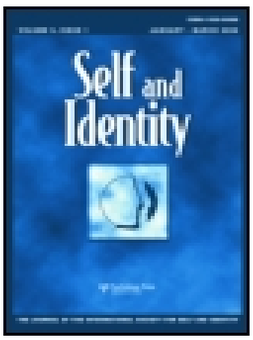

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ARTICLE

Double isolation: Identity expression threat predicts greater gender disparities in computer science

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ABSTRACT

Three studies examine the relationship between women's expression of interest in computer science and *identity expression threat*, the concern about conveying an identity inconsistent with one's gender role. Undergraduates perceive academic majors to signal who they are to peers (Study 1). Women imagining majoring in computer science report greater identity expression threat from their peers outside computer science than from those inside the field (Study 2). Women report greater identity expression threat in computer science (but not biology or English) than do men. Identity expression threat mediates gender differences in reported likelihood of downplaying interest in computer science (Study 3). Women considering computer science perceive they will be doubly isolated, both from those within and outside the field.

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Gender; STEM; identity; stereotypes; gender roles

When students consider entering an academic field, they consider both the subject matter and social factors associated with that field. Many behavioral studies have found that the social climate of STEM fields affects women's participation and success (Cheryan, Plaut, Davies, & Steele, 2009; Diekman, Clark, Johnston, Brown, & Steinberg, 2011; Good, Rattan, & Dweck, 2012; Leslie, Cimpian, Meyer, & Freeland, 2015; Logel et al., 2009; Moss-Racusin, Dovidio, Brescoll, Graham, & Handelsman, 2012). The anticipation of encountering a "chilly" climate in which one is not valued or integrated is clearly a deterrent to women (Moss-Racusin, Sanzari, Caluori, & Rabasco, 2018). However, in the current work, we propose an additional essential component of students' social experiences in the selection of an academic field: the social atmosphere that they anticipate facing *outside the field*. Women may be concerned that their choice of field will be perceived by others outside the field as incompatible with their gender role. Taken together with previous work on climate threats, this work suggests that women majoring in computer science face an unfortunate "double isolation" in that they anticipate isolation not only from those within the field but also from their peers outside the field for choosing computer science.

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The identity-expressive nature of choosing a major

The decision to take certain courses or embark on a career path is a public one. Indeed, "What is your major?" may be one of the first questions that students ask each other on college campuses. In Western societies, career and identity are inextricably linked (Holmegaard, Ulriksen, & Madsen, 2014; O'Reilly, Chatman, & Caldwell, 1991) and deciding a career path is associated with identity formation (e.g., Guerra & Braungart-Rieker, 1999; Holland, Gottfredson, & Power, 1980; Lucas, 1997). Students in the US are often urged to "find their passions," career advice that is based upon the assumption that finding the right occupational fit is about matching one's job to who one is as a person (Chen, Ellsworth, & Schwarz, 2015; Edwards, 1991; O'Keefe, Dweck, & Walton, 2018). When getting to know each other, students may thus perceive that academic majors provide an important source of information about who they are to their peers. We explore what is communicated by this information and how it may have different consequences for women and men, especially when the major itself is perceived as gendered.

Perceived incompatibility between women's gender role and computer science stereotypes

Women in computer science face a lack of fit between current computer science stereotypes and the female gender role (Cheryan et al., 2009). The female gender role prescribes being people-oriented as well as relatively uninterested in math, science, and technology (Cejka & Eagly, 1999; Diekman, Brown, Johnston, & Clark, 2010; Eagly, 1987; Prentice & Carranza, 2002). In contrast, computer scientists are stereotyped as socially inept, brilliant, and obsessively focused on technology (Cheryan, Plaut, Handron, & Hudson, 2013; Leslie et al., 2015). These stereotypes are less compatible with the female than male gender role (Cheryan et al., 2009; Diekman et al., 2011; Leslie et al., 2015). When computer science stereotypes are salient, women report not fitting in with the people and culture of the field (Bian, Leslie, Murphy, & Cimpian, 2018; Cheryan, Master, & Meltzoff, 2015; Cheryan et al., 2009). Expressing an interest in computer science may thus be less consistent with the female than male gender role.

Men, in contrast, are less deterred from male-dominated STEM fields when current male-oriented stereotypes are salient (Bian et al., 2018; Cheryan et al., 2009). In fact, because of strong norms placed on men to pursue male-oriented pursuits and interests (Cheryan, Cameron, Katagiri, & Monin, 2015; Moss-Racusin, Phelan, & Rudman, 2010; Vandello, Bosson, Cohen, Burnaford, & Weaver, 2008), men may perceive the inverse gender role pressure to express an interest in computer science.

Not all STEM fields are stereotyped as highly male-oriented. Biology graduates more women than men (Cheryan, Ziegler, Montoya, & Jiang, 2017; National Science Foundation, 2018). Stereotypes of biology-related careers (e.g., physician, dentist) are perceived to be more compatible with the female gender role than stereotypes of computer scientists and engineers (Cheryan et al., 2017; Diekman et al., 2011; Leslie et al., 2015). Biology may be a good example of a STEM field that is not seen as highly incompatible with either the female or male gender role.

