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# Using implicit bias training to improve attitudes toward women in STEM

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**Abstract** Implicit biases can foster negative attitudes and lead to damaging stereotypical behaviors. Stereotypes can negatively affect the education, hiring, promotion, and retention of women in science, technology, engineering, and mathematics (STEM). This study evaluated the impact of diversity training on university faculty ($N = 234$) by assessing changes in implicit associations and explicit attitudes toward women in STEM. Personal implicit associations about women in STEM improved for men, but not for women who already tended toward more positive implicit associations at pre-test. Men were more likely than women to explicitly endorse stereotypes about women in STEM at both pre- and post-test, and these attitudes did not change as a result of the diversity training. These findings suggest that participation in a brief diversity training can improve implicit associations about women in STEM.

**Keywords** Gender · Stereotypes · Implicit attitudes · Diversity training

## 1 Introduction

Although women are increasingly earning advanced degrees in science, technology, engineering, and math (STEM), they remain under-represented in these career fields (National Research Council 2007). In the United States, women earn 42 % of all Ph.D.s in science and engineering ( National Science Foundation [NSF] 2013a), yet they occupy only 28 % of tenure-track faculty positions in those fields (NSF 2013b).

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This problem is not limited to the United States. The same challenges confront women in STEM around the world. International research suggests that the primary cause of this under-representation is cultural in nature, rather than a result of innate differences, and policy changes can increase diversity in the workplace (De Welde et al. 2007). The Equal Futures Partnership, an initiative comprised of 13 countries, was recently launched with the intention of expanding economic opportunities for women (Office of the Press Secretary 2013). One goal of this program is to increase access to quality education and career opportunities for women in STEM fields around the world (Holdren 2012). Unfortunately, gender stereotypes and beliefs about the roles that men and women should occupy continue to hinder progress toward this goal (Heilman and Eagly 2008; Fuchs et al. 2004; Prentice and Carranza 2002).

Stereotypes negatively affect the education, hiring, promotion, and retention of women in STEM (Cundiff et al. 2013; Fuchs et al. 2004; Nosek et al. 2002b; National Research Council 2007; Wright et al. 2003). One strategy for reducing the negative effects of stereotyping is gender diversity training. Such training is widely used across public, private, and educational settings. In fact, most universities (approximately 81 %) provide some form of diversity training (McCauley et al. 2000). Existing research suggests that diversity training that focuses on education through disconfirming stereotypes (Blair 2002; Rudman et al. 2001) and increasing awareness of implicit bias (Carnes et al. 2012) may result in more positive attitudes toward referent groups. However, the effectiveness of such training is seldom evaluated (McCauley et al. 2000). Further, there is little research examining which approaches are most effective (Kalev et al. 2006). There is clearly a need to evaluate the effect of diversity initiatives, particularly in applied settings in which such training will ultimately be employed, and to provide research-based recommendations for future training programs (Paluck 2006).

One way to evaluate these programs is by assessing changes in explicit or implicit attitudes after exposure to diversity training. Explicit attitude measures, or self-reports, are easy to administer but are vulnerable to threats to validity, such as social desirability and experimenter demand effects (Wittenbrink and Schwarz 2007). Implicit attitude measures, such as the Implicit Association Task (IAT: Greenwald et al. 1998) or the Go/No-Go Association Task (Nosek and Banaji 2001), assess attitudes while reducing issues of response distortion. Implicit attitude measures are thought to reflect automatic activation of unconscious knowledge. With implicit measures, participants are not informed of what is being assessed and conscious introspection is not required, thereby minimizing reactivity and reducing threats to validity (Greenwald and Banaji 1995). Although the few existing studies on diversity training have used explicit measures, the present study examined changes in both explicit and implicit attitudes in response to gender diversity training for faculty in academic STEM disciplines.

## 1.1 Attitudes toward women in STEM

The underrepresentation of women in STEM is observed at multiple levels in education, including high school, college, graduate school, and in academic positions (National Research Council 2007). Increasing the representation of women in acad-

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emic STEM would increase diversity, which produces benefits for productivity and innovation (Woolley et al. 2000). The lack of representation is the result of numerous factors, including prescriptive gender stereotypes (Fuchs et al. 2004; Prentice and Carranza 2002), discrimination in the form of either benevolent sexism or hostile sexism (Christopher and Wojda 2008), stereotype and social identity threat (Steele and Aronson 1995; Murphy et al. 2007; Sekaquaptewa and Thompson 2002), and even unconscious gender-stereotypical cues in the environment (Cheryan et al. 2009). Strong gender stereotypes decrease women's identification with and career aspirations in science (Cundiff et al. 2013).

Although most people report positive explicit attitudes toward women (Eagly and Mladinic 1994), weak implicit associations between women and STEM fields may partly explain why women faculty are paid less, promoted more slowly, receive fewer honors, and are given fewer leadership positions than men (National Research Council 2007). However, people are often unaware that unconscious associations can influence their behavior. As a result, despite the fact that they disagree with overt prejudice, discrimination can occur if they do not consciously engage their egalitarian beliefs (Devine 1989). Applied to the current study, implicit association tasks reveal that most people associate men with science more strongly than women with science (Nosek et al. 2002b). Men and women in academia may have egalitarian beliefs, but if they fail to recognize that they possess discrepant implicit associations or if they do not understand the effect these implicit associations can have, they can inadvertently engage in discriminatory behaviors.

