Biological Psychology 156 (2020) 107948

Contents lists available at ScienceDirect

Biological Psychology

journal homepage: www.elsevier.com/locate/biopsycho

The influence of male faces on stereotype activation among women in STEM: An ERP investigation

Deborah J. Wu[a], Jiyoung Park[b,*], Nilanjana Dasgupta[a,**]

[a] Department of Psychological and Brain Sciences, University of Massachusetts, Amherst, United States
[b] Department of Psychology, The University of Texas at Dallas, United States

ARTICLE INFO

Keywords:
Face priming
Gender stereotyping
Error-related negativity (ERN)
Science, technology, engineering, and mathematics (STEM)

ABSTRACT

Members of stereotyped groups are vigilant to situational cues signaling threats to their social identity. In one psychophysiological experiment, we examined whether mere exposure to a watching male face would increase attentional vigilance among female STEM students due to the activation of math-gender stereotypes. Male and female students performed an alleged math intelligence task while being primed with male faces or control images. Automatic responses to errors were captured with error-related negativity (ERN), a neural index of error vigilance. Women showed larger ERN upon making errors when primed with male faces compared to control images, whereas no such priming effect occurred among men. Moreover, this face priming effect was pronounced only among women highly invested in pursuing STEM careers. These findings suggest that minimalistic social cues may activate negative stereotypes early in informational processing, thereby selectively shunting attention on errors in stereotype-relevant tasks among individuals invested in the performance domain.

1. Introduction

A central theme in social psychology is that people's attitudes, beliefs, and behavior are often shaped by factors that lie outside their awareness (Banaji & Dasgupta, 1998; Bargh, 1997; Greenwald & Banaji, 1995; Nisbett & Wilson, 1977). Through immersion in an unequal society and passive observation, human minds learn that social groups are differentially associated with particular roles and attributes that vary in status and power (Dasgupta, 2013). These mental associations are called implicit or automatic stereotypes, which can be passively learned even though they may not be actively endorsed by individuals (Blair, Dasgupta, & Glaser, 2014; Dasgupta, 2004; Greenwald & Banaji, 1995). For example, with regard to gender, a large literature has documented the ubiquity of implicit gender stereotypes (for a review, see Ellemers, 2018), showing that both women and men more readily associate: (a) women with domestic roles and men with professional roles (Banaji & Hardin, 1996; Blair & Banaji, 1996); (b) women with communal traits and men with agentic traits (Asgari, Dasgupta, & Stout, 2012; Dasgupta & Asgari, 2004; Eagly & Karau, 2002; White & Gardner, 2009); and (c) women with service-oriented careers and men with careers in science, technology, engineering and mathematics or STEM (Miller, Nolla, Eagly, & Uttal, 2018; Oakhill, Garnham, & Reynolds, 2005; Stout, Dasgupta, Hunsinger, & McManus, 2011).

In particular, implicit stereotypes about gender and STEM have profound effects on girls' and women's interest, confidence, and persistence in STEM education and career pathways (Dasgupta & Stout, 2014; Dasgupta, 2011). For example, women who exhibit stronger implicit stereotypes of associating men (more than women) with STEM-oriented professions feel less confident in their ability and are less likely to be interested in STEM careers (Miller, Eagly, & Linn, 2015; Nosek, Banaji, & Greenwald, 2002; Stout et al., 2011). Notably, according to studies using large national (Wang, Eccles, & Kenny, 2013) and international samples (Stoet & Geary, 2018), women either outperform men or perform equally well in math and science; however, there continues to be a large confidence gap based on gender, likely due to the cultural prevalence of negative stereotypes that cast doubt on women's abilities and their place in STEM (Dasgupta & Stout, 2014; Dasgupta, 2011; Dar-Nimrod & Heine, 2006; Leslie, Cimpian, Meyer, & Freeland, 2015).

Due to their concern about negative gender stereotypes, women in STEM fields are highly vigilant to the effects of situational cues signaling potential identity threat. Previous research suggests that situations that

---

* Corresponding author at: Department of Psychology, The University of Texas at Dallas, Richardson, TX 75080, United States.
** Corresponding author at: Department of Psychological and Brain Sciences, University of Massachusetts, Amherst, MA, 01003, United States.
E-mail addresses: dwu@umass.edu (D.J. Wu), j.park@utdallas.edu (J. Park), dasgupta@psych.umass.edu (N. Dasgupta).

https://doi.org/10.1016/j.biopsycho.2020.107948
Received 1 February 2020; Received in revised form 16 July 2020; Accepted 17 August 2020

activate gender-STEM stereotypes hamper women's interest and motivation in STEM and increase anxiety about their performance (e.g., Beilock, Rydell, & McConnell, 2007; Cheryan, Plaut, Davies, & Steele, 2009; Dasgupta, Scircle, & Hunsinger, 2015; Murphy, Steele, & Gross, 2007). For example, in one study, when women were explicitly told that men were better at math, they performed worse than men on a math test, whereas in the absence of this explicit statement, women and men performed equally well (Beilock et al., 2007). Additional evidence suggests that stereotype-eliciting cues do not need to be explicit. When exposed to computer science classroom environments containing stereotypically masculine cues (e.g., videogames, Star-Trek posters), women reported decreased interest in computer science than when they were exposed to classrooms with gender-neutral cues (e.g., nature posters; Cheryan et al., 2009). Other situational cues, such as exposure to work teams and conferences populated by mostly men, also increased women's anxiety while decreasing their interest in pursuing STEM (Dasgupta et al., 2015; Murphy et al., 2007).

Collectively, these findings suggest that when women are immersed in STEM-relevant situations, the presence of situational cues signaling male dominance activates gender stereotypes. Notably, these studies show how immersion in gender stereotypic situations influence women's reactions to stereotypically masculine cues slowly over time, which likely involve conscious and deliberate processing of stereotypic cues. The present research complements prior research by examining whether the split-second activation of gender stereotypes impacts women's reactions at an earlier stage of information processing, when conscious processing is not possible. To do so, we utilized neurophysiological measures (electroencephalogram or EEG) to shed light on automatic modulation of error responses during STEM-relevant performance tasks, well before one's thoughts can be consciously articulated.

Previous research examining implicit gender stereotyping using EEG has mainly focused on how people process gender stereotypic and counterstereotypic language (e.g., Pesciarelli, Scorolli, & Cacciari, 2019; Proverbio, Alberio, & De Benedetto, 2018; White, Crites, Taylor, & Corral, 2009). These studies found that reading counterstereotypic language (e.g., the engineer stained *her* skirt) elicits greater neurological reactivity on specific event-related brain potentials (ERP; P300, N400, and P600) as compared to stereotypic language, suggesting a surprise response. The present research aims to address a different question which has not yet been examined—i.e., whether the subtle activation of gender stereotypes signaling male dominance in STEM would elicit increased neurological reactivity during a STEM-relevant task, especially when women make task-related errors that are stereotype-consistent. Specifically, we examined whether incidental exposure to a watching male face during a math intelligence task, a social cue signaling male dominance in STEM, would modulate women's attentional vigilance to errors captured by neurophysiological signals.

Previous studies suggest that the mere presence of watching eyes can modulate social behaviors and associated neural responses by automatically evoking a concern about potential negative social evaluations (Haley & Fessler, 2005; Hitokoto, Glazer, & Kitayama, 2016; Park & Kitayama, 2014; Rigdon, Ishii, Watabe, & Kitayama, 2009). For example, Park and Kitayama (2014) presented an image of a watching face (or a control image) as a priming stimulus on some trials during a flanker task while monitoring participants' brain activities using EEG. After participants made errors following the face (vs. control) primes, they showed increased attentional vigilance to their errors, indexed by the enhanced magnitude of error-related negativity (ERN), an ERP component of error processing (Gehring, Goss, Coles, Meyer, & Donchin, 1993). Moreover, this face priming effect was only evident among East Asians, but not among European Americans, consistent with the view that the former group is more interdependent, and thus, more vigilant to errors following subtle social cues implying potential social evaluations.

1.1. *Overview of the present research*

Building on past evidence, the present research examined whether a watching *male* face would evoke attentional vigilance to errors among women invested in STEM, insofar as this image could be interpreted as the evaluative presence of a high-status person in the male-dominated STEM context, and thus, activate math-gender stereotypes in a math test-taking situation. Our first aim was to test this hypothesis using a modified paradigm from Park and Kitayama (2014), in which male and female college students performed an alleged math intelligence task while being exposed to an image of a watching male face as a priming stimulus on some trials. We hypothesized that women would show greater attentional vigilance to their errors when these errors were preceded by male face primes (compared to scrambled faces as control primes).

