bias could be driven by either positively
649 or negatively arousing images, as seen in Study 1, image ratings suggest that the
650 valence of arousal responses to STEMIs varied as a function of whether they were
651 specific to the stereotypicality of the image. When evaluating stereotypical images,
652 women (but not men) perceived stereotypical STEMIs more negatively than
653 stereotypical nonSTEMIs, replicating Study 1. However, when viewing
654 counterstereotypical images, women (unlike men) perceived STEMIs as more positive
655 than nonSTEMIs. Taken together, these findings at least initially suggest that the

656 arousal effect observed in the dot-probe task (i.e., vigilance for STEMIs compared to
657 nonSTEMIs) might be representative of an aversive response for women when
658 viewing stereotypical images but a positive arousal response when women were
659 exposed to counterstereotypical images, which would be consistent with past work
660 that demonstrates the positive buffering effects that female STEM role models have on
661 women's performance in ST contexts (e.g., Marx & Roman, 2002). While the
662 alternative interpretation could also be true, i.e., that women exhibited an aversion to
663 both stereotypic and counterstereotypic STEMIs, this would not be consistent with
664 explicit image ratings and, rather, would suggest a fundamental disconnect between
665 more implicit, reaction time-based and explicit self-report processes.

666 Study 3

667 Findings from Studies 1 and 2 provide evidence for the existence of learned
668 STEM aversions that may be activated in SIT contexts, rendering images synonymous
669 with these contexts as threatening or aversive in and of themselves. These aversions
670 presumably stem from initial stressful experiences in negatively stereotyped domains,
671 possibly via a deleterious cycle where initial stress and underperformance in
672 stereotyped domains biases memories for that experience, which begets negative affect
673 and underperformance in similar contexts in the future. More frequent negative affect
674 and underperformance catalyzes learned aversions over time that compromise
675 performance, affect and experiences in and of themselves. This is consistent with past

676 research indicating that when individuals are placed in negative mood states and then
677 asked to recall past autobiographical memories, they tend to both recall more negative
678 past memories and remember past events as being more negative than they might have
679 actually been (Bower, 1981; Lewis & Critchley, 2003; Miranda & Kihlstrom, 2005). If
680 true, it's possible learned aversions and negative memories forged in these domains
681 intensify over time as experiences and possible failures are compounded on one
682 another. The tenets of the aversive response, initial negative memories, coupled with
683 nascent or pre-existing learned aversions, could ultimately bias new experiences in the
684 domain to be more intensely negative over time. Thus, in addition to basic aversion
685 effects for STEMIs, in this study we examined the consequences of STEMi aversion
686 on women's emotional memories regarding an initial STEM-related performance over
687 time. We also predicted that greater aversive response to STEMIs at time 1 should
688 predict the extent to which women recall negative emotional memories regarding their
689 experience in a STEM-related context at time 2.

690 Study 3 examined this possibility in a group that is both intimately identified
691 with STEM domains and likely to find themselves in SIT contexts more regularly (and
692 thus are more likely to have pre-existing STEM aversions): a group of male and
693 female STEM majors who specialize in fields where women are largely
694 underrepresented.

695 Study 3 Methods

696 *Participants.* As part of a larger study, 107 STEM⁴ majors (60 Women) visited
697 the lab multiple times over the course of an academic year in exchange for \$10/hour.
698 With few exceptions, visits 1 and 2 were 5 weeks apart (but never less than 5 weeks).
699 All participants were assigned to a diagnostic math test (DMT) condition. All
700 participants had knowledge of the stereotype that men are better than women at math,
701 identified via the same means described in previous studies. We aimed for comparable
702 numbers of participants in each cell and numbers consistent with past research
703 utilizing dot probe procedures (e.g., Reese et al., 2010). Three women and 1 man were
704 identified as outliers on STEMI or NonSTEMI reaction times on the dot probe task via
705 Grubbs test; 1 man was identified as an outlier on the visit 2 memory variables. These
706 participants were excluded from all analyses. A sensitivity analysis conducted for the
707 analysis of the main question of interest (the effect of STEM aversions on negative
708 affective memory recall) revealed that our sample size would be enough to capture a
709 small size effect (Cohen's $f = .11$) with an alpha of .05, power of .80.

710 *Visit 1 Procedure.* Participants were seated in their own sound-dampened
711 chamber in front of a computer screen and prepped for EEG recording. Stereotype
712 threat was then induced via instructions and gender composition of research assistants
713 as in Study 1. Participants then completed the same math feedback task described in

⁴ STEM majors were comprised of engineering (all facets), applied mathematics, chemistry, physics, biological sciences, cognitive science and quantitative biology. All majors were classified as STEM majors by the University of Delaware at the time of the study.

714 Study 2 for 34 minutes. After completing the math test participants were prompted to
715 write for five minutes about the thoughts and feelings they were experiencing during
716 the math task. Finally, participants completed a dot-probe task and manipulation check
717 and were compensated for their participation.

718 *Math Feedback Task.* Participants completed the same math feedback task
719 described in Study 2. Again, math score accuracy was calculated by dividing the total
720 number of correct responses by the total number of attempted problems.

721 *Autobiographical memory encoding:* After the math test, participants were
722 prompted to write for 5 minutes (via typing their responses out on the computer) about
723 the thoughts and feelings they were experiencing during the math test. Specifically,
724 they were told "Take a moment to think back to the SAT-like math intelligence test
725 you completed earlier today. Please list all the thoughts you experienced during that
726 math intelligence test. This could include feelings, thoughts of past similar
727 experiences, or even things that were occurring in your life at that moment. Please be
728 specific." These text descriptions were then coded for anxiety, negative, and positive
729 affect using Linguistic Inquiry and Word Count (LIWC; Pennebaker et al., 2001). This
730 constituted a baseline measure of the potential memories participants encoded while
731 performing in a SIT context (for women); i.e., the thoughts and memories they
732 harbored as they left their first visit. Higher numbers represented greater frequencies
733 of emotionally relevant words from each category.