However, implicit associations can be influenced by the environment. For example, exposure to biographical information about famous women leaders, exposure to women in faculty and leadership positions, and a greater proportion of women in the academic environment reduced female students' automatic stereotyping about their in-group (Dasgupta and Asgari 2004). These findings suggest that automatic stereotypes regarding women in fields typically associated with men can be changed, and that implicit associations can change. However, research has rarely examined the effect of diversity training on implicit attitudes (Bezrukova et al. 2012). The present study investigates whether diversity training changes implicit associations that disadvantage women in STEM, which could reduce discrimination.

### 1.2 Effects of diversity training

A common goal of diversity training is to improve individuals' attitudes toward minority groups (Bezrukova et al. 2012; Paluck 2006). Previous research on educational interventions has examined some outcomes related to this goal. For example, increasing awareness of implicit bias (Hillard et al. 2013) may improve attitudes toward minority groups. Similarly, a workshop intended to raise awareness of gender bias and provide self-efficacy to avoid bias for STEM faculty was largely successful (Carnes et al. 2012). Faculty who attended the workshop had increased awareness of bias 4–6 months later, and those who were interviewed also either described plans to change behaviors or had already implemented personal changes to reduce bias (Carnes et al.

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2012). These encouraging findings suggest that diversity training can improve the STEM climate for women and increase gender equity.

However, it is possible for diversity training to be ineffective, as a number of approaches have revealed only modest to weak results. For example, increased contact through immersion does not result in significant changes (Rudman et al. 2001), training people to suppress their stereotypical thinking actually increases activation of stereotypes and avoidance of target group members (Rudman et al. 2001; Macrae et al. 1994), and forced diversity training can result in backlash because of reactance (Rudman et al. 2001). Furthermore, when efforts are made to increase representation of a minority group, high-prejudice majority group members could perceive a threat to group or individual identity, resulting in more discrimination (Fein and Spencer 1997).

Initiatives that have been shown to work well include those that help attendees appreciate differences rather than trying to eliminate or ignore them; diversity education that focuses on bias education and fear reduction has also been successful (Rudman et al. 2001). Rather than trying to suppress thoughts about a target group, activities that make use of subgrouping and other methods to encourage *more* thinking about the underlying reasons for stereotypes are effective in reducing stereotypes (Macrae et al. 1994; Richards and Hewstone 2001). These forms of deeper cognitive elaboration are more likely to change personal attitudes rather than surface-level extrapersonal associations (Richards and Hewstone 2001). Although immersion is generally not effective, automatic bias can be effectively reduced through exposure to exemplars, especially those in leadership positions or those who have attributes that are deemed desirable by society (Dasgupta and Asgari 2004).

### 1.3 Overview of the present study

The purpose of this research was to investigate the effect of gender diversity training on explicit attitudes and implicit associations of STEM faculty. Although the IAT is commonly used to measure implicit attitudes, some suggest that the IAT measures normative associations (Han et al. 2010) or extrapersonal associations (Olson and Fazio 2004). A personalized version of the IAT reduces the effects of normative or extrapersonal associations resulting in a more accurate measurement of personal implicit attitudes (Han et al. 2010; Nosek and Hansen 2008; Olson and Fazio 2004). For the present research, we developed a personalized implicit measure to assess associations between women and science/engineering.

To further test our new measure, we examined correlations among explicit measures, implicit measures, and individual traits. A number of studies have revealed no relationship between implicit and explicit measures (Fazio and Olson 2003; Hofmann et al. 2005; Karpinski and Hilton 2001; Nosek et al. 2002a, b). This dissociation suggests that implicit measures might reveal information about attitudes that explicit measures may not uncover, especially in strong situations where explicit responding is more likely to be guided by social norms (King and Bruner 2000; Mischel 1977; Mortel 2008). Based on this research, we expected weak correlations among implicit and explicit responses (Hypothesis 1). Diversity training aims to influence personal associations more than extrapersonal associations (e.g., Bezrukova et al. 2012; Paluck 2006). Consequently,

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we expected that personalized implicit associations would improve after the diversity training but would not change in a control group (Hypothesis 2). Past research shows that people generally report positive attitudes toward women on explicit measures (e.g., Eagly and Mladinic 1994). Thus, we hypothesized that we would find positive explicit attitudes (Hypothesis 3a), which would improve after diversity training (Hypothesis 3b).

## 2 Method

### 2.1 Participants

STEM faculty ($N = 251$) from four diverse midwestern universities participated. Consistent with past research using paper-based implicit measures (Teachman and Brownell 2001), 17 participants (7 %) were excluded due to error rates greater than 35 %. Our final $N$ was 234, with the same proportion of men ($n = 153$, 73 %) and women ($n = 58$, 28 %) as our original sample. Participants' average age was 48, with a range of 29–75 years. Participants included 84.4 % Caucasians (White, non-Hispanic), 6.4 % Asian/Pacific Islanders, 5.7 % African Americans, 0.7 % Hispanics, and 2.8 % other. Participants were distributed across rank with 26.2 % at the rank of assistant professor, 29.8 % at the rank of associate professor, and 23.9 % at the rank of full professor (19.1 % were other, such as instructor, lecturer, or administrative).