The degree to which male face priming evoked attentional vigilance to errors was assessed with the ERN, a neural index of early, automatic detection of errors during a speeded reaction time task (e.g., Amodio et al., 2004; Botvinick, Cohen, & Carter, 2004; Carter et al., 1998; Danielmeier, Wessel, Steinhauser, & Ullsperger, 2009). The ERN is characterized by a negative deflection peaking 50−100 ms following error commission at fronto-central electrode sites. Prior research suggests that the ERN may serve as an index of attentional vigilance to errors made in stereotypic domains (Forbes, Schmader, & Allen, 2008; Schmader, Johns, & Forbes, 2008). For example, Forbes et al. (2008) found that when racial minority students made errors while performing an alleged intelligence task, this elicited large ERN responses especially among those who valued academics more, presumably due to their increased concern about negative societal stereotypes regarding their intelligence (e.g., Steele & Aronson, 1995). Applied to our experiment, we predicted that if the watchful gaze of a male face is sufficient to activate negative gender-math stereotypes on a randomized trial-by-trial basis and if making errors in this context is perceived as confirming these stereotypes, women should exhibit greater neurological vigilance to their errors, when these errors are preceded by male face (vs. control) primes. Our primary aim was to test this prediction by examining whether women would exhibit larger ERN after making errors on trials in which they were primed with male faces (vs. control images), in comparison to men.

Our second aim was to examine whether women who are especially invested in pursuing STEM careers would be particularly vigilant to errors on face (vs. control) priming trials. Because proficiency in STEM is especially important to this subgroup of women, they may be attuned to gender-stereotypic cues more than other women who are less invested in STEM careers and also men. This prediction is consistent with prior work, which found that women who are highly identified with math were more sensitive to gender stereotypes when taking a math test in comparison to low-math identified women and all men (Lesko & Corpus, 2006). We thus hypothesized that women who are highly invested in pursuing STEM careers would show a stronger face priming effect on ERN than women who are less invested in STEM careers and all men.

2. Method

2.1. *Participants*

One hundred and twenty-seven undergraduate students from the University of Massachusetts, Amherst (66 men, 61 women, $M_{\text{age}} = 19.88$, $SD_{\text{age}} = 1.62$) participated in this study in exchange for course credit or $20. We recruited students who were either majoring in or interested in majoring in a STEM field through the human participant pool and through fliers posted around campus. In this sample, 57.5% were White, 17.3% Asian, 10.2% Black, 2.4% Hispanic, and 12.6% were multiracial or indicated other races/ethnicities.

Our sample size was guided by previous studies that involved similar neurophysiological assessments (Kitayama & Park, 2014; Park &

Kitayama, 2014). We sought to recruit a minimum of 25 participants per condition (four conditions based on participant gender and low or high investment in STEM careers), plus an additional 20% to guard against possible data attrition and to ensure that the study would be well-powered (Boudewyn, Luck, Farrens, & Kappenman, 2018; Button et al., 2013).

2.2. Procedure and materials

All procedure and materials were approved by the Institutional Review Board at the University of Massachusetts, Amherst. Upon arrival in the lab, participants provided informed consent and were prepared for EEG recording. Participants then performed a numerical Stroop task that was framed as diagnostic of “math intelligence” to make it relevant to gender-math stereotypes (e.g., Blascovich, Spencer, Quinn, & Steele, 2001; Martens, Johns, Greenberg, & Schimel, 2006). Specifically, participants were led to believe that their brain responses would be monitored during task performance to identify neurophysiological responses associated with math intelligence. In reality, we assessed their neural vigilance to errors, indexed by the ERN. The ERN emerges after the commission of errors in speeded choice reaction tasks that involve response conflict, such as Stroop tasks (e.g., Blascovich et al., 2001; Carter et al., 1998; Danielmeier et al., 2009). In particular, we chose the “numerical” version of the Stroop task to strengthen the believability of the cover story that this task was related to math intelligence. The numerical Stroop task has been used in previous studies as an alleged math task (Ashkenazi, 2018; Suárez-Pellicioni, Núñez-Peña, & Colomé, 2013) and has been found to be effective in eliciting ERN in response to errors, especially among individuals who are high in math anxiety (Suárez-Pellicioni et al., 2013).

Following the paradigm used in Suárez-Pellicioni et al. (2013), participants were presented with a pair of numbers (i.e., 1–2, 1–8, 9−2, 9−8) on each trial and asked to judge which number was larger in numerical magnitude while ignoring its physical size. There were three trial types: congruent, incongruent, and neutral (see Fig. 1-A for examples of each trial type). For congruent trials, the number of larger numerical magnitude within the pair was also larger in physical size, whereas for incongruent trials, the number of larger numerical magnitude was smaller in physical size. For neutral trials, the numbers only differed in numerical magnitude but were the same physical size.

On each trial, participants were first presented with a visual prime for 90 ms. Adapting a procedure from prior research (Park & Kitayama, 2014; see also Hitokoto et al., 2016), the prime was either an image of a watching male face or a scrambled face (as a control prime), each presented randomly for half of the trials in each block (see Fig. 1-B for sample images). The prime stimuli were borrowed from Park and Kitayama (2014), who created race-neutral, young adult male faces using FaceGen Modeller 3.3 (Singular Inversions Inc.) by morphing Caucasian (50%) and Asian (50%) faces—the two racial groups that are perceived to be superior in STEM fields relative to other racial groups (e.g., Canning, Muenks, Green, & Murphy, 2019). The morphed face images were then scrambled to create the scrambled faces. Participants were told that on each trial, an image would appear right before the presentation of the numbers, but that they should ignore these images because they were unrelated to the numbers that would follow. After the presentation of the prime, a fixation cross was presented for 500 ms, followed by a target pair of numbers, which remained on the screen for 100 ms. Participants were asked to press a designated key on the keyboard to indicate whether the number on the left (F) or right (J) was numerically larger, within a response window of 600 ms. The next trial began after an inter-trial interval of 600−800 ms (see Fig. 1-C for a sample trial structure).

After completing one practice block of 24 trials, participants completed 16 blocks of 48 trials each. Prime type (face vs. scrambled face) and target type (congruent vs. incongruent vs. neutral) were varied within each block, resulting in six types of trials that were each presented eight times per block. Trial order was randomized within block. At the end of each block, participants received feedback on their performance, adopted from Park and Kitayama (2014): participants were asked to respond faster in the next block if their accuracy in that block was higher than 90%, or asked to focus on improving accuracy if their accuracy was below 90%.

Participants performed the task using a Cybertron TGM1114C PC with Windows 8.1. The stimuli were presented using a 24-inch ASUS VG248QE HD monitor (1920 × 1080) with a 144 Hz rapid refresh rate and a 1 ms response time.

After completing the numerical Stroop task, participants answered a question about how likely they were to pursue a profession in a field related to STEM, using a 7-point scale (1 = *not at all likely*, 7 = *very likely*), which served as our measure of participants’ investment in STEM careers. In addition, they completed a series of questions assessing how engaging, interesting, boring, and difficult they found the task to be, and how satisfied they were with their task performance, using 7-point scales (1 = *not at all*, 7 = *very much*). See *Supplementary Materials* for the results from additional measures included for exploratory purposes.

2.3. EEG recording and processing

EEG was recorded with 64 electrodes that were placed according to the extended International 10–20 System in a nylon cap and referenced to the left mastoid. The electro-oculogram (EOG) was also recorded from four additional channels, two placed at the outer canthi of both eyes and two placed above and below the right eye, respectively. Sodium chloride gel was added to each sensor to lower the impedance under 5kOhm.[1] EEG and EOG signals were amplified with a band-pass of DC to 100 Hz with actiCHamp amplifier (Brain Products GmbH, Germany) and were sampled with 1024 Hz. All data were re-referenced to the left and right mastoid off-line and were then resampled at 256 Hz. Response-locked ERPs were extracted 200 ms before and 800 ms after each trial response. The data were baseline-corrected at 200 to 100 ms pre-response voltage and then corrected for ocular artifacts (Gratton, Coles, & Donchin, 1983). A low-pass filter with a half-amplitude cutoff at 30 Hz was applied to remove high frequency noise, following an approach from prior work (e.g., Gehring & Willoughby, 2004; Nieuwenhuis, Ridderinkhof, Blom, Band, & Kok, 2001; Themanson, Ball, Khatcherian, & Rosen, 2014). The data were then inspected to remove trials containing artifacts exceeding ±100μV at three midline centered electrodes (Fz, FCz, and Cz). On average, 1.65% (*SD* = 6.07) of trials were removed and the percentage of removed trials did not differ by gender and/or prime type, *ps* ≥ .091. After artifact rejection, a minimum number of six error trials per condition was required to be included in the analysis on ERN (Olvet & Hajcak, 2009). On average, participants had approximately 42 error trials per condition (face primes: *M* = 41.99, *SD* = 20.82; control primes: *M* = 41.78, *SD* = 19.18). The artifact-free epochs were then averaged separately based on response type (error vs. correct) and prime type (face vs. control).