734 *Dot Probe Task:* The dot-probe task was the same as that used in Study 1.

735 *Manipulation Check:* The manipulation check question was the same as
736 previous studies.

737 *Visit 2 Procedure:* 74 participants (42 women) returned to the lab for visit 2
738 (time 2) five weeks after their first visit. Participants were again seated in their own
739 sound-dampened chamber in front of a computer screen and prepped for EEG
740 recording. All participants were then told that they would be completing another series
741 of tests designed to measure their math intelligence, i.e., women were placed in a ST
742 context that mirrored visit 1. Participants were then asked to freely recall their
743 thoughts and feelings about visit 1 (time 1) in addition to answering manipulation
744 check questions. They then completed other tasks as part of a larger study, were
745 thanked and debriefed.

746 *Autobiographical Memory Recall:* Participants were asked to provide an
747 autobiographical recount of visit 1. Participants were asked to type for five minutes on
748 a computer about the thoughts and feelings they recall about their *past* visit (time 1),
749 describing memories in as much detail as they could. Specifically, they were told
750 "Take a moment to think back to the SAT-like math intelligence test you completed
751 last visit. Please list all of the thoughts you experienced during that math intelligence
752 test. This could include feelings, thoughts of past similar experiences, or even things
753 that were occurring in your life at that moment. Please be specific." These text

774 coded 1), the log odds of getting the question correct decreased by .598 units. In other
775 words, men were more likely than women to get a question correct on the math
776 feedback task. Thus, consistent with previous studies, these findings suggest that
777 women were exhibiting ST-consistent effects.

778 *Dot Probe Task.* A 2 (Gender: Men or Women) x 2 (Image Type: STEMI or
779 NonSTEMI) mixed factors ANOVA with repeated measures on the latter variable was
780 conducted on reaction times for STEMIs and NonSTEMIs at time 1. Replicating the
781 previous studies, this analysis yielded a main effect indicating both men and women
782 were faster to respond to STEMIs ($M=391.82$, $SD=57.4$) compared to NonSTEMIs
783 ($M=399.41$, $SD=68.62$), $F(1, 101)=6.57$, $p<.02$, $d=.50$. There was also a main effect
784 for gender indicating that men were faster overall to detect dots compared to women,
785 $F(1, 101)=4.94$, $p<.03$, $d=.44$. The interaction was not significant ($p=.36$), suggesting
786 that women were driving the main effect found between image type. Again replicating
787 previous studies, simple effect analyses using a bonferroni adjustment to control for
788 multiple comparisons found that only ST women exhibited a bias between image types
789 as they were faster to respond to STEMIs ($M=402.55$, $SD=55.21$) compared to
790 NonSTEMIs ($M=412.50$, $SD=66.13$), $F(1, 100)=6.75$, $p<.02$, $d=.52$, on the dot probe
791 task. Men, however, did not exhibit a bias towards STEMIs ($M=378.53$, $SD=57.99$)
792 compared to NonSTEMIs ($M=383.20$, $SD=68.89$; $p=.27$; Figure 6). Thus, consistent

793 with Studies 1 and 2, women once again revealed a unique bias towards negative
794 stereotypic images in ST contexts.

795 *Basic LIWC analyses (time 1 and time 2).* To test for basic differences in
796 positive or negative memory encoding (at time 1) and subsequent recall (at time 2)
797 between men and women, a 2 (Gender: Men or Women) by 2 (Valence reported:
798 Positive or Negative) by 2 (time: time 1 or time 2) mixed factors ANOVA was
799 conducted on LIWC values for positive or negative affective words reported by
800 participants during memory encoding and recall. These analyses yielded a main effect
801 for valence reported indicating that participants overall reported more negative
802 affective words compared to positive affective words, $F(1, 70)=15.43, p<.001, d=.95$.
803 No other effects reached significance ($p's>.14$). Simple effect analyses using a
804 bonferroni adjustment to control for multiple comparisons found that both men, $F(1,$
805 $70)=5.78, p<.02, d=.58$, and women, $F(1, 70)=5.84, p<.02, d=.59$, reported greater
806 negative affect ($M_{Women}=4.46, SD_{Women}=3.33; M_{Men}=5.18, SD_{Men}=8.50$) compared to
807 positive affect ($M_{Women}=1.91, SD_{Women}=2.24; M_{Men}=2.18, SD_{Men}=1.94$) immediately
808 after the difficult math task at time 1. However, only women reported more negative
809 affect ($M=5.25, SD=4.51$) compared to positive affect ($M=2.50, SD=2.89$) during
810 recall of time 1 at time 2, $F(1, 70)=10.60, p<.01, d=.79$. Men did not exhibit this bias
811 towards negative affective memory recall ($M=3.80, SD=3.26$) compared to positive

812 affective recall ($M=2.55$, $SD=2.99$) at time 2 ($p=.22$). No other comparisons reached
 813 significance ($p's > .15^5$).

814 *The effect of STEM Aversions on Negative Affective Memory Recall.* To
 815 determine whether there was a link between STEM aversions (STEMI reaction times
 816 on the dot probe task) exhibited at time 1 and negative affective recall exhibited over
 817 five weeks later, moderated regression analyses were conducted. We tested for
 818 moderation by deriving unstandardized regression coefficients and 95% bias-corrected
 819 confidence intervals (CIs) from 5,000 bootstrap estimates (Hayes, 2013; model 1).
 820 95% CIs are considered significant if the interval (e.g., [.5, .9]) does not contain zero
 821 (Cumming, 2008). In separate models for negative and positive affective recall at time
 822 2 and STEMI and NonSTEMI reaction times, STEMI or NonSTEMI RTs were
 823 entered as a predictor in all models and mean-centered Gender (women=0, men=1)
 824 was entered as a moderator predicting positive or negative affective LIWC scores at
 825 time 2. To account for the basic memory differences between men and women
 826 described above, all models included positive or negative affective LIWC scores at
 827 time 1 as a covariate when appropriate (e.g., when assessing LIWC negative affective
 828 scores at time 2, LIWC negative affective scores at time 1 were entered as a
 829 covariate).