### 2.2 Procedure

Random matched assignment was used to ensure both that an even number of experimental ($n = 127$, 17 departments) and control groups ($n = 107$, 11 departments) were assigned to each university, and to ensure an even distribution of physical science, social science, technology, engineering, and mathematics departments within each group. After being assigned to condition, participants gave informed consent and were administered the implicit and explicit measures. Participants completed a trait survey and practiced the implicit measure to ensure they understood directions. The implicit measure was presented as "brief, timed categorization tasks." Participants then completed the implicit measure followed by the explicit attitude measures. After completing the pre-training measures, participants in the experimental condition were exposed to the half-hour diversity training presentation, whereas participants in the control condition attended a regularly scheduled department faculty meeting.

The diversity training presented data on the representation of women in STEM nationally and locally; the local workplace climate; research on the effects that implicit bias has on hiring, promotion, and retention; and ways to overcome bias. Content was informed by research on diversity training, persuasion research (Schneider et al. 2009), and teaching methods aimed at reducing threat and increasing interest and efficacy (Hillard et al. 2012). Specific evidence-based recommendations used in the development of the presentation included non-confrontational, research-based content, the use of inclusive language, and the introduction of practical remedies for overcoming bias (Hillard et al. 2012).

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## 2.3 Measures

### *2.3.1 Implicit associations*

The Go/No-Go Association Task (GNAT) is a variant of the IAT (Nosek and Banaji 2001) that assesses association strength toward a single target concept rather than dichotomous targets. Participants are instructed to respond (Go) when a stimulus item fits in either the target or attribute category or do nothing (No Go) if the item fits in neither category. However, the GNAT may be influenced by extrapersonal associations because it employs the same general IAT category labels (*pleasant* vs. *unpleasant*). We developed and administered a personalized GNAT (PGNAT; using labels *I like* vs. *I don't like*) based on procedures for personalizing the IAT (Olson and Fazio 2004). In addition, we administered paper-based (rather than computer-based) GNAT and PGNAT measures based on procedures used for the paper-based IAT (Nosek and Lane 1999), which has been shown to have predictive validity (Teachman and Brownell 2001). The dependent measure in a paper-based implicit test is the difference in the number of items correctly categorized in both parts in a specified amount of time, typically 20–30 s (Vargas et al. 2007), during which participants are unable to sort all stimuli items.

Our paper-based GNAT and PGNAT used a single target category (female scientist/engineer) and a single attribute category (GNAT: *pleasant* or *unpleasant*; PGNAT: *I like* or *I don't like*) at the top of the test (see Fig. 1). When a stimuli item belonged in either the target or attribute category, the participants were to circle the item (Go). If an item did not belong to either category participants were to skip the item (No Go) and move to the next item. They were instructed to draw a line below the last item they categorized. Participants were timed for 15 s per block. Each pairing of a target and attribute category was considered one block (e.g., pleasant paired with female scientist), and both stereotype congruent (e.g., female scientist paired with *unpleasant/I don't like*) and incongruent (e.g., female scientist paired with *pleasant/I like*) were presented for both the GNAT and PGNAT. The presentation of the GNAT and PGNAT and pairing of category labels within each task were counterbalanced across participants.

Stimuli items were a combination of words (i.e., pleasant and unpleasant words; Greenwald et al. 1998; Nosek et al. 2002b; Olson and Fazio 2004) and symbols (i.e., male and female forms; Nosek et al. 2007) from past research. Science and non-science symbols were overlaid on top of the gender forms. We conducted a pilot study to validate the symbols, which yielded consistency in the interpretation of the science and non-science symbols. An additional symbol was added to represent engineering.

The number of items correctly categorized in the time allowed reflects speed, whereas the number of items correctly categorized reflects accuracy. To obtain difference in sensitivity between the in/congruent blocks we used the following algorithm: $[(\pm \text{ max value } (A,B))/(\text{min value } (A,B))] \times (\text{square root of } |(A - B)|)$ (Nosek and Lane 1999), where A represents the number of items correctly categorized in the incongruent block (female scientist paired with *pleasant/I like*) and B represents the number of items correctly categorized in the congruent block (female scientist

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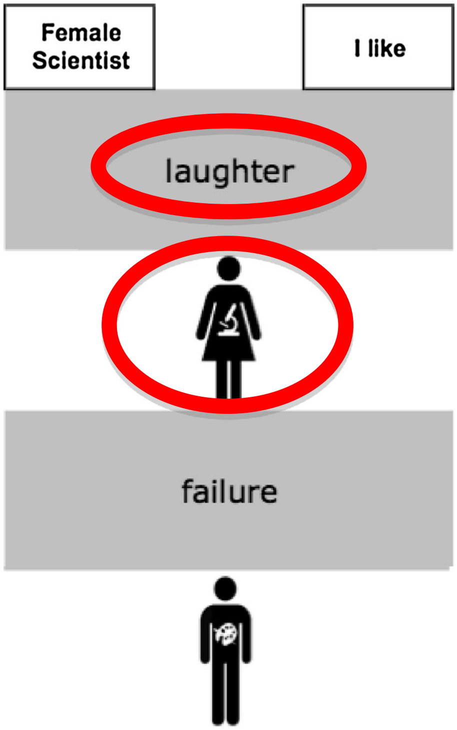


**Fig. 1** Sample stimuli used for the PGNAT

paired with *unpleasant/I don't like*). When A exceeded B, no changes were made; when B exceeded A, we took its inverse, such that positive GNAT or PGNAT scores indicated more favorable implicit attitudes toward women in STEM, and negative GNAT or PGNAT scores indicated more negative implicit attitudes toward women in STEM.