Since the ERN peaked an average of 30 ms after incorrect responses across participants, it was quantified as the mean amplitude between 20 ms before and 80 ms after the incorrect response. Our analysis focused on ERN amplitudes from two channels—the fronto-central and central midline electrodes (FCz and Cz)—because these are sites at which ERN amplitudes tend to be largest. Following an approach used in prior research (Brazil et al., 2009), we examined the ERN from these two regions by including channel (FCz, Cz) as a within-participant predictor in addition to our two primary predictors: gender (men vs. women) as a

---

[1] Due to equipment malfunction, we were not able to check impedance levels for seven participants (two men and five women). After visual inspection of their data, we decided to include them in the final analysis. The results remained the same regardless of whether these participants were included or excluded.

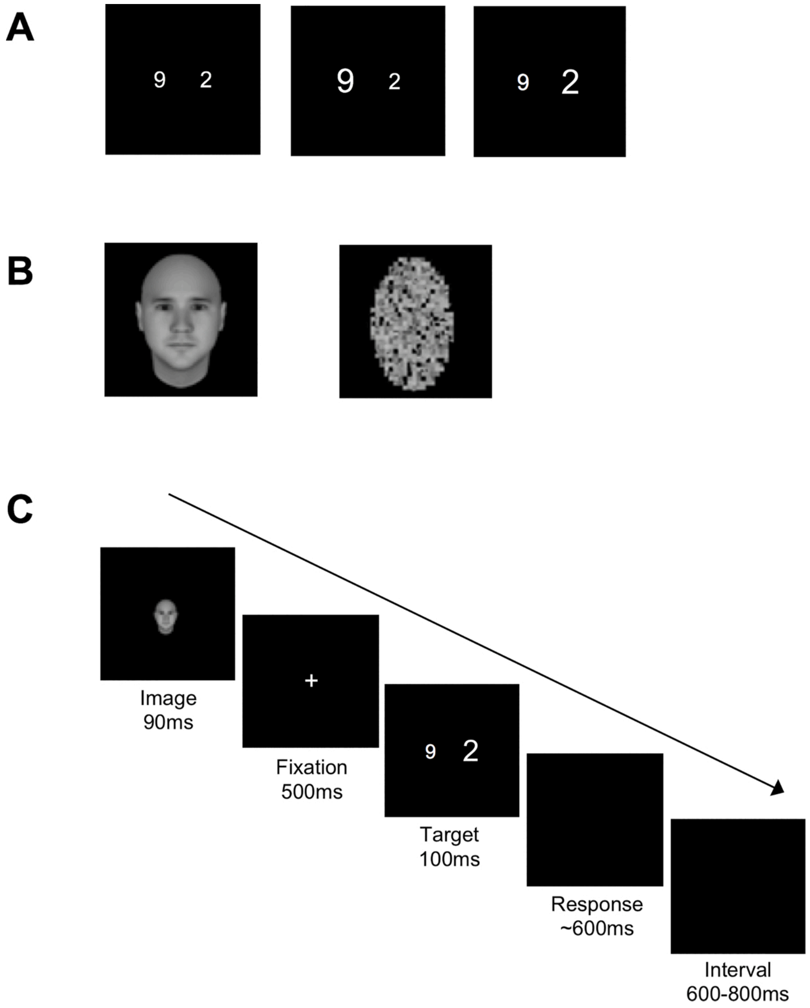

Fig. 1. (A) Examples of a neutral (both numbers are the same in size), congruent (the larger number in magnitude is also larger in size), or incongruent target (the larger number in magnitude is smaller in size). (B) Sample images of a male face and a scrambled face. (C) A sample trial structure.

between-participant predictor and prime type (face vs. control) as a within-participant predictor.

3. Results[2]

3.1. Data attrition and sensitivity power analysis

We excluded two participants who failed to follow task instructions and focused on a sample of 125 participants (65 men, 60 women) for the analyses on self-report measures and behavioral performance. For the analysis on ERN, nine additional participants were excluded because one participant did not make enough errors (i.e., a minimum of six trials per condition; Olvet & Hajcak, 2009) and the remaining eight participants had noisy EEG data, leaving a sample of 116 participants (61 men, 55 women). Participants who were dropped from the ERN analysis did not differ from those retained on key variables, such as gender, age, and interest in pursuing a career in STEM, *ps* $\geq$ .201.

A sensitivity power analysis using G*Power (Faul, Erdfelder, Buchner, & Lang, 2009) revealed that our primary analysis on ERN (the Gender x Prime Type interaction) based on the final sample ($N = 116$) is sufficient to detect a small effect ($d = 0.22$; $\alpha = .05$, power = .80). An observed power analysis also revealed that we reached power > .99 for the ERN results.

3.2. Self-report measures

We first tested whether women and men differed in their interest in pursuing STEM careers. Since we had actively recruited participants interested in STEM, not surprisingly, the overall mean interest in pursuing careers in STEM was high ($M = 5.36$ on the 7-point scale, $SD = 2.08$) and the distribution of the scores was negatively skewed (skewness = -1.03, $se = 0.22$). Due to the skewness, we tested whether the two gender groups differed in their indicated interest in STEM careers by conducting a non-parametric test, which is not constrained by normality violations (Blair & Higgins, 1985). We found that the two gender groups did not differ on this variable, U = 1723.50, $p = .235$ (men: $M = 5.20$, $SD = 2.08$; women: $M = 5.53$, $SD = 2.09$). Upon examining the data further, we found that approximately half of the sample reported that they were highly certain in pursuing a STEM career (47.2% gave a rating of 7 on the 7-point scale), while the other half reported less certainty (52.8% gave a rating of 6 or below; see histograms in Fig. 2). When we examined the percentage of women and men who were highly certain in pursuing STEM careers, no significant gender difference emerged; the percentage of participants who chose 7 did not vary by gender (women: 53.3%, men: 41.5%), $\chi^2(1) = 1.74$, $p = .187$.

Further, the questionnaire responses showed that men and women were no different in their experience during the task (see Table 1 for statistics). Specifically, the two groups did not differ in their levels of

---

[2] The data from this study are publicly available in Open Science Framework (OSF) at osf.io/pwyt3/.

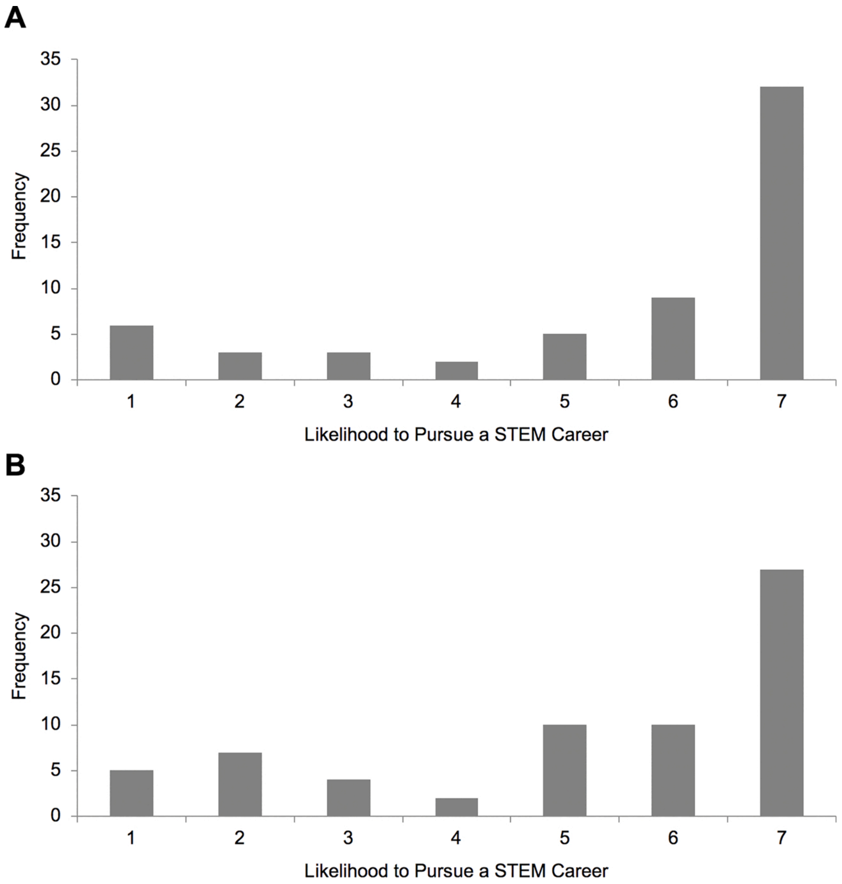

Fig. 2. Histograms of the distribution of the STEM career question (i.e., how likely are you to pursue a professional career in a field related to STEM?) for (A) women and (B) men (1 = *not at all likely*, 7 = *very likely*).