⁵ There was a marginal effect for gender in the analysis including NonSTEMI RTs predicting negative affective recall but this effect reflected the general tendency for participants to report greater negative affect in general.

850 highlight a more insidious role of STEM aversion, suggesting it may play a role in
851 biasing, and potentially exacerbating the encoding and subsequent recall of negative
852 STEM memories in future identity threatening STEM contexts. Specifically, only
853 female STEM majors exhibited a relationship between STEM aversion exhibited at
854 time 1, and more negative affective STEM memories reported at time 2. This provides
855 some evidence for a vicious cycle where pre-existing STEM aversion biases
856 individuals towards encoding more negative aspects of a STEM experience. These
857 memories are then spontaneously recalled in similar future contexts to beget more
858 negative affective experiences in ST contexts, perhaps not unlike what individuals
859 tend to report in SIT contexts in general. Given that negative affect has been linked to
860 decreases in performance in SIT contexts in general (e.g., Cadinu et al., 2005; Forbes
861 et al., 2015), we might also expect a link between STEM aversion and
862 underperformance on standardized measures of math ability among the stigmatized.
863 Study 4 probed for evidence of this relationship by examining how brain regions
864 integral for identification of aversive stimuli process STEMIs on the order of
865 milliseconds, and examining what role, if any, this neural response played in women's
866 performance in ST contexts, and on a more traditional math task utilized in ST studies
867 specifically.

868 Study 4

869 Studies 4 and 5 sought to expand upon evidence from Study 3 by examining
870 whether STEM aversion plays a role in another standard identity threat outcome: the
871 underperformance of women compared to men on difficult math tasks. In Study 4 we
872 sought converging evidence for the existence of STEM aversions by examining neural
873 activity in regions integral for arousal and threat detection on-line, while women were
874 exposed to STEMIs, in ST contexts. Furthermore, we used a different, well established
875 task from cognitive psychology known to assess the extent to which stimuli are
876 deemed threatening or arousing to individuals-the attentional blink/emotion induced
877 blindness task.

878 Specifically, all women were placed in an ST context and completed an
879 attentional blink/emotion-induced blindness task while continuous EEG activity was
880 recorded to assess neural communication between the calcarine sulcus and Inferior
881 Frontal Gyrus; two regions known to play an integral role in emotion induced
882 blindness effects (Kennedy et al., 2014). Individuals then completed a difficult math
883 test and analyses were conducted to determine whether the (neural) threat/arousal
884 response elicited by women in response to STEMIs influenced performance outcomes
885 in an ST context. Consistent with previous studies, we predicted that women would
886 exhibit a neural threat response to STEMIs compared to NonSTEMIs. Furthermore,
887 we predicted that to the extent aversion and negative affective processes taxes
888 executive function processes otherwise needed for optimal performance on difficult

889 cognitive tasks (much like any stressor tends to compromise performance on
890 cognitively intensive tasks, e.g., Shields, Sazma, & Yonelinas, 2016; Beilock, 2008),
891 the severity of this threat response would be associated with more negative
892 performance outcomes for women compared to men on a standard difficult math test
893 often used in ST studies.

894 Study 4 Methods

895 *Participants.* 61 White undergraduates were recruited and participated for
896 partial course credit. The study was a 2(gender) x 2(T1 type: STEM stereotypical)/
897 NON-STEM stereotypical) x 2 (Stimulus Onset Asynchrony or SOA length:
898 Short/Long SOA) mixed factors design with repeated measures on the latter two
899 variables. Eligible participants were right-handed, native English speakers and had no
900 disabilities that would impair performance. Of the 69 participants, 59 (32 women) are
901 included in the present analysis. Reasons for exclusion included incomplete data (2
902 men), excessive motion during EEG recording (2 men and 2 women), less than 10
903 usable epochs for data analysis in main categories of interest (2 women), and
904 statistical outliers identified via Grubb's Test (2 men). All participants had knowledge
905 of the stereotype that men are better than women at math; this was assessed in the
906 same way as the previous studies. Based on past stereotype threat EEG research,
907 which found moderate to large effects sizes both overall and in moderated regression
908 analyses (Forbes et al., 2008; Forbes et al., 2014; Forbes et al., 2015), we aimed for

909 approximately 35 subjects per cell knowing that equipment malfunction would result
910 in loss of some data. Our stopping rule was to stop collecting participants once we had
911 35 men and women in each cell. A sensitivity analysis was conducted for the main
912 analyses (the effect of phase locking on GRE performance) and showed that 59
913 participants would be enough to capture a small to medium size effect on that analysis
914 (Cohen's $f = .14$) with an alpha of .05, power of .80.

915 *Procedure.* After being screened and prepared for EEG recording, participants
916 were seated in front of a computer screen in a sound-dampened chamber, where they
917 received pre-recorded instructions, read by a male experimenter (along with written
918 instructions). All participants were placed in a diagnostic math test context as in
919 Studies 1 and 3. Participants first completed the “experimental” math task, which was
920 in actuality an RSVP task, commonly referred to as an attentional blink or emotion
921 induced blindness task. Next, participants completed the traditional math task, which
922 was a difficult math test comprised of 15 GRE questions. Continuous EEG activity
923 was recorded during these tasks. Finally, participants answered questions including
924 our manipulation check and were fully debriefed.

