Research Article

Signaling Threat

How Situational Cues Affect Women in Math, Science, and Engineering Settings

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ABSTRACT—*This study examined the cues hypothesis, which holds that situational cues, such as a setting's features and organization, can make potential targets vulnerable to social identity threat. Objective and subjective measures of identity threat were collected from male and female math, science, and engineering (MSE) majors who watched an MSE conference video depicting either an unbalanced ratio of men to women or a balanced ratio. Women who viewed the unbalanced video exhibited more cognitive and physiological vigilance, and reported a lower sense of belonging and less desire to participate in the conference, than did women who viewed the gender-balanced video. Men were unaffected by this situational cue. The implications for understanding vulnerability to social identity threat, particularly among women in MSE settings, are discussed.*

In order to maintain physical integrity, people must attend to situational cues that may signal various threats in the environment. For example, the smell of fire can alert people to the possibility of physical threat in the environment, prompting them to scan for signs of this potential danger. Similarly, a situational cue—such as being outnumbered in an environment—may alert people to the possibility of psychological threat, such as isolation or ostracism.

One important psychological threat that people may be vigilant to is social identity threat—a threat that occurs when people recognize they may be devalued in a setting because of one of their social identities (Abrams & Hogg, 1999; Crocker, Major, & Steele, 1998; Major & O'Brien, 2005; Tajfel & Turner, 1986). In the present research, we examined what we term the *cues hypothesis*, investigating whether one subtle situational cue can trigger objective and subjective experiences of social identity

threat among traditionally stereotyped groups even if the setting exhibits no overt evidence of prejudice or discrimination.

VULNERABILITY TO SOCIAL IDENTITY THREAT

Social identity threat is a broad threat that people experience when they believe that they may be treated negatively or devalued in a setting simply because of a particular social identity they hold (Abrams & Hogg, 1999; Crocker et al., 1998; Major & O'Brien, 2005; Tajfel & Turner, 1986). Although stereotype threat—a type of social identity threat that occurs when one fears being judged in terms of a group-based stereotype (Steele, 1997; Steele & Aronson, 1995)—is a well-documented phenomenon, it remains unclear what makes a person vulnerable to experiences of stereotype and other social identity threats. Many stereotype-threat researchers have argued that targets' reduced psychic resources—stemming from low self-esteem, low expectations, weak persistence, evaluation apprehension, or anxiety—render them vulnerable to deficits in performance when they experience stereotype threat (e.g., Ashcraft, 2002; Chapell & Overton, 2002; Stangor, Carr, & Kiang, 1998). However, we contend that a person's vulnerability to identity threat need not be inherent to him or her. Instead, situational cues may contribute to experiences of social identity threat among groups potentially stereotyped in a setting—even when targets are interested, confident, proven achievers in the relevant domains.

THE POTENTIAL POWER OF SITUATIONAL CUES

Every person is a member of multiple social groups, and thus everyone has multiple social identities. Race, gender, socioeconomic status, and political and religious affiliations are examples of social identities that people carry with them. Yet the salience of people's group memberships varies depending on the situational cues in a setting. In fact, previous research has shown that people often see themselves in terms of their social identity that is most stigmatized in the current setting (Branscombe, Ellemers, Spears, & Doosje, 1999; Brewer & Brown, 1998;

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Maalouf, 2001; Steele, Spencer, & Aronson, 2002; Tajfel & Turner, 1979, 1986; Turner, Hogg, Oakes, Reicher, & Wetherell, 1987). Does this mean that targets will *always* experience identity threat in settings where they might be stigmatized? The hypothesis tested in the present study is that even within settings in which certain groups are traditionally stigmatized, subtle situational cues may modulate the experience of social identity threat among potential targets.