Table 1
Descriptive Statistics of the Post-Task Questionnaire Variables.

	Men (n = 65)		Women (n = 60)		t(df), p-value
Variables	*M*	*SD*	*M*	*SD*	
Engagement	5.11	1.53	4.85	1.45	$t(123) = 0.97$, $p = .337$
Satisfaction	3.65	1.40	3.25	0.99	$t(115.25) = 1.84$, $p = .068$[1]
Interesting	3.98	1.91	3.47	1.64	$t(122) = 1.59$, $p = .115$
Boring	4.48	1.77	4.78	1.44	$t(120.61) = -1.05$, $p = .296$[1]
Difficult	4.09	1.40	3.62	1.54	$t(123) = 1.81$, $p = .073$

[1] Levene's test for equality of variances was violated for this specific analysis; thus, the statistic for unequal variances is reported.

task engagement or satisfaction with their performance, $ts \leq 1.82$, $ps \geq .068$. There were also no significant gender differences in how interesting, boring, and difficult they found the task, $ts \leq 1.81$, $ps \geq .073$.

3.3. *Behavioral performance*

Next, we tested whether face priming modulated behavioral performance differently across the two gender groups. We first conducted a 2 Gender (men vs. women) × 2 Prime Type (face vs. control) mixed analysis of variance (ANOVA) on accuracy, with gender as a between-participant factor and prime type as a within-participant factor. Neither the main effects of gender and prime type nor the interaction effect between the two were statistically significant, $Fs(1, 123) \leq 0.88$, $ps \geq .350$, suggesting that the two gender groups did not differ in their accuracy both on face priming trials (women: $M = 87.49\%$, $SE = 0.98$; men: $M = 87.71\%$, $SE = 0.94$) and on control priming trials (women: $M = 87.80\%$, $SE = 0.92$; men: $M = 87.70\%$, $SE = 0.89$).

We next conducted a 2 Gender (men vs. women) × 2 Prime Type (face vs. control) × 2 Response Accuracy (correct vs. error) mixed ANOVA on response time with gender as a between-participant factor and prime type and response accuracy as within-participant factors. Only the main effect of response accuracy was statistically significant, $F(1, 123) = 458.71$, $p < .001$, $d = 3.87$. Participants were significantly faster on error trials ($M = 189.82$ ms, $SE = 3.92$) than on correct trials ($M = 227.13$ ms, $SE = 3.85$). All other effects were non-significant, $Fs(1, 123) \leq 1.65$, $ps \geq .202$.[3]

3.4. *Gender differences in the face priming effect on error-related negativity*

Our primary aim was to examine whether women and men differ in their neural vigilance to face priming. We tested our prediction by conducting a 2 Gender (men vs. women) × 2 Prime Type (face vs. control) × 2 Channel (FCz vs. Cz) mixed ANOVA with gender as a between-participant factor and prime type and channel as within-participant factors. There was a significant main effect of gender, $F(1, 114) = 5.14$, $p = .025$, $d = 0.42$. Overall, women exhibited larger ERN ($M = 1.23\mu\text{V}$, $SE = 0.63$) than men ($M = 3.21\mu\text{V}$, $SE = 0.60$), regardless of prime type (note that because the ERN is a negative deflection from

---

[3] Previous studies suggest that after making errors, people often engage in compensatory behaviors in an attempt to improve their performance on subsequent trials, which emerge as increased post-error accuracy (e.g., Amodio et al., 2004; Hajcak et al., 2003). In an exploratory analysis, we examined whether face priming modulated post-error accuracy differently between the two gender groups. The results from this analysis are reported in *Supplementary Materials*.

baseline, mean amplitudes that are less positive correspond to larger ERN). The main effect of channel was also significant, $F(1, 114) = 15.98$, $p < .001$, $d = 0.75$, indicating that the overall ERN amplitudes were greater at FCz ($M = 1.78\mu\text{V}$, $SE = 0.47$) than at Cz ($M = 2.66\mu\text{V}$, $SE = 0.44$). The main effect of prime type was not significant, $F(1, 114) = 1.76$, $p = .187$. The two-way interactions between gender and channel and between prime type and channel were also not significant, $F(1, 114) = 1.80$, $p = .182$ and $F(1, 114) = 0.04$, $p = .842$, respectively.

Importantly, as predicted, we found a significant Gender × Prime Type interaction effect, $F(1, 114) = 4.65$, $p = .033$, $d = 0.40$. Women displayed significantly larger ERN after being primed with male faces ($M = 0.89\mu\text{V}$, $SE = 0.66$) than control images ($M = 1.57\mu\text{V}$, $SE = 0.64$), $F(1, 114) = 5.76$, $p = .018$, $d = 0.45$ (see Fig. 3-A and 3-B for waveforms and topographic maps, respectively). In contrast, men's ERN did not vary as a function of prime type, $F(1, 114) = 0.36$, $p = .549$ (face primes: $M = 3.13\mu\text{V}$, $SE = 0.61$; control primes: $M = 3.29\mu\text{V}$, $SE = 0.62$) (see Fig. 4-A and 4-B). Furthermore, the three-way interaction between gender, prime type, and channel was not significant, $F(1, 114) = 0.23$, $p = .636$, as we found a significant Gender × Prime Type interaction at each electrode site separately (see *Supplementary Materials* for the results from the separate analyses by channel).[4]

3.5. The moderating effect of interest in pursuing a STEM career

Our second aim was to test whether the gender difference we observed was more pronounced for women who are highly interested in pursuing STEM careers. As noted above, approximately half of our women participants indicated that they were highly certain that they would pursue a STEM career (see Fig. 2). Due to the highly skewed distribution of participants' responses on this variable, we computed a median split based on the total sample to categorize participants into two groups: those who were very certain that they would pursue a STEM career (i.e., who chose 7 on the 7-point scale) and others who were somewhat less certain that they would pursue a STEM career (i.e., who chose 6 or below on the 7-point scale). This median split resulted in four groups: women who were highly certain about pursuing STEM careers ($n = 31$) vs. less so ($n = 24$) and men who were highly certain about pursuing STEM careers ($n = 24$) vs. less so ($n = 37$).

We had an *a priori* prediction that women highly certain about pursuing STEM careers would be the most vigilant to errors following the face (vs. control) primes compared to everybody else. This prediction was motivated by prior research on stereotype threat suggesting that the effects of negative gender stereotypes in STEM on the self (which largely affect women but not men) are especially stronger for women who are highly identified with the STEM domain (e.g., Lesko & Corpus, 2006; Steele, 1997; Steinberg, Okun, & Aiken, 2012). We expected that the other three groups would be less impacted by gender stereotypes, due to their lack of domain identification (i.e., women who are less invested in STEM) or their superior status in the stereotyped domain (i.e., men regardless of their likelihood to pursue a STEM career). Consistent with this prediction, these three groups did not differ from each other in their ERN responses to face (vs. control) primes, $Fs(1, 112) \leq 1.24$, $ps \geq .268$. We thus conducted a planned contrast comparing women who were highly certain about pursuing STEM careers (+3) to the remaining three groups (-1, -1, -1).

To capture the degree to which participants were vigilant to errors made in the context of a watching male face vs. errors made in the context of control primes, we computed a difference score by subtracting ERN amplitudes for the face priming trials from those for the control priming trials. Because the effects of face priming were similar for both FCz and Cz, we averaged the scores from these two electrode sites to compute this index of differential vigilance to face (vs. control) priming (see *Supplementary Materials* for the analyses separated by channel). Positive scores on this index, which we refer to as the *face priming effect*, indicate greater vigilance to errors made in the context of face (vs. control) priming.