Error rates are also examined to produce a more reliable score on implicit measures. In their study utilizing a paper-based IAT, Teachman and Brownell (2001) omitted participants with an error rate of greater than 35 %. This is somewhat more liberal than the standard error rate omission of 20 % generally seen in computer-based IAT administration (Olson and Fazio 2004). Given the fact that the paper-based implicit measure, by its design, does not provide error feedback, it is logical to use this less stringent recommendation. In the current study, 17 participants (7 %) were omitted due to error rates greater than 35 %, resulting in the final *N* of 234. This is less than the proportion omitted by Teachman and Brownell (i.e., 18 %).

### *2.3.2 Explicit attitudes*

Participants completed three explicit attitude scales both before and after the diversity training (i.e., experimental group) or meeting (i.e., the control group). We assessed participants' favorable beliefs about women in STEM. Participants completed eight semantic differential items, adapted from Olson and Fazio (2004), by circling a num-

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ber from 1 (e.g., *weak*) to 5 (e.g, *strong*), indicating which number best reflected their beliefs regarding women scientists. Items on this scale were scored so that higher scores reflect more favorable beliefs about women in STEM ($\alpha = .92$ pre-test and .93 post-test). We also developed nine stereotype statements, such as "Women are worse at math than men" (National Research Council 2007). Participants indicated their agreement with items on a scale of 1 (*strongly disagree*) to 5 (*strongly agree*). The stereotype endorsement scale was scored so that higher scores reflect less endorsement of stereotypes ($\alpha = .83$ pre-test and .87 post-test). Lastly, participants used a feeling thermometer to rate the degree of warmth they felt toward three groups (*female scientists*, *female engineers*, and *women*) on a scale from 0 (*very cold/unfavorable*) to 100 (*very warm/favorable;* $\alpha = .88$ pre-test and .90 post-test).

### *2.3.3 Trait measures*

Participants completed four measures of traits that might be related to their propensity to change attitudes in response to diversity training. For all trait scales, participants indicated their agreement with items on a scale of 1 (*strongly disagree*) to 5 (*strongly agree*). Participants rated three items to assess trait-level social desirability (Crowne and Marlowe 1960; e.g., "I am always willing to admit it when I make a mistake;" $\alpha = .58$). Participants completed to two items to assess reactance (Hong and Faedda 1996; e.g., "Advice and recommendations induce me to do just the opposite;" $\alpha = .72$). Participants rated three items to measure egalitarianism (Katz and Hass 1988; e.g., "There should be equality for everyone because we are all human beings;" $\alpha = .64$). Participants completed two pairs of "should" and "would" statements, a total of four items, to measure self-discrepancy (Monteith and Voils 1998; e.g., "I should enjoy collaborating with a woman on a research project" and "I would enjoy collaborating with a woman on a research project;" $\alpha = .71$).

## 3 Results

### 3.1 Correlational analyses

Table 1 presents correlations among trait measures (social desirability, reactance, egalitarianism, and self-discrepancy), implicit association scores (GNAT, PGNAT), and explicit attitude scores (favorable beliefs, stereotype endorsement, and feeling thermometer) for the sample as a whole at pre-test. Consistent with Hypothesis 1, none of the implicit and explicit measures correlated significantly, all $ps > .29$. The trait scales also did not correlate significantly with the implicit measures (all $ps > .22$). There were, however, several significant correlations among traits and explicit attitudes. Social desirability was related to less stereotype endorsement and warmer feelings toward women in STEM. Reactance was related to more stereotype endorsement. Egalitarianism correlated with all three explicit attitude scales,

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**Table 1** Correlations among traits, implicit associations, and explicit attitudes at pre-test

| | Measure | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Social desirability | | | | | | | | |
| 2 | Reactance | −.26** | | | | | | | |
| 3 | Egalitarianism | .29** | −.14* | | | | | | |
| 4 | Self-discrepancy | .03 | −.01 | .08 | | | | | |
| 5 | GNAT | −.07 | −.08 | .00 | .03 | | | | |
| 6 | PGNAT | .07 | −.03 | .04 | .05 | .10 | | | |
| 7 | Favorable beliefs | .07 | −.06 | .18** | −.18** | .07 | .04 | | |
| 8 | Stereotype | .26** | −.24** | .38** | .02 | .03 | −.03 | .38** | |
| 9 | Feeling thermometer | .22** | −.08 | .23** | .05 | −.02 | .04 | .46** | .48** |

such that those who were more egalitarian were more positive toward women in STEM.

## 3.2 Implicit associations

To test Hypothesis 2 that diversity training improves personalized implicit associations, a series of 2 (Time: pre-test, post-test) ×2 (Group: control, experimental) × 2 (Gender: men, women) analyses of variance (ANOVAs) were conducted on implicit measures.[1]

### *3.2.1 GNAT*

With GNAT scores as the dependent variable, there were no significant main effects of Time or Gender, $ps > .50$, but there was a marginal main effect for Group, $F(1, 207) = 2.77$, $p = .10$. The control group had marginally lower scores ($M = 0.31$, $SD = 3.18$) than the experimental group ($M = 0.65$, $SD = 2.79$). There was a significant Time by Group by Gender interaction, $F(1, 207) = 4.53$, $p = .04$. As shown in Fig. 2a, women's implicit associations in the control group increased marginally, $t(25) = -1.69$, $p = .10$, whereas men's associations in the control group did not change significantly, $t(66) = 1.26$, $p = .21$. In the experimental group (Fig. 2b), implicit associations did not significantly change for women, $t(31) = 0.29$, $p = .78$, or men, $t(85) = -1.36$, $p = .18$. There were no other significant interactions, all $ps > .26$. Thus, the GNAT revealed no significant effect of training, which is consistent with Hypothesis 2.