Which situational cues might affect targets' experiences of social identity threat? Numerical representation is a good candidate because several studies have shown that being outnumbered in settings where group stereotypes might apply decreases targets' performance expectations, as well as their actual performance (Inzlicht & Ben-Zeev, 2000, 2003; Inzlicht & Good, 2006; Sekaquaptewa & Thompson, 2003). The research we report here offers a possible explanation for why situational cues, such as numerical representation, might contribute to such performance outcomes. We propose that, by triggering objective experiences of identity threat (e.g., cognitive and physiological vigilance) and subjective experiences of identity threat (e.g., a decreased sense of belonging and decreased desire to participate in the setting), subtle situational cues may have powerful and far-reaching effects for potential targets of stereotypes and stigma.

WOMEN IN MATH, SCIENCE, AND ENGINEERING

One group that contends with the possibility of stereotypes and stigma is women who participate in math, science, and engineering (MSE) domains. The underrepresentation of women in these domains constitutes a serious social problem lamented by psychologists, the media, and university presidents (Hennessy, Hockfield, & Tilghman, 2005). Explanations for this underrepresentation include both biological differences in aptitude (Benbow & Stanley, 1980, 1983) and more socially constructed differences, including the gendered socialization of boys and girls (e.g., Simpkins, Davis-Kean, & Eccles, 2005), gender-role stereotypes (Eccles, Jacobs, & Harold, 1990), and the unattractiveness of perceived prototypical members of the fields (Cheryan, Plaut, Davies, & Steele, 2007). In addition, hypotheses about targets' own evaluation apprehension (Spencer, Steele, & Quinn, 1999), lack of confidence and low self-esteem (Eccles, Barber, Jozefowicz, Malenchuk, & Vida, 1999), and negative expectancies and negative thinking (Cadinu, Maass, Frigerio, Impagliazzo, & Latinotti, 2003; Cadinu, Maass, Rosabianca, & Kiesner, 2005) have been advanced. We argue that although these explanations are compelling, they underestimate the degree to which MSE environments and their organization play a role. We propose that, in addition, threatening features of a setting—such as poor numerical representation—may cause even highly confident, highly domain-identified women to avoid or leave MSE fields.

THE PRESENT RESEARCH

To test the cues hypothesis, we chose a population of advanced undergraduates majoring in MSE—students who strongly identified with MSE domains. We reasoned that with such high interest, ability, and confidence, the females in this population might be more likely than other female populations to enter MSE professions in the future. Thus, effects of subtle situational cues among this population would be especially instructive—underlining the environment's role in the experience of identity threat despite strong domain identification, ability, and confidence.

We took a fine-grained look at an MSE environment and tested whether the situational cue of numerical representation might affect women's experiences of identity threat. We exposed men and women to an MSE conference video depicting a balanced or unbalanced gender representation. Given the potent combination of existing ability stereotypes and women's historical underrepresentation in MSE domains, we hypothesized that women would be sensitive to the cue of gender representation in the MSE setting. We expected to find objective (heightened cognitive and physiological vigilance) and subjective (decreased sense of belonging and decreased desire to participate) evidence of identity threat among women who watched the gender-unbalanced video, compared with women who watched the balanced video. In other words, we expected that when women interacted in an MSE domain—a domain implying social identity threat—the situational cue of numerical representation would powerfully shape their experiences of threat.

METHOD

Design and Participants
The experiment consisted of a 2 (gender of the participant) × 2 (situational cue: gender-balanced or gender-unbalanced video) factorial design. Advanced MSE majors, who were highly identified with math, were selected for participation. Via e-mail, potential participants answered a series of demographic questions, including two math-identification questions (adapted from Steele & Aronson, 1995): "I am good at math tasks" and "It is important to me that I do well on math tasks." Responses to these questions were made on scales from 0 (*not at all*) to 6 (*extremely*). A combined score of 11 or higher on the two items was required for participation.

Forty-seven Stanford University undergraduates, 25 males and 22 females, were recruited and paid $10 for their participation. The experimenter for the study was female.