The planned contrast on this dependent variable was statistically significant, $F(1, 112) = 4.57$, $p = .035$, $d = 0.40$. As displayed in Fig. 5, women who were highly invested in pursuing STEM careers showed a greater face priming effect compared to the other three groups. Specifically, this subgroup of women displayed significantly larger ERN amplitudes in response to face priming ($M = 0.76\mu\text{V}$, $SE = 0.88$) compared to control priming ($M = 1.69\mu\text{V}$, $SE = 0.86$), $F(1, 112) = 6.11$, $p = .015$, $d = 0.46$. In contrast, the other three groups' ERN responses were of similar magnitude, regardless of prime type, $Fs(1, 112) \leq 0.65$, $ps \geq .422$.[5]

4. Discussion

Two research questions guided our investigation. First, during stereotype-relevant achievement tasks, do women show enhanced vigilance to errors following minimalistic cues signaling male dominance even when these cues appear for a split-second? Second, are women who are highly invested in pursuing STEM careers more attuned to these stereotype-relevant situational cues than their peers?

We found support for our primary hypothesis that minimalistic stereotypic cues such as the mere presence of male watching eyes were sufficient to increase neural vigilance to errors, indexed by enhanced ERN. Notably, this effect was pronounced among women but not men, consistent with prior work indicating that men are less attuned to situational cues that prime gender stereotypes in STEM contexts (e.g., Murphy et al., 2007; Spencer, Steele, & Quinn, 1999). While previous work utilized relatively more explicit situational cues to trigger stereotype activation (e.g., Cheryan et al., 2009; Murphy et al., 2007), our work shows that very subtle visual cues signaling male dominance in the context of STEM are sufficient to result in cognitive modulation of neural responses to errors on a trial-by-trial basis in a matter of milliseconds, thereby suggesting that stereotype activation results in automatic regulation of attentional responses at an early stage of informational processing, well before deliberate and conscious processes can be engaged.

One might argue that women's enhanced attentional vigilance to errors following male face priming may have been driven by exposure to outgroup faces, rather than male faces in particular. That is, individuals may feel more threatened when evaluated by any outgroup member than an ingroup member. However, this explanation cannot account for why only a subgroup of women—those highly invested in pursuing STEM careers—exhibited enhanced attentional vigilance. If the alternative explanation were valid, one would expect that all women in our sample should show this effect, not just a subgroup of women. Thus, it seems more probable that greater vigilance was evoked among a subgroup of women who found it particularly threatening to make mistakes in a domain that is important to their self-concept. This finding is consistent with previous research showing that members of stigmatized groups who chronically anticipate being a target of stereotypes, such as

---

[4] See *Supplementary Materials* for an exploratory analysis we conducted to examine the effects of face priming on error positivity (Pe), an ERP component linked to conscious error awareness or an emotional reaction to an error (Falkenstein, Hoormann, Christ, & Hohnsbein, 2000).

[5] We also tested each of the three groups separately as a single comparison group contrasted with women highly interested in pursuing a STEM career. Consistent with the main analysis, this subgroup of women showed a greater face priming effect than men who were highly interested in pursuing a STEM career, $F(1, 112) = 4.90$, $p = .029$, $d = 0.42$. A similar but weaker pattern of group differences emerged when these women were compared with men who reported low interest in pursuing a STEM career, $F(1, 112) = 3.73$, $p = .056$, $d = 0.36$, and with women who reported low interest in pursuing a STEM career, $F(1, 112) = 1.07$, $p = .304$, $d = 0.19$.

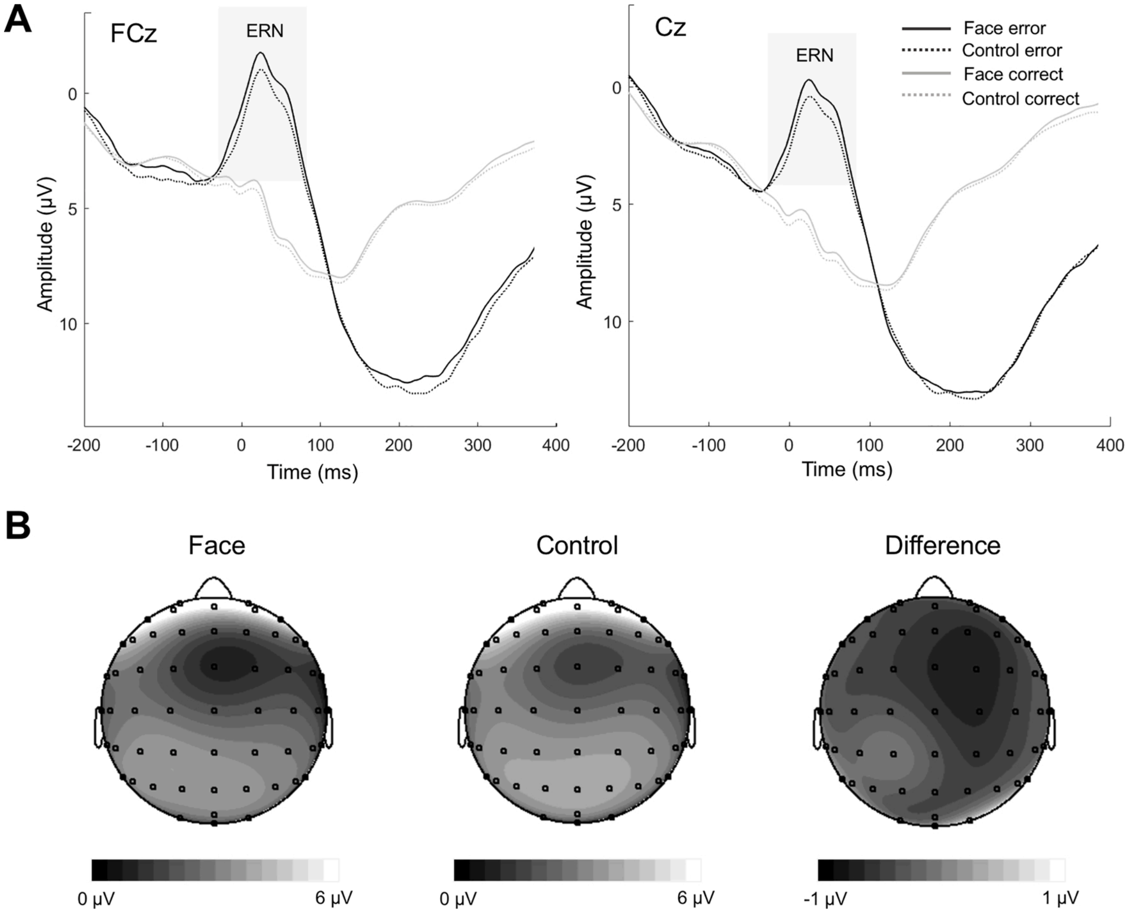

Fig. 3. (A) Grand averaged event-related brain potentials (ERPs) elicited by errors (black lines) and correct responses (gray lines) as a function of the prime type (face vs. control) at FCz and Cz electrodes for women. (B) Topographic maps respresenting the scalp distribution of the ERN in the time range of −20 ms to 82 ms for the face priming condition, control priming condition, and the difference between the two conditions (face – control). The front of the head is at the top of the maps.

those who are strongly identified with their social group (Schmader, 2002) or with the stigmatized domain (Spencer et al., 1999), are more vulnerable to social identity threat (Townsend, Major, Gangi, & Mendes, 2011), likely due to their heightened alertness to identity threat cues in their environments (Kaiser, Vick, & Major, 2006).

We theorized that male face priming should evoke attentional vigilance among women in STEM, insofar as it is interpreted as signaling the evaluative presence of a dominant, high-status individual, whose group is positively regarded in that domain. That said, it remains unclear if our participants perceived the faces as higher in status or dominance in the context of STEM, since we did not measure perceived male dominance or status. Future research should directly address this issue by experimentally manipulating features of primed faces to signal high (vs. low) status, such as head posture and eye gaze. For example, faces with a direct eye gaze and an upward head tilt are perceived as more dominant whereas faces with an averted eye gaze and a downward head tilt are perceived as more submissive (Mignault & Chaudhuri, 2003; Rule, Adams, Ambady, & Freeman, 2012). Future work should examine whether women will show enhanced attentional vigilance to errors specifically when primed with more dominant (rather than submissive) male faces or whether any male faces will elicit vigilance.