[1] For men, some traits were correlated with implicit measures. Social desirability correlated significantly with the pre-test GNAT and PGNAT ($r$'s $= -.22$ and .23, respectively), and self-discrepancy correlated with the pre-test PGNAT ($r = .22$). There were no significant correlations between traits and implicit measures at post-test. ANCOVAs controlling for traits did not change the pattern of results.

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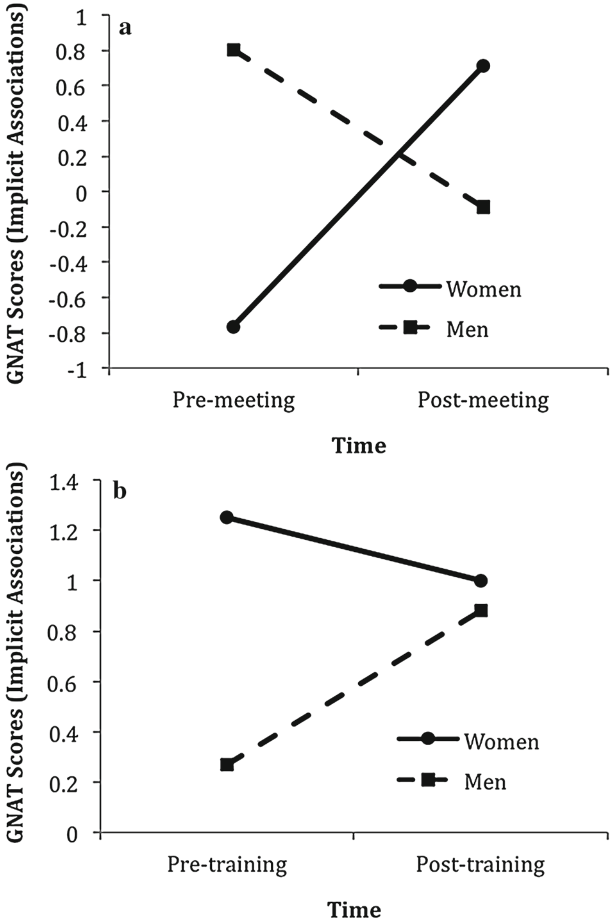


**Fig. 2** **a** Control group GNAT scores, by time and gender. **b** Experimental group GNAT scores, by time and gender

*3.2.2 PGNAT*

With PGNAT scores as the dependent variable, there was not a significant main effect of Group, $p = .49$, but there were marginal effects of Time, $F(1, 203) = 2.48$, $p = .12$, and Gender, $F(1, 203) = 3.09$, $p = .08$. Both groups appeared to improve over time from pre- (control: $M = 0.03, SD = 4.08$; experimental: $M = 0.14, SD = 3.19$) to post-test (control: $M = 0.63, SD = 2.64$; experimental: $M = 0.90, SD = 3.17$). Men's overall personalized implicit associations ($M = 0.25, SD = 2.62$) were marginally lower than women's overall personalized associations ($M = 0.93, SD = 1.86$). There were no significant interactions, all $p$s $> .39$. To further investigate the effects of training over time by gender, we conducted planned comparisons to directly test Hypothesis 2. In the control group (Fig. 3a), personalized implicit associations for men and women did not change over

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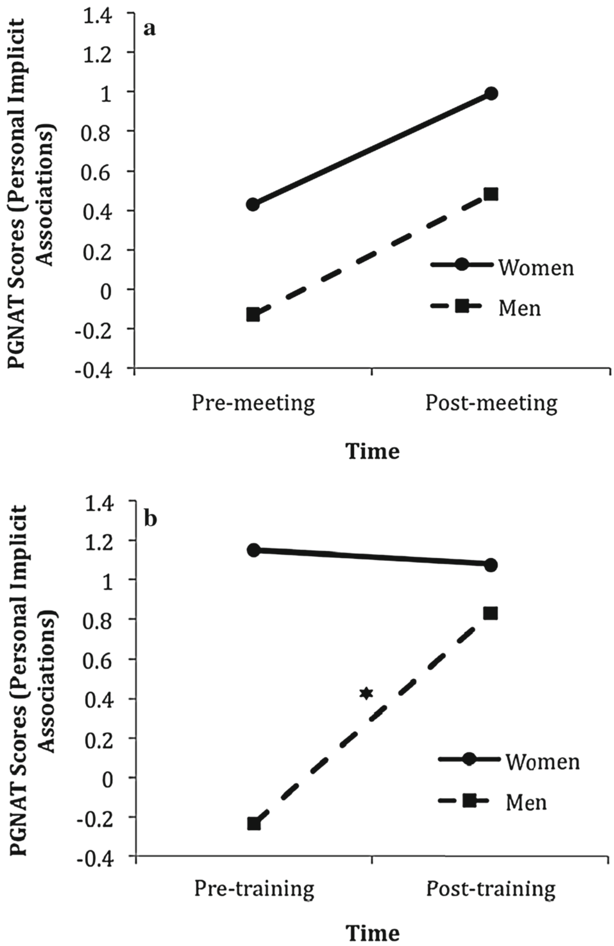