925 *Attentional Blink/RSVP.* The attentional blink occurs when stimuli that are
926 presented in a RSVP stream captures the attention of individuals. It has been well
927 established in the literature that as emotionally arousing stimuli hijacks attentional
928 resources, when a target image (termed T2) is presented in close approximation with

929 the image (termed T1, which in this study are the STEMIs compared to the
930 NonSTEMIs), recognition of the target image is impaired (for detailed explanations of
931 the cognitive processes underlying this effect see Chun & Potter, 1995; Raymond,
932 Shapiro, & Arnell, 1992; Smith, Most, Newsome, & Zald, 2006). Thus given that
933 arousing images are particularly attention grabbing, the degree to which T1 is aversive
934 (to women) or positively arousing (to men) can be gauged by assessing the extent to
935 which individuals fail to detect a neutral image (T2) that is presented immediately
936 after T1.

937 To determine whether exposure to STEMIs elicit basic aversive responses in
938 women, it is important to assess both behavioral outcomes in the aggregate as well as
939 responses to the images *in vivo*, or as individuals are exposed to images. This can be
940 achieved by examining activity in neural regions that have been linked to the
941 processing of aversive responses during the attentional blink task, which are readily
942 identifiable in the brain. With respect to the attentional blink task, CS is thought to
943 process the T1 image and relay that information to IFG, which serves as the bottleneck
944 that inhibits processing of T2 when it's presented temporally close to T1. Thus, more
945 aversive or attention-grabbing images should engender greater communication
946 between occipital and prefrontal cortical regions⁶.

⁶ For a more detailed rationale behind the use of these neural regions to index the attentional blink task please see the supplementary methods and results.

947 Procedures for the attentional blink task were identical to Sergeant, Baillet and
948 Dehaene (2005) with 2 primary exceptions: 1) T1 was always either a STEMI (72
949 trials) or Non-STEMI (72 trials) image, and 2) to maximize the number of blinks
950 assessed in relation to the STEMIs or NonSTEMIS, more short SOA trials (which
951 yield the expected blink effect) were included in the task compared to long SOA trials
952 (see supplementary methods or SOM for complete description of the method).
953 Participants were shown a series of 7 images in a rapid serial visual presentation
954 format for a total of 144 trials and were asked to identify whether T2 was present
955 using a scale of 0(not visible)-99(highly visible). Participants were considered to have
956 seen T2 if their rating was above the midway point on the scale. Consistent with
957 standard attentional blink paradigm analyses, only trials in which the participants
958 correctly identified T1 (indicating whether the picture contained only men or only
959 women) were included in the analysis (MacLean & Arnell, 2012). Participants
960 correctly identified T1 on 89% of the trials.

961 *Difficult Math Test:* Participants were given 5 minutes to solve 15 difficult
962 math problems taken from the GRE (Forbes & Schmader, 2010). Participants were
963 allowed to use scrap paper to help them with this task. Accuracy percentage scores
964 were calculated for each participant by taking the number of correctly answered
965 problems and dividing it by the number of problems they attempted and multiplying
966 the quotient by 100.

967 *Manipulation Check:* Participants were asked the same question used in Studies
968 1-3.

969 *EEG Recording and Data Reduction.* Continuous EEG activity was recorded
970 using an ActiveTwo head cap and the ActiveTwo BioSemi system (BioSemi,
971 Amsterdam, Netherlands). Recordings were collected from 64 Ag-AgCl scalp
972 electrodes and two electrodes located on the right and left mastoids. Two additional
973 electrodes were placed near the right eye; one was placed 2 centimeters below the
974 participant's pupil and one was placed 2 centimeters to the right of the outer canthi.
975 EEG activity was digitized with ActiView software (BioSemi) and was sampled at
976 2048Hz.

977 All analyses were conducted off-line with Brain Electromagnetic Source
978 Analysis (BESA) 5.3 software (MEGIS Software GmbH, Grafelfing, Germany). EEG
979 data were referenced offline to the original average reference for all analyses. EEG
980 signals were epoched and stimulus locked to T1 STEMIs and NonSTEMIs in the
981 attentional blink task. Epochs extended from 500ms pre-stimulus onset to 1000ms
982 post-stimulus onset. Ocular artifacts were corrected using the subspace projection
983 regression correction method in BESA (Lins, Picton, Berg, & Scherg, 1993;
984 Wallstrom, Kass, Miller, Cohn, & Fox, 2004). Epochs containing artifacts
985 (amplitude > 120 μ V, gradients > 75 μ V, low signal < .01) were identified and rejected
986 using BESA's artifact scanning tool. All participants had at least 10 accepted epochs

987 for each stimulus type (correctly identified SIT and correctly identified SIS). Average
 988 waveforms were created for each stimulus type at each electrode.

989 *Source localization and Time Frequency Analyses.* We utilized source
 990 localization and time-frequency analyses to assess neural activity in regions of
 991 interest. Phase-locking, i.e., the extent to which oscillations in two regions resonate in
 992 synchrony with one another in specific frequency bands, was calculated. One way to
 993 determine whether stimuli are perceived to be aversive is to assess whether occipital
 994 and prefrontal cortical regions phase lock with one another in response to a given
 995 stimulus. Higher phase locking values in response to a stimulus would suggest that
 996 stimulus was perceived to be more aversive or arousing in the brain. The method for
 997 this was identical to previous studies (Hanslmayr et al., 2008; Forbes & Leitner,
 998 2014; Forbes et al., 2015). See SOM for complete description of EEG analyses.

999 Study 4 Results

1000 *Manipulation check.* An independent samples T-test conducted on the
 1001 manipulation check question indicated that women reported greater concern that the
 1002 researcher will judge them based on their performance compared to men, $t(57)=2.36$,
 1003 $p=.02$ $d_{Cohen's}=.62$, ($M_{women}=4.09$, $SD=2.13$; $M_{men}=2.82$, $SD=1.72$). Thus, evaluative
 1004 concerns associated with the negative math stereotype in typical ST contexts were
 1005 successfully primed in women compared to men.