Future research should also address whether the degree to which women are vigilant to errors is reduced when primed with *female* faces. Previous work shows that women feel more accepted and show better performance when surrounded by same-sex peers (Griffith, 2010). In particular, exposure to female role models is shown to be particularly beneficial for women in STEM fields (Dasgupta, 2011; Drury, Siy, & Cheryan, 2011). For example, according to the Stereotype Inoculation Model (Dasgupta, 2011; Dennehy & Dasgupta, 2017; Stout et al., 2011), the presence of women role models leads women to feel less anxiety and more belonging in STEM by protecting against negative gender stereotypes. Thus, we expect that female faces may serve as a cue signaling identity safety (rather than identity threat) to women in STEM, thereby decreasing their attentional vigilance to errors made in the context of gender-stereotyped tasks.

Beyond STEM contexts, it would also be important to examine the effects of female watching eyes in achievement domains in which women are stereotypically perceived to be superior to men (e.g., verbal skills). Previous work shows that when women's gender identity in female-dominant domains is made salient, they perform better on tasks that favor their group (Shih, Pittinsky, & Trahan, 2006), while men underperform when reminded of stereotypes that do not favor their group (Koenig & Eagly, 2005). Building on these results, we anticipate that situational reminders of female superiority, in the form of female face priming on a different task, may evoke attentional vigilance to errors among men, but not among women. This is another avenue for future research.

Despite significant gender differences in neural responses to face priming, there was no corresponding effect on behavioral performance. We speculate that these null results were driven by the fact that the task was relatively easy (i.e., 88% accuracy for both women and men), consistent with prior evidence suggesting that women and men perform equally on easy math tasks but women underperform on difficult math tests (e.g., Ben-Zeev, Fein, and Inzlict, 2005; Keller, 2007; O'Brien & Crandall, 2003). Future research should examine whether face priming modulates women's performance differently if the task was more

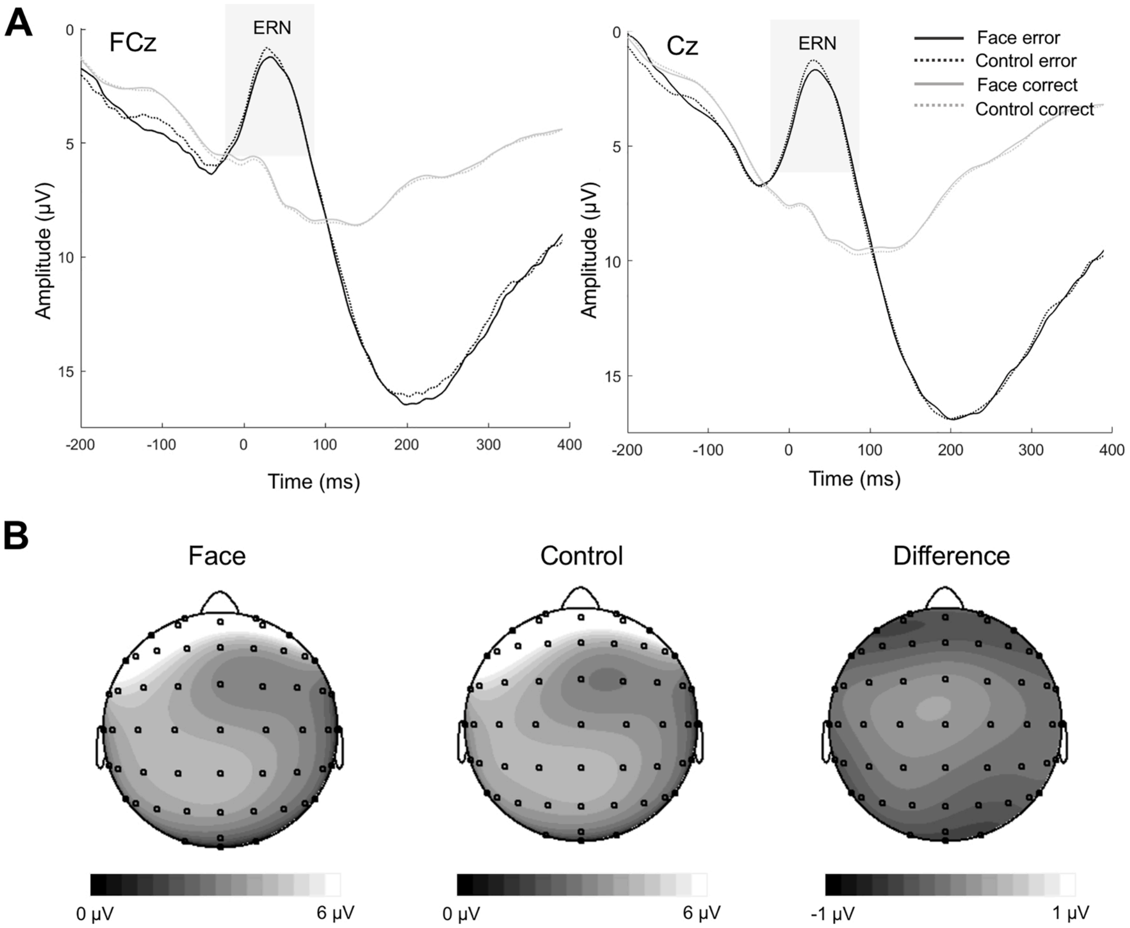

Fig. 4. (A) Grand averaged event-related brain potentials (ERPs) elicited by errors (black lines) and correct responses (gray lines) as a function of the prime type (face vs. control) at FCz and Cz electrodes for men. (B) Topographic maps respresenting the scalp distribution of the ERN in the time range of −20 ms to 82 ms for the face priming condition, control priming condition, and the difference between the two conditions (face – control). The front of the head is at the top of the maps.

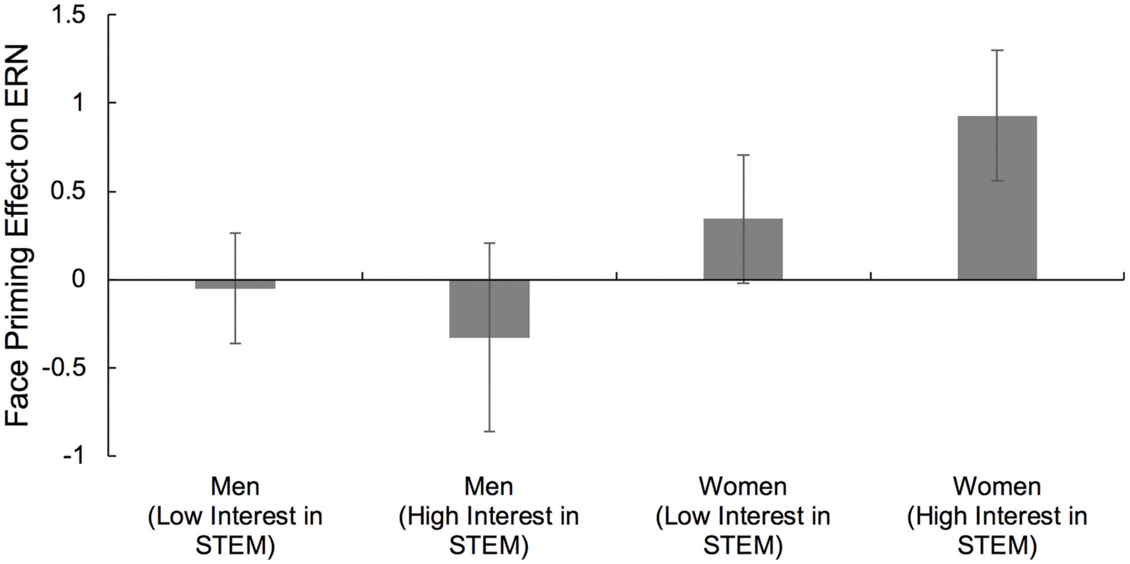

Fig. 5. The face priming effect on ERN separated by gender and interest in pursuing STEM careers. This index was computed by subtracting the ERN amplitudes on the face priming trials from the ERN amplitudes on the control priming trials, such that positive values indicate larger ERN on the face (vs. control) priming trials.

difficult. Another important future extension would be to test whether women's increased attentional vigilance has any implications for their subsequent levels of motivation, persistence, and performance in other STEM-related tasks. On the one hand, previous research suggests that women in STEM contexts may experience decreased working memory capacity when under stereotype threat, which in turn, leads to impaired performance on following tasks (Beilock et al., 2007). Alternatively, other studies have found that increased ERN is often associated with better cognitive control (e.g., Amodio et al., 2004; Hajcak, McDonald, & Simons, 2003), implying that attentional vigilance may increase motivation to improve performance. Future research should test these competing predictions by examining whether heightened attentional vigilance is helpful or detrimental for women's performance on a subsequent, STEM-related task.