Procedure
Participants were run individually. Upon arriving at the lab, they were asked for their opinions of an advertising video for an MSE summer leadership conference that Stanford University was considering hosting the next summer. Participants were told that the researchers were interested not only in students' opinions of the conference, but also in their physiological responses to the

video itself. Physiological sensors were then attached to measure cardiac interbeat interval, finger pulse amplitude, finger and ear pulse transit time, finger temperature, and skin conductance level. Participants watched a 7-min nature video, pretested for its emotional neutrality, while baseline physiological measurements were collected. Afterward, they viewed the assigned 7-min conference video while physiological measures were again collected. The experimental videos depicted approximately 150 people in either a ratio of 3 men to 1 woman (gender-unbalanced video) or a ratio of 1 man to 1 woman (gender-balanced video).[1] The script, narration, and details of the two videos (including where the conference was held, procedures for admission, and the activities included) were identical. The videos were pretested among a separate sample of undergraduate students ($N = 20$) in a between-subjects design. Neither gender reported differences between the two videos along the dimensions of "interesting," "boring," "pleasant," and "attractive" (all $ts < 1$, n.s.).

After participants watched the conference video, their memory for details in the video and their anticipated sense of belonging were measured. Participants then rated how much they would like to participate in the conference should Stanford decide to host it the next summer.

At the end of the study, participants were led to another room and asked to recall as many details about the experimental room as possible. In both conditions, MSE-related items had been planted in the room. After completing the recall task, participants were debriefed and paid.

Dependent Measures

Cognitive Vigilance

Two forms of cognitive vigilance were measured. First, we measured cognitive vigilance to the MSE setting by testing participants' recall and recognition memory for details in the conference video. Second, we measured cognitive vigilance to the current physical context by assessing recall of MSE-related items placed in the experimental room. If the cue of numerical underrepresentation caused identity threat among the women, they would be expected to show increased cognitive vigilance to the MSE conference setting and to their own physical context, exhibiting better memory for the MSE video and for the MSE-related cues planted in the experimental room.[2]

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[1]We chose the 3:1 gender ratio on the basis of data showing that women earn approximately 27.5% of the MSE bachelor's degrees awarded in the United States (National Science Foundation, 2004). We chose the 1:1 ratio because we thought this structure might prove to be more identity-safe for women than the commonly found 3:1 ratio.

[2]Whereas previous research has shown that token status can reduce cognitive function (Saenz & Lord, 1989), we hypothesized that potential targets would allocate *more* attention toward identity-relevant cues in order to assess the likelihood of encountering identity threat in a specific MSE setting. It would not be surprising if the general cognitive functioning of women in the threatening setting was inhibited because of this allocation of attention toward MSE-related cues.

Memory for the Conference Video. After watching the video, participants completed a 15-item memory test on information in the video. They were asked about details such as the location of the conference, the requirements for participation, and the activities that were included. The test included both forced-choice and free-recall items. The percentage of items answered correctly served as a measure of participants' vigilance to the MSE conference setting.

Memory for the Experimental Room. Seven items related to MSE were placed throughout the experimental room. These items included posters on the walls (a portrait of Einstein, the periodic table), magazines on the coffee table (*Science* and *Nature*), and MSE textbooks on the bookshelves. After participants completed all other dependent measures, they were led to another room, where they were asked to recall as many details of the experimental room as possible. The number of MSE-related items recalled served as a measure of participants' vigilance to their physical context.

Physiological Vigilance

While participants watched the baseline and conference videos, cardiac interbeat interval, finger pulse amplitude, finger and ear pulse transit time, finger temperature, and skin conductance level were measured continuously to assess cardiovascular and electrodermal activation. Mean responses during the baseline and experimental periods were computed for each measure by taking the average across the entire 7 min of each video.

To test our hypothesis regarding cardiovascular activation, we created standard scores for finger pulse transit time, finger pulse amplitude, ear pulse transit time, and finger temperature and then averaged these scores to form a sympathetic-activation composite (Gross & Levenson, 1997). This composite was then reverse-scored so that greater numbers indicated greater sympathetic activation of the cardiovascular system.

Sense of Belonging

Participants completed three items assessing their anticipated sense of belonging in the summer conference (e.g., "I would belong at this conference"). The response scale ranged from 1 (*not at all*) to 5 (*extremely*).