1006 *Attentional Blink Task:* To examine any differences in the attentional blink
 1007 task, we conducted a 2 (Gender) x 2 (T1 type: STEMI/NonSTEMI) x 2 (SOA length:
 1008 Short/Long SOA) mixed factors analysis with repeated measures on the latter 2
 1009 variables. We used the General Estimating Equation (GEE) procedure, a form of
 1010 multilevel modeling, given that participants provided multiple responses over time
 1011 (Liang & Zeger, 1986). Results revealed a main effect for SOA length,
 1012 $Wald_{\chi^2}(1)=18.53, p<.001$, providing evidence for the standard blink effect:
 1013 participants had fewer T2 trials correct following lag 1 T1 images ($M=63.10$,
 1014 $SE=4.22$) compared to lag 2 T1 images ($M=71.27, SE=4.01$).

1015 Furthermore there was a main effect for T1 type, $Wald_{\chi^2}(1)=6.32, p<.02$.
 1016 Participants got less T2 trials correct following STEMIs ($M=65.72, SE=4.21$)
 1017 compared to NonSTEMIs ($M=68.66, SE=3.88$). No other effects were significant
 1018 ($p's> .58$). Thus, to the extent attentional blinks reflect arousal oriented responses to
 1019 stimuli, these findings suggest that both men and women found STEMIs more
 1020 arousing in a diagnostic math test setting compared to NonSTEMIs, corroborating
 1021 results from the previous studies utilizing the dot probe task.

1022 *The effect of phase locking on GRE performance.* All standard time-frequency
 1023 analyses for power and phase locking can be found in the SOM; these analyses
 1024 provided converging evidence that overall, women elicited greater power and
 1025 communication between regions integral for threat detection in response to STEMIs

1026 compared to NonSTEMIs and men. Findings from the attentional blink task suggest
1027 that both men and women perceived STEMIs as more arousing or attention-grabbing.
1028 We next tested whether greater communication between CS and IFG differentially
1029 predicted math performance for men and women using bootstrapped moderated
1030 regression analyses (Hayes, 2012).

1031 We note that although performance on the GRE was measured repeatedly, with
1032 questions nested within participant, phase locking values were computed as a single
1033 average score representing the strength of the association between brain regions across
1034 the study. Therefore, we reasoned that it made the most conceptual sense to examine
1035 the effect of aggregate phase locking scores on aggregate accuracy scores on the math
1036 test (rather than on the likelihood that any one question was correct).

1037 Separate models were analyzed for each frequency band. Separate phase
1038 locking values were calculated for STEMI and NonSTEMIs in line with EEG
1039 analyses. Regression analyses consisting of Gender (women=0, men=1), phase locking
1040 values between CS and IFG in response to stereotypic STEM or non-STEM images
1041 (per the four frequency bands), and the 2-way interaction variable were conducted for
1042 a total of eight analyses. Specific to CS-IFG phase locking in the Beta band elicited in
1043 response to stereotypic STEM images there was a main effect for gender ($\beta=-63.55$,
1044 $SE= 31.42$, $t(55)= -2.02$, $p<.05$, $LLCI= -126.52$, $ULCI= -.58$). Consistent with basic
1045 ST effects, women underperformed on the math test in comparison to men in general.

1046 There was no main effect for phase locking ($p=.097$), but there was a gender by phase
 1047 locking interaction, $\beta=417.99$, $SE=189.28$, $t(55)=2.21$, $p<.04$, $LLCI=38.65$, $ULCI=$
 1048 797.33 .

1049 We next examined the interaction between phase locking and gender as the
 1050 simple effect of phase-locking on performance, separately for men and women.
 1051 Simple slope analyses indicated that while women tended to underperform on the
 1052 math test to the extent they elicited greater CS-IFG phase locking in response to
 1053 STEMIs ($\beta=-6.89$, $SE=4.08$, $t(55)=-1.69$, $p=.097$, $LLCI=-401.06$, $ULCI=34.18$), men
 1054 exhibited the opposite pattern (although not significant), performing better on the math
 1055 test to the extent they exhibited greater phase locking to stereotypic STEM images,
 1056 ($\beta=8.81$, $SE=5.82$, $t(55)=1.51$, $p=.14$, $LLCI=-76.15$, $ULCI=545.26$).

1057 Finally, we examined the interaction of the simple effect of gender on
 1058 performance, at one standard deviation below and above the mean of phase locking.
 1059 These results revealed that women performed worse than men on the math test to the
 1060 extent they exhibited greater CS-IFG phase locking in the beta band in response to
 1061 STEMIs, $\beta=22.23$, $SE=10.51$, $t(55)=2.12$, $p<.04$, $LLCI=1.17$, $ULCI=43.28$ (Figure
 1062 8). Similar patterns were found in the theta and gamma frequency band ($p's=.12$ for
 1063 the interaction term) but not the alpha band ($p=.84$), consistent with past literature
 1064 indicating neural activity in the theta, beta and gamma band tap into similar neural
 1065 processes compared to activity in the alpha band (Klimesch et al., 2005; Lee,

1066 Whittington & Kopell 2013). No other neural variables associated with viewing
1067 STEMIs were significant predictors of performance outcomes on the math test $p's > .2$,
1068 nor were there any relationships between neural variables associated with viewing
1069 NonSTEMIs and performance outcomes on the math test, $p's > .3$.

1070 Study 4 Discussion

1071 Results from Study 4 provided further evidence, this time neurally and with a
1072 different, well-vetted measure of attentional capture/arousal, that women perceive
1073 STEMIs to be more arousing, and perhaps aversive, than NonSTEMIs in ST contexts.
1074 While both men and women exhibited more attentional blinks in response to STEMIs
1075 compared to NonSTEMIs, women performed worse on the difficult GRE task to the
1076 extent they displayed greater communication between CS and IFG in response to
1077 STEMIs. Conversely men tended to perform better (though not significantly) to the
1078 extent they exhibited a comparable neural response to STEMIs. To the extent that
1079 aversion and negative affect tax cognitive/executive resources otherwise needed for
1080 optimal performance on cognitively intensive tasks, finding also suggest that learned
1081 aversions primed by ST contexts may also undermine cognitive resources needed for
1082 optimal performance on difficult math problems. Consistent with Study 3's finding
1083 that STEM aversions can predict negative affective responses in ST contexts, findings
1084 from this study provide additional evidence that learned STEM aversions can possibly
1085 engender standard ST effects, such as underperformance on difficult math tests, in-

1086 and-of-itself. This study merely provided correlational evidence for that possibility,
1087 however. Thus, a final study was conducted to determine whether directly
1088 manipulating the STEM aversive response could alter women's (and men's)
1089 performance in ST contexts, either positively or negatively as a function of whether
1090 the arousal response was attenuated or exacerbated.