**Fig. 3** **a** Control group PGNAT scores, by time and gender. **b** Experimental group PGNAT scores, by time and gender. $^{*}p < .05$

time, *p*s > .30. In the experimental group (Fig. 3b), women's personalized implicit associations remained positive over time, $t(30) = 0.11$, $p = .92$, whereas men's personalized associations increased significantly, $t(149) = -2.42$, $p = .02$. Further analysis revealed that men's personalized implicit associations were marginally lower than women's at pre-test, $F(1, 117) = 3.26$, $p = .07$; however, there was no difference between men and women at post-test, $F(1, 115) = 0.14$, $p = .71$. Thus, men's implicit associations improved and became more similar to women's associations at post-test. This finding suggests that diversity training improved men's personalized implicit associations of women in STEM, which is partially consistent with Hypothesis 2.

To further examine the effect of training on men specifically and to account for the dependency in measures, we conducted dependent-samples $t$-tests for men only, com-

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**Table 2** Pre- and post-test adjusted means (standard error) for explicit measures, by group and gender

| | Pre-training | | Post-training | |
|---|---|---|---|---|
| | Men | Women | Men | Women |
| *Control* | | | | |
| Favorable beliefs | $3.92^{a}$ (0.09) | $4.19^{b}$ (0.14) | $3.91^{a}$ (0.09) | $4.17^{b}$ (0.14) |
| Stereotype endorsement | $4.00^{a}$ (0.06) | $4.41^{b}$ (0.09) | $3.95^{a}$ (0.06) | $4.41^{b}$ (0.09) |
| Feeling thermometer | $71.47^{a}$ (2.02) | $81.80^{b}$ (3.22) | $70.13^{a}$ (2.07) | $83.09^{b}$ (3.29) |
| *Experimental* | | | | |
| Favorable beliefs | $3.78^{a}$ (0.08) | $4.23^{b}$ (0.14) | $3.75^{a}$ (0.08) | $4.33^{b}$ (0.14) |
| Stereotype endorsement | $3.98^{a}$ (0.05) | $4.21^{b}$ (0.09) | $3.91^{a}$ (0.05) | $4.13^{b}$ (0.09) |
| Feeling thermometer | $72.45^{ac}$ (1.76) | $80.53^{b}$ (3.03) | $71.13^{ad}$ (1.81) | $80.30^{b}$ (3.10) |

The stereotype endorsement scale is reverse-scored so that higher scores indicate less endorsement of stereotypes

$^{a,b}$ Different superscripts denote significant differences, $p < .01$

$^{c,d}$ Different superscripts denote significant differences, $p < .05$

paring the control and experimental groups. In the control group, men's personalized implicit associations did not change significantly (pre-test: $M = -0.26$, $SD = 5.25$; post-test: $M = .48$, $SD = 2.75$), $t(64) = -1.07$, $p = .29$. In the experimental group, men's personalized implicit associations improved significantly from pre- ($M = -0.23$, $SD = 3.20$) to post-test ($M = 0.83$, $SD = 3.46$), $t(149) = -2.43$, $p = .02$. These findings provide further partial support for Hypothesis 2.[2]

## 3.3 Explicit attitudes

To test Hypothesis 3a that explicit attitudes would be positive, we examined whether pre-test explicit attitudes were above the mid-point on the scale using a one-sample $t$-test. The favorable beliefs scale, $t(233) = 46.34$, stereotype scale, $t(233) = 65.15$, and feeling thermometer, $t(233) = 257.45$, were significantly above the mid-point on their scales, all $ps < .01$. Consistent with Hypothesis 3a, explicit attitudes toward women were generally positive. To test Hypothesis 3b that explicit attitudes would improve over time, a series of 2 (Time: pre-test, post-test) × 2 (Group: control, experimental) × 2 (Gender: men, women) analyses of covariance (ANCOVAs) were conducted for each measure, controlling for traits. Table 2 includes the pre- and post-test means for explicit attitudes by Group and Gender. Overall, explicit attitudes were positive toward women in STEM, supporting Hypothesis 3a, but there was no significant improvement from pre- to post-test, contrary to Hypothesis 3b.

[2] We conducted a simple slopes analysis comparing men only in the experimental and control groups. Group was entered in the first step of a linear regression equation along with the pre-test PGNAT score. The interaction term of group by pre-test PGNAT score was added in step 2. The interaction term of group by pre-test PGNAT score explained a marginal amount of variance ($\Delta R^2 = 0.02$) in the post-test PGNAT score, $\Delta F(1, 146) = 2.69$, $p = .10$. The slopes of the experimental and control lines were marginally different, suggesting that the two groups changed differently over time. The lack of significance is likely due to low power. It is probable that a larger sample size would yield significant results.

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### *3.3.1 Favorable beliefs*

There were no main effects of Time or Group, $ps > .30$, but there was a significant main effect of Gender, $F(1, 198) = 11.02$, $p = .001$. Men ($M = 3.80$, $SD = 0.73$) reported significantly less favorable attitudes toward women in STEM than women ($M = 4.30$, $SD = 0.65$). There were no significant interactions, all $ps > .27$.