Desire to Participate in the MSE Conference

Responses to seven items measuring participants' desire to participate in the summer conference (e.g., "I would like to attend this conference") were averaged to form a composite. The response scale for these items ranged from 1 (*extremely disagree*) to 7 (*extremely agree*).

RESULTS

We hypothesized that the cue of numerical representation would affect objective and subjective experiences of identity threat in

the MSE setting. We did not expect the cue to affect men in this setting. For statistical tests, we report both p_{rep} and standard p values, as indicators of replicability and significance (Killeen, 2005).

Cognitive Vigilance

Memory for the Conference Video

The percentage of items answered correctly served as the video memory score for each participant. A 2 (participant's gender) × 2 (situational cue) analysis of variance (ANOVA) conducted on these scores revealed only the predicted interaction, $F(1, 43) = 7.79$, $p < .01$, $p_{rep} = .96$, $\eta_p^2 = .15$. Simple-effects tests revealed that women who watched the gender-unbalanced video showed more vigilance to details about the conference than did women who watched the gender-balanced video ($Ms = 95.76$ and 81.21, respectively), $F(1, 43) = 4.70$, $p < .05$, $p_{rep} = .90$, $\eta_p^2 = .10$. The video manipulation did not have a significant effect on men's scores, and the scores of men and women who watched the gender-balanced video did not differ significantly (see Fig. 1).

Memory for the Experimental Room

An ANOVA conducted on number of items recalled revealed only the predicted Gender × Cue interaction, $F(1, 43) = 4.40$, $p < .05$, $p_{rep} = .89$, $\eta_p^2 = .09$. Simple-effects tests revealed that women who watched the gender-unbalanced video remembered significantly more MSE-related items in the experimental room than did women who watched the gender-balanced video ($Ms = 5.73$ and 4.18, respectively), $F(1, 43) = 4.69$, $p < .05$, $p_{rep} = .90$, $\eta_p^2 = .10$. Again, the cue manipulation had no significant effect on men's memory scores, and there was no significant difference between men's and women's memory scores in the gender-balanced condition (see Fig. 1).

Physiological Vigilance

We hypothesized that women who watched the gender-unbalanced video would show greater decreases in cardiac interbeat interval (indicative of faster heart rates) as well as greater increases in skin conductance, compared with women who watched the gender-balanced video. All ANOVAs were calculated on change scores computed within individuals (by subtracting the response during the baseline from the response during the MSE video) for each physiological channel. ANOVAs on the mean change in cardiac interbeat interval and in skin conductance revealed significant Gender × Cue interactions, $F(1, 43) = 3.94$, $p = .05$, $p_{rep} = .87$, $\eta_p^2 = .08$, and $F(1, 43) = 8.76$, $p < .01$, $p_{rep} = .97$, $\eta_p^2 = .17$, respectively. Simple-effects tests revealed that compared with women watching the gender-balanced video, women watching the gender-unbalanced video showed significantly greater decreases in interbeat interval ($Ms = -56.21$ and -24.50, respectively), $F(1, 43) = 4.39$, $p < .05$, $p_{rep} = .89$, $\eta_p^2 = .09$, and greater increases in skin conductance ($Ms = 1.69$ and 0.62, respectively),
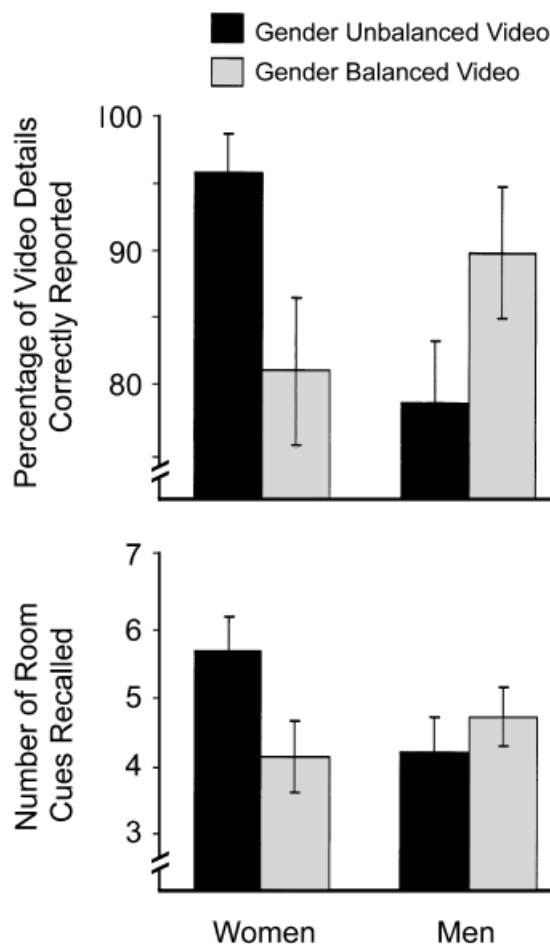