In conclusion, the current findings illustrate how exquisitely attuned and nimble the mind is in selectively attending to stereotypic cues in one moment and then turning attention away quickly when the cue no longer exists. We show that such strategic allocation of attention occurs swiftly and automatically, when individuals who are deeply invested in a performance domain encounter minimalistic cues signaling the gaze of a high-status member in a stereotyped domain.

Author contributions

J. Park and N. Dasgupta conceived the study. D. J. Wu collected data and carried out data analysis under the supervision of J. Park. All three authors drafted the manuscript and have approved the final version of the manuscript for submission.

Funding

The research was conducted without external funding sources.

Declaration of competing interest

The authors have no conflicts of interest to report.

Appendix A. Supplementary material

Supplementary material related to this article can be found, in the online version, at https://doi.org/10.1016/j.biopsycho.2020.107948.

References

Amodio, D. M., Harmon-Jones, E., Devine, P. G., Curtin, J. J., Hartley, S. L., & Covert, A. E. (2004). Neural signals for the detection of unintentional race bias. *Psychological Science, 15*(2), 88–93.

Asgari, S., Dasgupta, N., & Stout, J. G. (2012). When do counterstereotypic ingroup members inspire vs. deflate? The effect of successful professional women on women's leadership self-concept. *Personality & Social Psychology Bulletin, 38*, 370–383.

Ashkenazi, S. (2018). Intentional and automatic processing of numerical information in mathematical anxiety: Testing the influence of emotional priming. *Cognition & Emotion, 32*(8), 1700–1707.

Banaji, M. R., & Dasgupta, N. (1998). The consciousness of social beliefs: A program of research on stereotyping and prejudice. In V. Y. Yzerbyt, G. Lories, & B. Dardenne (Eds.), *Metacognition: Cognitive and social dimensions* (pp. 157–170). Great Britain: Sage Publications.

Banaji, M. R., & Hardin, C. D. (1996). Automatic stereotyping. *Psychological Science, 7*(3), 136–141.

Bargh, J. A. (1997). The automaticity of everyday life. In R. S. Wyer, Jr. (Ed.), *Advances in social cognition* (Vol. 10, pp. 1–61). Lawrence Erlbaum Associates Publishers.

Beilock, S. L., Rydell, R. J., & McConnell, A. R. (2007). Stereotype threat and working memory Mechanisms, alleviation, and spillover. *Journal of Experimental Psychology General, 136*(2), 256–276.

Ben-Zeev, T., Fein, S., & Inzlict, M. (2005). Arousal and stereotype threat. *Journal of Experimental Social Psychology, 41*(2), 174–181.

Blair, I. V., & Banaji, M. R. (1996). Automatic and controlled processes in stereotype priming. *Journal of Personality and Social Psychology, 70*(6), 1142–1163.

Blair, I. V., Dasgupta, N., & Glaser, J. (2014). Implicit attitudes. In M. Mikulincer, & P. R. Shaver E (Eds.), *APA handbook of personality and social psychology, volume 1: Attitudes and social cognition* (pp. 665–691). Washington DC: American Psychological Association.

Blair, R. C., & Higgins, J. J. (1985). Comparison of the power of the paired samples t test to that of Wilcoxon's signed-ranks test under various population shapes. *Psychological Bulletin, 97*(1), 119–128.

Blascovich, J., Spencer, S. J., Quinn, D., & Steele, C. (2001). African Americans and high blood pressure: The role of stereotype threat. *Psychological Science, 12*(3), 225–229.

Botvinick, M. M., Cohen, J. D., & Carter, C. S. (2004). Conflict monitoring and anterior cingulate cortex: An update. *Trends in Cognitive Sciences, 8*(12), 539–546.

Boudewyn, M. A., Luck, S. J., Farrens, J. L., & Kappenman, E. S. (2018). How many trials does it take to get a significant ERP effect? It depends. *Psychophysiology, 55*(6), Article e13049.

Brazil, I. A., de Bruijn, E. R., Bulten, B. H., von Borries, A. K., van Lankveld, J. J., Buitelaar, J. K., et al. (2009). Early and late components of error monitoring in violent offenders with psychopathy. *Biological Psychiatry, 65*(2), 137–143.

Button, K. S., Ioannidis, J. P. A. I., Mokrysz, C., Nosek, B. A., Flint, J., Robinson, E. S. J., et al. (2013). Power failure: Why small sample size undermines the reliability of neuroscience. *Nature Reviews Neuroscience, 14*, 365–376.

Canning, E. A., Muenks, K., Green, D. J., & Murphy, M. C. (2019). STEM faculty who believe ability is fixed have larger racial achievement gaps and inspire less student motivation in their classes. *Science Advances, 5*(2). eaau4734.

Carter, C. S., Braver, T. S., Barch, D. M., Botvinick, M. M., Noll, D., & Cohen, J. D. (1998). Anterior cingulate cortex, error detection, and the online monitoring of performance. *Science, 280*, 747–749.

Cheryan, S., Plaut, V. C., Davies, P. G., & Steele, C. M. (2009). Ambient belonging: How stereotypical cues impact gender participation in computer science. *Journal of Personality and Social Psychology, 97*(6), 1045–1060.

Danielmeier, C., Wessel, J. R., Steinhauser, M., & Ullsperger, M. (2009). Modulation of the error-related negativity by response conflict. *Psychophysiology, 46*(6), 1288–1298.

Dar-Nimrod, & Heine, S. J. (2006). Exposure to scientific theories affects women's math performance. *Science, 314*(5798), 435.

Dasgupta, N. (2004). Implicit ingroup favoritism, outgroup favoritism, and their behavioral manifestations. *Social Justice Research, 17*(2), 143–169.

Dasgupta, N. (2011). Ingroup experts and peers as social vaccines who inoculate the self-concept: The stereotype inoculation model. *Psychological Inquiry, 22*(4), 231–246.

Dasgupta, N. (2013). Implicit attitudes and beliefs adapt to situations: A decade of research on the malleability of implicit prejudice, stereotypes, and the self-concept. In P. G. Devine, & E. A. Plant (Eds.), *Advances in experimental social psychology, 47* pp. 233–279). UK: Academic Press.

Dasgupta, N., & Asgari, S. (2004). Seeing is believing: Exposure to counterstereotypic women leaders and its effect on automatic gender stereotyping. *Journal of Experimental Social Psychology, 40*, 642–658.

Dasgupta, N., & Stout, J. G. (2014). Girls and women in science, technology, engineering, and mathematics: STEMing the tide and broadening participation in STEM careers. *Policy Insights from the Behavioral and Brain Sciences, 1*(1), 21–29.

Dasgupta, N., Scircle, M. M., & Hunsinger, M. (2015). Female peers in small work groups enhance women's motivation, verbal participation, and career aspirations in engineering. *Proceedings of the National Academy of Sciences of the United States of America, 112*(16), 2988–2993.

Dennehy, T. C., & Dasgupta, N. (2017). Female peer mentors early in college increase women's positive academic experiences and retention in engineering. *Proceedings of the National Academy of Sciences of the United States of America, 114*(23), 5964–5969.

Drury, B. J., Siy, J. O., & Cheryan, S. (2011). When do female role models benefit women? The importance of differentiating recruitment from retention in STEM. *Psychological Inquiry, 22*, 265–269.

Eagly, A. H., & Karau, S. J. (2002). Role congruity theory of prejudice toward female leaders. *Psychological Review, 109*(3), 573–598.

Ellemers, N. (2018). Gender stereotypes. *Annual Review of Psychology, 69*(1), 275–298.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods, 41*(4), 1149–1160.

Forbes, C. E., Schmader, T., & Allen, J. J. B. (2008). The role of devaluing and discounting in performance monitoring: A neurophysiological study of minorities under threat. *Social Cognitive and Affective Neuroscience, 3*(3), 253–261.

Gehring, W. J., & Willoughby, A. R. (2004). Are all medial frontal negativities created equal? Toward a richer empirical basis for theories of action monitoring. In M. Ullsperger, & M. Falkenstein (Eds.), *Errors, conflicts, and the brain: Current opinions on performance monitoring* (pp. 14–20). Leipzig: Max Plank Institute of Cognitive Neuroscience.