1091 Study 5

1092 Study 5 sought to provide definitive evidence that arousal based responses
1093 elicited by STEMI primes differentially affects performance for women and men in
1094 DMT contexts. This would provide direct evidence that STEM aversions play a direct
1095 role in facilitating typical ST effects, or perhaps even serve as the ultimate source of
1096 typical ST effects (i.e., learned domain aversions are the "threat" in stereotype threat).
1097 We employed a well-documented experimental approach for demonstrating this effect
1098 known as manipulating the mediator (Jacoby & Sassenberg, 2011; Pirlott &
1099 MacKinnon, 2016). That is, we directly manipulated the arousal response elicited to
1100 STEMI and NonSTEMIs via a dot probe task in which men and women were
1101 instructed to either attend towards or away from STEMIs. Then women were placed in
1102 a ST context and completed a math task in the presence of men. We hypothesized that
1103 women who were instructed to attend towards STEMIs would exhibit standard ST
1104 effects and underperform compared to men in the same condition. Conversely, women
1105 instructed to attend away from STEMIs should be buffered from ST effects and

1106 perform comparably to men instructed to either attend towards or away from STEMIs.
1107 Men should exhibit the opposite patterns consistent with a stereotype lift effect.

1108 Methods

1109 *Participants.* 114 participants were selected for Study 5. Fifty-eight participants
1110 (32 women, 26 men) were randomly assigned to the “exacerbate arousal condition”
1111 while 56 participants (26 women, 30 men) were assigned to the “mitigate arousal
1112 condition”. All participants had knowledge of the stereotype that men are better than
1113 women at math and were identified via the same means described in previous studies.
1114 We aimed for comparable numbers of participants in each cell and numbers similar to
1115 past research that utilized dot probe training procedures (e.g., Reese et al., 2010). Our
1116 stopping rule was to reach between 110-120 participants. A sensitivity analysis on the
1117 gender by condition interaction (the effect of primary interest here) showed that 114
1118 participants would be enough to capture a small to medium size effect (Cohen’s $f =$
1119 .27) with an alpha of .05, power of .80.

1120 *Procedure.* Participants were brought into the lab and seated at computers four at
1121 a time. All sessions contained at least 1 female and male participant. Participants first
1122 completed a Dot Probe task that either directed attention towards (exacerbate
1123 condition) or away (mitigate condition) from STEMIs. Then, participants received
1124 instructions indicating they would be taking a math test that was diagnostic of their
1125 math intelligence. Instructions were presented on the computer screen and read aloud

1126 by a recording of a male experimenter. Following instructions, participants completed
 1127 demographic questions including being asked to indicate their gender, thus priming ST
 1128 (Steele & Aronson, 1995). Next, participants completed a difficult math test in a room
 1129 with 1 to 3 men (the same test described in Study 4). Finally, participants completed
 1130 the manipulation check and were debriefed.

1131 *Dot Probe Task:* This task was identical to the task used in Study 1 and 3 with
 1132 the exception that dependent on condition, the dot would appear either in the location
 1133 where the STEMI (exacerbate) or NonSTEMI (mitigate) image had been, directing
 1134 attention either towards or away from STEMIs accordingly.

1135 *Difficult Math Test:* This task was identical to the tests used in Study 4.

1136 *Manipulation Check:* Participants were asked the same question used in all
 1137 previous studies.

1138 Study 5 Results

1139 *Manipulation check:* To ensure our manipulation was successful ANOVA was
 1140 conducted on the manipulation check question. Results yielded no differences
 1141 between condition ($p=.35$), however, there was a main effect for gender, $F(1,110)$
 1142 $=8.60$, $p<.01$, $\eta^2=.073$ (women $M=4.33$, $SD=2.16$; men $M=3.20$, $SD=2.04$), indicating
 1143 that women were more concerned that the researcher would judge them based on their
 1144 performance on the math task compared to men. The interaction was not significant
 1145 ($p=.98$). Thus women reported the desired ST consistent response.

1146 *Difficult Math Test*: Given the repeated measures nature of the math task and
 1147 within subject variability, performance data was again analyzed using Generalized
 1148 Estimating Equations (GEE; Ballinger, 2004; Liang & Zeger, 1986), specifying a logit
 1149 model given that the outcome variable is binary (correct coded 1; wrong coded 0) and
 1150 an unstructured working correlation matrix (Fitzmaurice, Laird, & Rotnitzky, 1993).
 1151 We included the main effects of condition, gender, and the two-way condition by
 1152 gender interaction as predictors. There were no main effects of gender or condition,
 1153 p 's > .41, however, the hypothesized gender x condition interaction was found,
 1154 $\text{Wald}\chi^2(1) = 7.51, p < .01$ (95% Wald LL CI = .312; UL CI = 1.880). Breaking down
 1155 this interaction revealed that in the exacerbate arousal condition, for every one unit
 1156 increase in gender (from women, coded -1, to men, coded 1) the log odds of getting
 1157 the question correct decreased by .357 units $B = -.357 (SE = .14)$; $\text{Wald}\chi^2(1) = 6.122$,
 1158 $p = .013$ (95% Wald LL CI = -.640; UL CI = -.074). In other words, women were less
 1159 likely to get the question correct in the exacerbate arousal condition than men. This
 1160 effect was not present in the mitigate arousal condition, however ($p = .17$). For men, a
 1161 main effect of condition was also found, $B = .35 (SE = .15)$; $\text{Wald}\chi^2(1) = 5.75, p < .02$
 1162 (95% Wald LL CI = .064; UL CI = .635), indicating that for every one unit increase in
 1163 condition (from mitigate, coded -1, to exacerbate, coded 1), the log odds of getting the
 1164 question correct increased by .35 units; men were more likely to get a question correct

1165 in the exacerbate arousal condition than the mitigate arousal condition. Women did not
1166 show this relationship ($p=.15$, Figure 9).