Fig. 1. Cognitive vigilance: mean memory for details of the math, science, and engineering conference video and mean memory for math, science, and engineering cues in the experimental room, as a function of gender and situational cue (gender-unbalanced vs. gender-balanced video). Error bars represent standard errors.

$F(1, 43) = 10.70$, $p < .01$, $p_{rep} = .98$, $\eta_p^2 = .20$. The cue manipulation had no significant effect on men's cardiac interbeat interval or skin conductance, and these physiological measures showed no significant gender differences among participants who watched the gender-balanced conference video (see Fig. 2).

We submitted the cardiovascular composite scores to an ANOVA, which yielded a main effect of gender, $F(1, 43) = 6.20$, $p < .05$, $p_{rep} = .93$. However, this main effect was qualified by the predicted Gender × Cue interaction, $F(1, 43) = 11.78$, $p < .01$, $p_{rep} = .99$, $\eta_p^2 = .22$. Simple-effects tests revealed that women who watched the gender-unbalanced video showed greater increases in sympathetic activation of the cardiovascular system than did women who watched the gender-balanced video ($Ms = 0.63$ and -0.19, respectively), $F(1, 43) = 10.07$, $p < .01$, $p_{rep} = .97$, $\eta_p^2 = .19$. The cue manipulation did not significantly affect men's sympathetic activation, and the cardiovascular composite scores showed no significant gender difference among participants who watched the gender-balanced conference video (see Fig. 2).
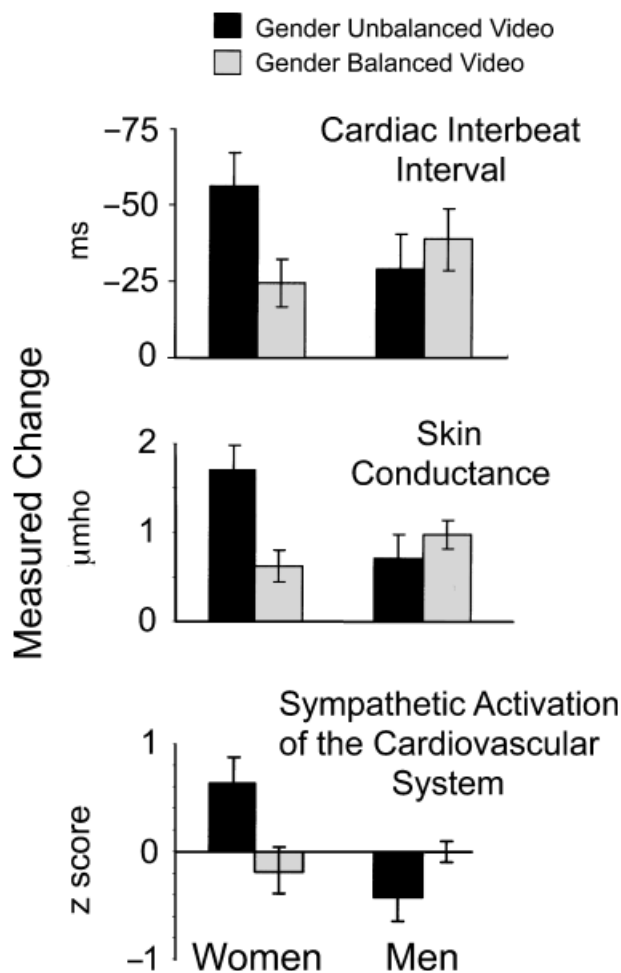
Fig. 2. Physiological vigilance: mean change in physiological activation while watching the math, science, and engineering conference video, as a function of gender and situational cue (gender-unbalanced vs. gender-balanced video). The three graphs present results for cardiac interbeat interval (top), skin conductance (middle), and the composite score for sympathetic cardiovascular activation (bottom). Error bars represent standard errors.