Gehring, W. J., Goss, B., Coles, M. G. H., Meyer, D. E., & Donchin, E. (1993). A neural system for error detection and compensation. *Psychological Science, 4*(6), 385–390.

Gratton, G., Coles, M. G., & Donchin, E. (1983). A new method for off-line removal of ocular artifact. *Electroencephalography and Clinical Neurophysiology, 55*(4), 468–484.

Greenwald, A. G., & Banaji, M. R. (1995). Implicit social cognition: Attitudes, self-esteem, and stereotypes. *Psychological Review, 102*(1), 4–27.

Griffith, A. L. (2010). Persistence of women and minorities in STEM field majors: Is it the school that matters? *Economics of Education Review, 29*(6), 911–922.

Hajcak, G., McDonald, N., & Simons, R. F. (2003). To err is autonomic: Error-related brain potentials, ANS activity, and post-error compensatory behavior. *Psychophysiology, 40*(6), 895–903.

Haley, K. J., & Fessler, D. M. T. (2005). Nobody's watching? Subtle cues affect generosity in an anonymous economic game. *Evaluation and Human Behavior, 26*, 245–256.

Hitokoto, H., Glazer, J., & Kitayama, S. (2016). Cultural shaping of neural responses: Feedback-related potentials vary with self-construal and face priming. *Psychophysiology, 53*(1), 52–63.

Kaiser, C. R., Vick, S. B., & Major, B. (2006). Prejudice expectations moderate preconscious attention to cues that are threatening to social identity. *Psychological Science, 17*(4), 332–338.

Keller, J. (2007). Stereotype threat in classroom settings: The interactive effect of domain identification, task difficulty and stereotype threat on female students' maths performance. *The British Journal of Educational Psychology, 77*(2), 323–338.

Kitayama, S., & Park, J. (2014). Error-related brain activity reveals self-centric motivation: Culture matters. *Journal of Experimental Psychology General, 143*(1), 62–70.

Koenig, A. M., & Eagly, A. H. (2005). Stereotype threat in men on a test of social sensitivity. *Sex Roles, 52*, 489–496.

Lesko, A. C., & Corpus, J. H. (2006). Discounting the difficult: How high math-identified women respond to stereotype threat. *Sex Roles, 54*(1/2), 113–125.

Leslie, S. J., Cimpian, A., Meyer, M., & Freeland, E. (2015). Expectations of brilliance underlie gender distributions across academic disciplines. *Science, 347*(6219), 262–265.

Martens, A., Johns, M., Greenberg, J., & Schimel, J. (2006). Combating stereotype threat: The effect of self-affirmation on women's intellectual performance. *Journal of Experimental Social Psychology, 42*(2), 236–243.

Mignault, A., & Chaudhuri, A. (2003). The many faces of a neutral face: Head tilt and perception of dominance and emotion. *Journal of Nonverbal Behavior, 27*(2), 111–132.

Miller, D. I., Eagly, A. H., & Linn, M. C. (2015). Women's representation in science predicts national gender-science stereotypes: Evidence from 66 nations. *Journal of Educational Psychology, 107*(3), 631–644.

Miller, D. I., Nolla, K. M., Eagly, A. H., & Uttal, D. H. (2018). The development of children's gender-science stereotypes: A meta-analysis of 5 decades of U.S. Draw-A-Scientist studies. *Child Development, 89*(6), 1943–1955.

Murphy, M. C., Steele, C. M., & Gross, J. J. (2007). Signaling threat: How situational cues affect women in math, science, and engineering settings. *Psychological Science, 18*, 879–885.

Nieuwenhuis, S., Ridderinkhof, K. R., Blom, J., Band, G. P., & Kok, A. (2001). Error-related brain potentials are differentially related to awareness of response errors: Evidence from an antisaccade task. *Psychophysiology, 38*, 752–760.

Nisbett, R. E., & Wilson, T. D. (1977). Telling more than we can know: Verbal reports on mental processes. *Psychological Review, 84*(3), 231–259.

Nosek, B. A., Banaji, M. R., & Greenwald, A. G. (2002a). Harvesting implicit group attitudes and beliefs from a demonstration web site. *Group Dynamics: Theory Research and Practice, 6*(1), 101–115.

Oakhill, J., Garnham, A., & Reynolds, D. (2005). Immediate activation of stereotypical gender information. *Memory & Cognition, 33*, 972–983.

Olvet, D. M., & Hajcak, G. (2009). The stability of error-related brain activity with increasing trials. *Psychophysiology, 46*(5), 957–961.

Park, J., & Kitayama, S. (2014). Interdependent selves show face-induced facilitation of error processing: Cultural neuroscience of self-threat. *Social Cognitive and Affective Neuroscience, 9*(2), 201–208.

Pesciarelli, F., Scorolli, C., & Cacciari, C. (2019). Neural correlates of the implicit processing of grammatical and stereotypical gender violations: A masked and unmasked priming study. *Biological Psychology, 146*(107714).

Proverbio, A. M., Alberio, A., & De Benedetto, F. (2018). Neural correlates of automatic beliefs about gender stereotypes: Males are more prejudicial. *Brain and Language, 186*, 8–16.

Rigdon, M. L., Ishii, K., Watabe, M., & Kitayama, S. (2009). Minimal social cues in the dictator game. *Journal of Economic Psychology, 30*(3), 358–367.

Rule, N. O., Adams, R. B., Ambady, N., & Freeman, J. B. (2012). Perceptions of dominance following glimpses of faces and bodies. *Perception, 41*(6), 687–706.

Schmader, T. (2002). Gender identification moderates stereotype threat effects on women's math performance. *Journal of Experimental Social Psychology, 38*(2), 194–201.

Schmader, T., Johns, M., & Forbes, C. (2008). An integrated process model of stereotype threat effects on performance. *Psychological Review, 115*(2), 336–356.

Shih, M., Pittinsky, T. L., & Trahan, A. (2006). Domain-specific effects of stereotypes on performance. *Self and Identity, 5*(1), 1–14.

Spencer, S. J., Steele, C. M., & Quinn, D. M. (1999). Stereotype threat and women's math performance. *Journal of Experimental Social Psychology, 35*(1), 4–28.

Steele, C. M. (1997). A threat in the air: How stereotypes shape the intellectual identities and performance of women and African-Americans. *The American Psychologist, 52*, 613–629.

Steele, C. M., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African Americans. *Journal of Personality and Social Psychology, 69*(5), 797–811.

Steinberg, J. R., Okun, M. A., & Aiken, L. S. (2012). Calculus GPA and math identification as moderators of stereotype threat in highly persistent women. *Basic and Applied Social Psychology, 34*(6), 534–543.

Stoet, G., & Geary, D. C. (2018). The gender equality paradox in science, technology, engineering, and mathematics education. *Psychological Science, 29*(4), 581–593.

Stout, J. G., Dasgupta, N., Hunsinger, M., & McManus, M. A. (2011). STEMing the tide: Using ingroup experts to inoculate women's self-concept in science, technology, engineering, and mathematics (STEM). *Journal of Personality and Social Psychology, 100*(2), 255–270.

Suárez-Pellicioni, M., Núñez-Peña, M. I., & Colomé, À. (2013). Abnormal error monitoring in math-anxious individuals: Evidence from error-related brain potentials. *PloS One, 8*(11), Article e81143.

Themanson, J. R., Ball, A. B., Khatcherian, S. M., & Rosen, P. J. (2014). The effects of social exclusion on the ERN and the cognitive control of action monitoring. *Psychophysiology, 51*(3), 215–225.

Townsend, S. M., Major, B., Gangi, C. E., & Mendes, W. B. (2011). From "in the air" to "under the skin": Cortisol responses to social identity threat. *Personality & Social Psychology Bulletin, 37*(2), 151–164.

Wang, M. T., Eccles, J. S., & Kenny, S. (2013). Not lack of ability but more choice: Individual and gender differences in choice of careers in science, technology, engineering, and mathematics. *Psychological Science, 24*(5), 770–775.

White, J. B., & Gardner, W. L. (2009). Think women, think warm: Stereotype content activation in women with a salient gender identity, using a modified Stroop Task. *Sex Roles: A Journal of Research, 60*(3-4), 247–260.

White, K. R., Crites, S. L., Taylor, J. H., & Corral, G. (2009). Wait, what? Assessing stereotype incongruities using the N400 ERP component. *Social Cognitive and Affective Neuroscience, 4*(2), 191–198.