1167 General Discussion

1168 In five studies, we utilized methods from neuroscience, cognitive, and clinical
1169 psychology to demonstrate that when coupled with ST-oriented primes, stereotypic
1170 STEMI primes evoke a basic aversive response in women that undermines
1171 performance on difficult math tasks in the moment, and intensifies negative affective
1172 memories forged in the domain over time. First, women in ST contexts exhibited an
1173 aversive-like response when viewing STEMIs (vs. nonSTEMIs) in a dot-probe
1174 paradigm (Studies 1-3); the aversive connotations of these images were confirmed via
1175 women's post-task image ratings (Studies 1 and 2). Based on Study 2, similar to men's
1176 responses to STEMIs, counterstereotypical images of women in STEM contexts
1177 appeared to be more positively arousing to women in ST contexts.

1178 Importantly, Study 3 replicated the basic STEM aversion effects found in
1179 Studies 1 and 2 among a sample of individuals most likely to chronically find
1180 themselves in contexts that elicit them: Female STEM majors. Furthermore, findings
1181 demonstrated that learned STEM aversions may bias long-term memory processes to
1182 prompt ST consistent responses like reported negative affect, in and of themselves.
1183 Study 4 provided corroborating evidence for STEM aversions among women utilizing
1184 both neural indices and a completely different behavioral task. Similar to Study 3, this

1185 study provided additional evidence that STEM aversions are associated with ST
1186 consistent effects, in this instance in the form of the classic ST performance effect..

1187 Finally, Study 5 provided evidence of a direct role for STEM aversions in
1188 performance in ST contexts. When the mediator (STEM aversion) was manipulated
1189 via blunting or exacerbating the aversive response with a variant of the dot probe task,
1190 performance differences between men and women placed in ST contexts were
1191 essentially reversed. Women who had STEM aversions attenuated tended to perform
1192 better than women who had STEM aversions exacerbated, whereas men exhibited the
1193 opposite effect. Throughout the studies there was also strong evidence that STEMIs
1194 engendered a stereotype lift effect in men; men found STEMIs to be positively
1195 arousing (as evidenced by STEM image ratings in Studies 1 and 2), and attending
1196 toward them (exacerbating the arousal response) facilitated their performance (Study
1197 5). Those findings suggest a direct role for positive stereotype-based arousal as a
1198 mechanism in stereotype lift affects, which heretofore have never been clearly
1199 understood in the literature (e.g., Walton & Cohen, 2003).

1200 Given the link between STEM aversion indices and classic ST effects like self-
1201 reported negative affect and performance, it's possible these studies elucidate a
1202 mechanism for what exactly the "threat" is in stereotype threat. In Steele's (1997)
1203 seminal work, he clearly highlighted what the "threat" stems from-the fear of
1204 confirming a negative group stereotype-but it wasn't clear exactly what the nature of

1205 the “threat” was. Findings from these studies suggest that the “threat” in stereotype
1206 threat may be a learned aversion forged in a stigmatized domain over time. That is,
1207 individuals respond to identity threatening contexts by spontaneously activating
1208 learned aversions and retrieving negative domain-specific memories. These memories,
1209 in turn, prompt increases in negative affect and tax cognitive resources that yield
1210 underperformance on cognitively intensive tasks (like difficult math tasks), suggesting
1211 learned domain aversions can serve as the impetus for, and manifestation of, the
1212 downstream symptoms normally found in ST contexts.

1213 For instance, according to Schmader et al. (2008), when ST is triggered it
1214 facilitates a cascade of physiological stress responses, negative affect and appraisal
1215 processes, and performance monitoring processes that tax working memory capacity
1216 otherwise necessary for optimal performance on cognitively intensive tasks. Schmader
1217 et al (2008) argue that the trigger for this cascade is the cognitive imbalance that
1218 results from conflicts between one’s personal identity (the extent to which they
1219 identify with a given domain), their group identity (the extent to which they identify
1220 with their stigmatized group), and the stereotype specific to their group in the given
1221 domain (the extent to which they are stigmatized in a domain). While there is some
1222 evidence that group identity, domain identity, and stereotype knowledge moderate ST
1223 effects, in addition to the model never being formally tested, it’s not entirely clear how
1224 the conflict between these dimensions would manifest at the neural or cognitive level

1225 to instantiate the symptoms found in ST contexts. We propose a different trigger and
1226 manifestation here that has clear biological and cognitive foundations. When ST
1227 contexts prime spontaneous recall of memories that evoke stress and negative affect
1228 then it's possible that the cascade of physio/stress/negative affect and appraisals *is the*
1229 *product* of spontaneous memory recall from past ST experiences and learned domain
1230 aversions. Future research would be necessary to formally test these conjectures, but at
1231 this stage there is mounting evidence for a primary role for negative oriented
1232 memories and possible domain aversions in facilitating and/or instantiating primary
1233 ST effects (Forbes et al., 2015; Forbes et al., 2018).