### *3.3.2 Stereotype endorsement*

There was not a significant main effect of Time, $p = .38$, but there were significant main effects for Group, $F(1, 202) = 3.97$, $p = .05$, and Gender, $F(1, 202) = 19.40$, $p < .001$. Those in the control group ($M = 4.19$, $SD = 0.08$) were less likely to endorse stereotypes than those in the experimental group ($M = 4.06$, $SD = 0.07$), and men ($M = 3.96$, $SD = 0.06$) were more likely to endorse stereotypes than women ($M = 4.29$, $SD = 0.09$). There were no significant interactions, all $ps > .14$.

### *3.3.3 Feeling thermometer*

There was not a significant main effect for Group, $p = .84$, but there was a marginal effect for Time, $F(1, 194) = 3.13$, $p = .08$, and a significant main effect for Gender, $F(1, 194) = 13.95$, $p < .001$. Men ($M = 71.30$, $SD = 1.92$) reported significantly colder feelings than women ($M = 81.43$, $SD = 3.16$). This effect was qualified by a significant Time by Gender interaction, $F(1, 194) = 4.04$, $p = .05$. Men's feelings toward women in STEM grew colder from pre- ($M = 71.96$, $SD = 1.89$) to post-test ($M = 70.63$, $SD = 1.94$), whereas women's feelings toward women in STEM did not change from pre- ($M = 81.17$, $SD = 3.13$) to post-test ($M = 81.70$, $SD = 3.20$). There were no other significant interactions, all $ps > .38$.

## 4 Discussion

Stereotypes and implicit bias negatively affect the hiring, retention, and promotion of women in STEM. This research investigated the effect of gender diversity training on faculty's implicit and explicit attitudes toward women in STEM. We developed a new measure for implicit associations toward women in STEM and found that men's personalized implicit associations improved following diversity training. We also found that, while both men and women faculty reported positive explicit attitudes, men had less positive attitudes toward women in STEM.

As predicted in Hypothesis 1, we did not find significant correlations between the explicit and implicit measures. These results are consistent with previous research showing no correlation or weak correlations between implicit and explicit assessments (Fazio and Olson 2003; Hofmann et al. 2005; Karpinski and Hilton 2001; Nosek et al. 2002a, b). This finding lends support to the notion that implicit measures might provide additional information about people's attitudes that is not captured by explicit measures, particularly in strong situations where social norms might result in socially desirable responding.

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After participating in diversity training, we expected more positive, personal implicit associations toward women in STEM by faculty in the experimental group (Hypothesis 2), and this hypothesis was partially supported. Women's implicit associations started off and remained positive, as reflected in both the GNAT and the PGNAT. Men's GNAT scores did not change, but their PGNAT scores did change. After diversity training, men had a significant increase in personal, positive implicit associations toward women in STEM. Comparatively, women had more positive initial implicit associations, which did not change, whereas men's scores had room to improve. Personal associations for men in the experimental group did improve significantly, whereas there was no change for men in the control group, indicating a positive effect of the diversity training. The GNAT did not provide evidence of change for men or women. Consistent with previous research, this finding suggests that personalized measures of implicit associations are more sensitive to changes in personal associations than traditional implicit measures. Cognitive elaboration, which is elicited as a result of participation in effective diversity training, is more likely to result in personal attitude change (Richards and Hewstone 2001). Our diversity training shared several key components with the workshop implemented by Carnes et al. (2012), including the goals of increasing awareness of implicit bias and motivation to change, providing strategies that increase self-efficacy, and setting expectations for positive outcomes. It is noteworthy that, despite not including more time-intensive activities as in Carnes et al. (2012), our brief training session changed men's personalized implicit associations. In addition, the present study is the first to our knowledge to measure implicit associations following diversity training.

Explicit attitude measures may be vulnerable to response distortion, particularly when evaluations about the attitude object are especially subject to social norms. As a result, we expected to find generally positive explicit attitudes toward women in STEM (Hypothesis 3a), and we expected attitudes to improve following training (Hypothesis 3b). Hypothesis 3a was supported. All three explicit scales revealed positive attitudes toward women in STEM. Men and women reported explicit attitudes that were significantly more positive than the mid-point for each scale. Hypothesis 3b was not supported. Explicit attitude scores did not change significantly following training, compared to the control group. The tendency toward ceiling effects in our explicit measures may have worked against finding attitude improvement. However, we uncovered significant differences in explicit attitudes reported by men and women. Men reported less positive attitudes toward women, more endorsement of stereotypes, and cooler feelings toward women in STEM. These findings suggest that gender diversity training is still needed in this area. Because social desirability correlated with the stereotype endorsement scale and the feeling thermometer, participants may have been motivated to respond in a socially desirable way on the explicit measures. If this is the case, the findings of this study also support the assertion that a personalized implicit measure of attitudes might reveal differences in situations where social norms exert considerable pressure on participants, as is the case when the topic is highly sensitive or controversial (King and Bruner 2000; Mischel 1977; Mortel 2008). Together, these findings suggest that men in STEM, in particular, might benefit from training on implicit bias. However, we believe that it is important to provide gender diversity training to both men and women, because everyone

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is susceptible to the influence of implicit bias (Devine 1989; Moss-Racusin et al. 2012).