Sense of Belonging

An ANOVA on participants' anticipated sense of belonging in the conference revealed only a significant Gender × Cue interaction, $F(1, 43) = 4.36$, $p < .05$, $p_{rep} = .89$, $\eta_p^2 = .09$. Simple-effects tests revealed that women who watched the gender-unbalanced video reported significantly less belonging than did women who watched the gender-balanced video ($Ms = 3.33$ and 4.79, respectively), $F(1, 43) = 6.53$, $p < .05$, $p_{rep} = .94$, $\eta_p^2 = .13$. The cue manipulation had no significant effect on men's sense of belonging, and this measure showed no significant gender difference among participants who watched the gender-balanced conference video (see Fig. 3).

Desire to Participate in the MSE Conference

An ANOVA on participants' desire to participate in the MSE conference yielded only a significant main effect of cue, $F(1,$
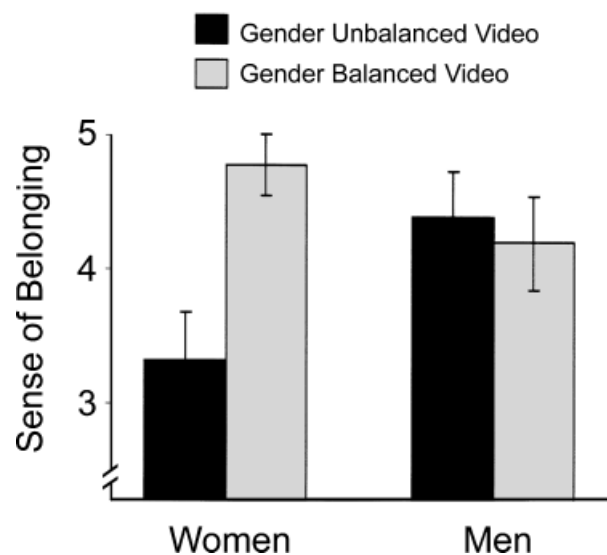

Fig. 3. Mean sense of belonging in the math, science, and engineering conference, as a function of gender and situational cue (gender-unbalanced vs. gender-balanced video). Error bars represent standard errors.

$43) = 6.02$, $p < .05$, $p_{rep} = .93$, $\eta_p^2 = .12$. Men and women expressed significantly more desire to participate in the conference after watching the gender-balanced conference video ($Ms = 5.39$ and 5.29, respectively) than after watching the gender-unbalanced video ($Ms = 4.88$ and 4.14). Thus, both men and women wanted to participate in the conference more when it was depicted as gender balanced than when it was depicted as unbalanced.

DISCUSSION

How do people come to know whether social identity threat is "in the air" in a particular setting? In the present study, people relied on the organizational features of a setting to help them determine the likelihood of encountering identity threat in that setting. We manipulated the situational cue of gender representation in an MSE setting among a population of men and women who were highly identified with MSE domains, hypothesizing that the cue would affect a broad array of outcomes among the women, including their objective experiences of identity threat, such as their levels of cognitive and physiological vigilance, as well as their subjective experiences of threat, such as their sense of belonging and desire to participate in the setting.