1234 These findings also have important implications for how ST/Social identity
1235 threatening (SIT) effects are exacerbated in everyday STEM settings. From classroom
1236 decor, industry welcome packets, to college admissions pamphlets, images similar to
1237 our STEMIs are ubiquitous in STEM settings. What types of images are women most
1238 likely to find aversive in STEM settings? Based on the nature of our stimuli, we
1239 theorize that any image of STEM settings that implicitly suggest a woman either does
1240 not belong or is not expected to succeed are potentially aversive. Such cues might not
1241 only involve images of men, but also of women engaging in stereotypical behaviors
1242 that are inconsistent with behaviors needed to succeed in STEM. Likewise, any image
1243 of women struggling or experiencing frustration in STEM contexts, even if that
1244 woman appeared highly competent, could prime negative performance-oriented STEM

1245 stereotypes and elicit aversive responses. Given that inclusivity of women in STEM is
1246 a top priority for many organizations, it is important to examine how images of
1247 women that may on the surface be positive may actually prompt aversive responses
1248 that bias behaviors necessary for success in a particular context. Moreover, although
1249 we utilized static images in the present research, dynamic cues of men and women that
1250 prime negative stereotypes could also prompt aversive responses, such as those
1251 manifested through behaviors of professors, fellow students, role models, or
1252 commercials.

1253 The primary impetus for the studies was to examine the presence and role of
1254 STEM aversions in ST contexts. However, it would also be important in future work
1255 to identify how and when exactly domain aversions affect performance (i.e., why were
1256 performance differences not always linked to domain aversions across studies).
1257 Evidence from Studies 1-3 suggests STEM aversions have more pronounced effects
1258 among women in overtly identity threatening contexts, however, even in spite of using
1259 more non-traditional math tasks across the studies there was partial support for the
1260 notion that STEMIs may subtly prime aversive responses that undermine performance
1261 and contextual perceptions even in stereotype neutral settings (e.g., in Study 1 women
1262 in general underperformed on the math task, rated STEMIs as more negatively
1263 arousing, and reported a stronger concern that the researcher expected them to perform
1264 in a negative stereotype consistent manner). These findings are consistent with past

1265 research suggesting ST can be primed implicitly or indirectly via stereotype consistent
1266 primes such as negative stereotypic commercials (Davies, Spencer, & Quinn, 2002),
1267 cartoons (Oswald & Harvey, 2000), STEM oriented videos documenting gender
1268 imbalance (Murphy et al., 2007), or simply placing women in diagnostic STEM
1269 contexts and outnumbering them with men (Inzlicht & Ben-Zeev, 2000). Nevertheless,
1270 it would be important to determine whether STEM aversions play a chronic role in
1271 biasing performance, domain perceptions and affect even in STEM contexts that
1272 appear otherwise non identity threatening for women (e.g., in women in science clubs
1273 on campus), ideally using more traditional math tests often seen in ST studies (e.g.,
1274 those used Studies 4 and 5).

1275 In sum, findings from five studies suggest that women may develop learned
1276 STEM aversions that can undermine performance and bias memory when primed in
1277 ST contexts. STEM aversions may vary in strength among women to influence
1278 performance, but they can also be directly manipulated to either exacerbate or
1279 attenuate ST effects. Future research should focus on how these aversions develop
1280 over time and how they undermine performance and domain perceptions in the
1281 absence of overt ST primes. Taken together, these findings provide a novel
1282 conceptualization and ramification of the deleterious consequences that identity
1283 threatening contexts may have on stigmatized individuals. They suggest ST contexts

1284 can instill a fear of stigmatized domains in individuals that evolve via basic neural
1285 mechanisms and processes that are largely unconscious and difficult to control.
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1484

Figures

- 1485
1486 Figure 1. STEMI arousal ratings for men and women in DMT and PST conditions.
1487 STEMIs were rated as more negatively arousing for female targets compared to all
1488 image-target combinations.
1489
- 1490 Figure 2. STEMI dot-probe reaction times. DMT contexts exacerbate arousal
1491 responses to stereotypic STEMIs.
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- 1493 Figure 3. Image ratings of perceived stressfulness. Participants rated STEMIs as more
1494 stressful than nonSTEMIs. Higher scores indicate more perceived stress.
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- 1496 Figure 4. Valence image ratings, higher scores indicate more positive affect. A) All
1497 valence ratings. B) Valence ratings for Stereotypical STEMIs (men in STEM contexts)
1498 C) Valence ratings for stereotypical nonSTEMIs (women in nonSTEM contexts) D.
1499 Valence ratings for counterstereotypical STEMIs (women in STEM contexts) E.
1500 Valence ratings for counterstereotypical nonSTEMIs (men in nonSTEM contexts).
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- 1502 Figure 5. Dot-Probe Reaction Times. A) All reaction times. B) Reaction times to
1503 Stereotypical STEMIs (men in STEM contexts) C) Reaction times to stereotypical
1504 nonSTEMIs (women in nonSTEM contexts) D. Reaction times to counterstereotypical
1505 STEMIs (women in STEM contexts) E. Reaction times to counterstereotypical
1506 nonSTEMIs (men in nonSTEM contexts).
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- 1508 Figure 6. STEMI dot-probe reaction times. DMT contexts exacerbate arousal
1509 responses to stereotypic STEMIs.
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- 1511 Figure 7. Scatter plot of LIWC negative affect score residuals at time 2 (accounting for
1512 LIWC negative affect scores at time 1) and STEMI reaction times. Female STEM
1513 majors recall more negative affective math memories associated with their first visit at
1514 time 2, five weeks after their first visit, to the extent they exhibit greater STEM
1515 aversion at time 1.
1516
- 1517 Figure 8. The effect of phase locking on GRE performance. Gender X phase locking
1518 interaction for CS-IFG phase locking in beta band; Increased phase locking to
1519 STEMIs predicted worse performance on the difficult math test for women but not
1520 men.
1521
- 1522 Figure 9. The effect of exacerbating or mitigating threat on performance. Women's
1523 performance improves in the mitigate threat condition while men's performance
1524 improves in the exacerbate threat condition.

Figure 1.

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1544 Figure 3.
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Error bars: 95% CI

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Figure 5.

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1565 Figure 6.
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Error bars: 95% CI

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