A potential limitation in this study was the use of a paper-based rather than a computer-based GNAT and PGNAT. Computer-based implicit software allows for more precision by using reaction time to assess implicit associations. However, the present research is one of very few studies that have used multiple implicit measures in the same experimental setting or study. Bar-Anan and Nosek (in press) examined numerous indirect measures simultaneously, but the measures were all based on computerized assessments. In their study, the IAT, a brief IAT, and the GNAT were all moderately correlated amongst themselves, suggesting that the computerized GNAT provides convergence with other, more traditional computerized implicit measures. However, there has not been a comparison of the paper-based GNAT with these computerized measures. Paper-based measures of the IAT have been developed and have been found to have predictive validity (Teachman and Brownell 2001). Although such research has yet to be conducted on the GNAT, one benefit of the GNAT as a tool over the IAT is the capacity to examine associations of a single target object, as opposed to comparing groups. Future research should employ multiple indirect measures, which will help to expand the tools available to measure implicit associations as well as aiding in the refinement of relevant theory. Specifically, future research should employ a computer-based personalized implicit association measure and compare it with this paper-based task to investigate its precision and convergent validity.

There were no significant changes in the explicit measures from pre- to post-training. One explanation is that participants may have recalled their prior responses, given the short time span between completing the measures (about 30 min). Use of parallel forms or a longitudinal methodology would address this limitation. Another explanation for the lack of change in explicit measures is demand characteristics. That is, participants may have been motivated, either by awareness of the purpose of the study or a desire to appear non-prejudiced, to provide socially desirable responses. This concern is partly addressed by the inclusion of implicit measures, but additional analyses examined situational cues, which may have increased demand characteristics. Specifically, we estimated a series of multilevel models including effects of time, gender, and proportion of women present during training. In addition to the significant effect of faculty gender found in previous results, the final models showed an additional significant effect of proportion of women present for training on favorable beliefs, $b = 0.72$, $p < .01$, which suggests that the proportion of women present during training increased favorable beliefs toward women in STEM within that training group. Thus, demand characteristics may have influenced responses to the explicit measures. This effect was not significant for implicit measures, which suggests that implicit measures may be less responsive to demand characteristics. In addition, demand characteristics are specific to the immediate study, which suggests that the effects would not be found outside of the study. However, there is evidence to suggest that diversity training benefits can be lasting. Carnes et al. (2012) found that several months after participating in their bias awareness workshop, participants reported reduced bias and described plans to change behaviors. Thus, although demand characteristics are clearly a concern in any research on diversity training, the inclusion of implicit

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measures—as in the present study—may reduce these concerns, and evidence from previous research indicates that these changes may not be limited to the experiment.

### 4.1 Implications

This study demonstrates that implicit associations can change as a result of participation in a brief diversity training session. Implicit measures may be preferable to explicit attitude measures when there is reason to believe that participants might engage in response distortion, particularly when assessing personal attitudes regarding topics that are sensitive, controversial, or when the situation is strongly prescriptive. This research revealed that a personalized GNAT is effective at detecting changes in personal implicit associations and that men's personal implicit associations changed as a result of diversity training. The paper-based PGNAT developed for use in this study can be used to measure associations in future educational interventions, particularly when the use of a computer is not possible or practical.

Because our diversity training had positive effects, we can make some recommendations about future educational interventions addressing implicit bias. To be effective, presentations should include numerical representation information and local (college) climate indicators. Importantly, these presentations should be research-driven (e.g., including stereotype-disconfirming information vs. emotional or moral appeals; Hewstone et al. 1992) and should provide steps to address bias. For example, presenters can discuss the importance of awareness of bias as a first step to avoid implicit bias (Carnes et al. 2012; Devine 1989; Monteith et al. 2010) or describe perspective taking as a method to reduce bias (Todd et al. 2011). Information that recognizes and appreciates differences (e.g., multiculturalism) is more effective than minimizing differences (e.g., colorblindness; Wolsko et al. 2000).

To reduce reactance in diversity training participants, it is recommended that presenters use non-confrontational language. Both the use of a non-confrontational message and avoiding negatively evaluating bias may be equally effective (Czopp et al. 2006; Hillard et al. 2013). To reduce threat and increase group cohesion, presenters should use inclusive language (e.g., we, our, men *and* women) in presentations and should also explicitly acknowledge that everyone holds biases (Morton and Rosse 2011). Maintaining a research focus also helps to minimize threat (Morris et al. 2011). Future research might also consider the gender of the presenter. Research has indicated that a majority group member challenging stereotypes is as effective in producing attitude change but also produces more positive evaluations of the messenger (vs. when the message comes from a minority group member; Czopp and Monteith 2003). Finally, making diversity training optional rather than mandatory, as was done in this study and Carnes et al. (2012), may reduce reactance and increase personal buy-in.

Interestingly, we found that implicit attitudes were closer to a neutral point. However, participation in a training session on implicit bias had a positive effect on personal implicit attitudes. Combined with the continued underrepresentation of women in STEM fields, this finding suggests that there is still work to be done to improve the climate for STEM women. Education and awareness of the biases that occur toward this group could help to create a warmer climate, resulting in more women entering into, remaining in, and advancing through the ranks of STEM fields.

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## 5 Conclusion

More research is needed on the effectiveness of educational interventions to improve the STEM climate for women, and this study addressed this need in two ways. First, we developed an effective tool for measuring the effects of such interventions. Second, we found that the diversity training had a positive effect on men's personal implicit associations toward women in STEM. Because implicit associations can affect behavioral outcomes, the change in implicit associations found in this study may help to reduce stereotype-driven behaviors and foster a warmer climate for women in STEM.

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