The results provided strong support for the cues hypothesis. Women who watched the gender-unbalanced MSE video showed more vigilance to both the details of the conference video and cues in their physical context, compared with women who watched the gender-balanced video. Also, women showed faster heart rates, greater skin conductance, and greater sympathetic activation of the cardiovascular system while watching the gender-unbalanced video than while watching the gender-balanced video. Finally, women anticipated a lower sense of belonging in the conference

and reported less desire to participate in it after watching the unbalanced video than after watching the balanced video. The cue of gender representation did not significantly affect any of the men's outcomes except their desire to participate in the conference. Both men and women wanted to participate in the conference more when it was depicted as gender balanced rather than unbalanced. Though this effect was likely a result of different concerns among the two groups—perhaps women felt more identity-safe among other women, whereas men might have been attracted by the uncommon number of women in the gender-balanced MSE environment—it is nonetheless interesting that both groups favored an MSE environment containing more women.

Taken together, the compelling convergence of subjective and objective indicators signals a meaningful experience of social identity threat among women in the gender-unbalanced setting. Thus, women who were highly identified with MSE domains relied on the cue of numerical representation to assess the degree of identity threat in this context. These data demonstrate that rather than being endemic to women, the experience of identity threat is attributable to the situation—its cues and organization.

Why were men's outcomes unaffected by the cue of numerical representation? Because men are not traditionally stereotyped or outnumbered in MSE domains, the cue of numerical representation may not hold significant meaning for them in MSE settings.[3] However, previous work has shown that men can be quite sensitive to other situational cues in MSE domains. In studies involving a math tutorial setting, men used cues including the gender of the math tutor and the tutor's reputation to assess their own level of identity threat (Murphy & Steele, 2007). In addition, research has demonstrated that when White men are vulnerable to a stereotype—such as when they are compared with Asian men in a math context or with Black men in an athletic context—they show stereotype-threat performance decrements similar to those of women who are compared with men in a math context (Aronson et al., 1999; Stone, Lynch, Sjomeling, & Darley, 1999).

Although the present study highlights the extensive effects of gender representation on women in an MSE setting, it has some limitations. First, because women who are highly identified with the MSE domains are the ones who will most likely enter MSE professions—helping to address their gender's underrepresentation in MSE fields—the present study tested the broad effects of one cue among this particular population of women. However, it is unclear whether the results will generalize to populations not highly identified with these domains. Perhaps other cues—

such as the gender segregation of different MSE tracks or the gender of MSE teachers—might be stronger signals of identity threat for students not yet identified with MSE domains. Because both entry and retention of women in MSE domains remain problematic, studying the situational cues that affect both women who are highly domain identified and women who are not is a worthwhile endeavor.

Second, it is difficult to imagine an MSE setting where only a single situational cue is present, as it was in this experiment. As James (1890, p. 462) aptly stated, "the world is a buzzing, blooming confusion" made even more so by the many situational cues found in each new setting that people encounter. Future work should examine the effects of multiple cues in settings. In fact, research has demonstrated that situational cues can interact in interesting ways to affect important outcomes, such as people's level of trust in a setting (Purdie-Vaughns, Steele, Davies, & Crosby, 2007).

Despite these limitations, the present research demonstrates that potentially stigmatized groups are significantly affected by situational cues that speak to the likelihood of encountering identity threat in a setting. Thus, the way an environment is organized has important meaning and impact for groups who may be vulnerable to identity threat. As we have shown, when a setting contains threatening situational cues, it raises the specter of identity threat—prompting heightened cognitive and physiological vigilance, decreased feelings of belonging, and decreased desire to participate in the setting. It is our hope that the present research underlines the importance of situational cues and inspires greater motivation to attend to such cues when creating and modifying environments so that they may foster perceptions of identity safety rather than threat.

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[3]Because the focus of the present work was to examine the effects of gender representation on women in MSE settings, and because we were concerned with the plausibility of our manipulated MSE setting, we did not present a video in which men were in the numerical minority. It is possible that men who find themselves outnumbered by women in an MSE setting might experience threat as well, though this effect would likely be due to token status rather than to social identity threat.

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