Outside of STEM, English is a female-dominated field and is perceived as such (Cheryan & Plaut, 2010). Men report a greater mismatch between themselves and English majors than do women (Cheryan & Plaut, 2010). Expressing an interest in English may be less consistent with the male than female gender role.

People who deviate from gender role prescriptions face social and economic sanctions (Moss-Racusin et al., 2010; Rudman, 1998; Williams & Tiedens, 2016). As a result, people are often motivated to avoid gender role violations (Cheryan et al., 2015; Moss-Racusin et al., 2010; Willer, Rogalin, Conlon, & Wojnowicz, 2013). The motivation to avoid signaling a gender-role incompatible identity is particularly strong in public settings, where one is more likely to be judged and potentially punished by others (Bosson, Prewitt-Freilino, & Taylor, 2005; Daubman, Heatherington, & Ahn, 1992; Deaux & Major, 1987; Eagly, 1987).

Defining and distinguishing identity expression threat

The bulk of work on identity-based threats in academic contexts has focused on how people relate to, and believe they will be judged by, others in the field, such as professors and classmates. These multifaceted threats, sometimes known as "climate threats," address the perceived and actual hostile and unwelcoming climate faced by women who are considering and already inside male-dominated STEM fields. Several commonly studied climate threats contribute to gender disparities in male-dominated fields. For instance, women may be aware of blatant and subtle *discrimination* that makes it more difficult for them to enter and progress in STEM (Logel et al., 2009; Moss-Racusin et al., 2012) or of being *devalued* based on their gender more broadly (Benner, 2017). In addition, women contend with *stereotype threat*, namely concerns about being judged as less competent than their male counterparts because of existing negative stereotypes about women's abilities (Schmader, Johns, & Forbes, 2008; Spencer, Steele, & Quinn, 1999). Women may also report lower *self-efficacy* in STEM than do men (Ehrlinger & Dunning, 2003; Sax, Kanny, Riggers-Piehl, Whang, & Paulson, 2015), due in part to negative stereotypes about their abilities in these fields (Correll, 2004). Furthermore, women may feel a lower *sense of belonging* with the people and environment of these fields (Cheryan et al., 2009; Good et al., 2012). Additionally, women may perceive that pursuing STEM is *incompatible with their goals of helping and working with people* (Diekman et al., 2011). Each of these climate threats has been shown to discourage women from pursuing male-dominated STEM fields.

In the current work, we focus on a novel identity threat that is distinct from perceptions of a threatening climate inside the field. When considering male-dominated fields, women may also be thinking about how they will be viewed by the people *outside the field* for associating themselves with a stereotypically masculine domain. The mismatch between the male-oriented stereotypes of computer science and expectations placed on women to conform to their gender role may lead women to experience *identity expression threat*, or concerns about displaying an identity that violates one's prescribed gender role.

Identity expression threat is similar to fear of backlash, or social and economic sanctions for violating norms prescribed by one's gender role (Daubman et al., 1992;

Eagly & Karau, 2002; Rudman, 1998) because both involve gender role violations. However, identity expression threat differs from fear of backlash in two ways. First, backlash does not explicitly distinguish between judgment from those outside the domain and those inside the domain (Rudman, 1998; Rudman & Phelan, 2008). In contrast, identity expression threat reflects the specific threat evoked by those outside the field in question. Second, identity expression threat focuses on meta-perceptions, or perceptions of what others think about oneself (Vorauer, Main, & O'Connell, 1998), rather than more explicit sanctions such as being teased or sabotaged (Rudman, 1998; Rudman & Fairchild, 2004). Women might not expect such overtly negative responses from peers upon announcing their desired major, but they may be concerned about violating their gender role by expressing an interest in a stereotypically masculine field.

Identity expression threat is also distinct from romantic concerns, or women's concerns that they will be seen as unattractive to men if they enter male-dominated fields (Park, Young, Troisi, & Pinkus, 2011). Whereas romantic concerns focus specifically on attractiveness to potential romantic partners, identity expression threat centers on a broader threat of worrying that one will be seen as violating gender role prescriptions.

Implications of identity expression threat on downplaying interest in CS

One important consequence of identity expression threat is that it may contribute to gender disparities in STEM. Women downplay performance in male-dominated fields in order to avoid negative consequences of gender role violations (Daubman et al., 1992; Heatherington et al., 1993). Women may also downplay their interest in computer science because they are concerned about expressing an identity to others that is perceived as incompatible with their gender role.

Downplaying interest may result in women avoiding opportunities that involve public displays of interest, even if those opportunities would otherwise be beneficial (e.g., extracurricular learning opportunities). Furthermore, downplaying one's interest might make changing the masculine stereotypes associated with computer science more difficult by reinforcing the perception that women are not interested in computer science. However, alleviating the threat by reducing the perceived mismatch between the field and the female gender role among those outside the field, or counteracting the belief that field of study is deeply linked to identity, may encourage students to express greater interest in academic environments in which they are underrepresented.

Current work

Three studies investigate whether (a) undergraduates believe that academic major signals important information about who they are (Study 1), (b) women report greater concerns about expressing an identity that is incompatible with their gender role to their peers outside computer science compared to authority figures and peers inside computer science (Study 2), (c) women report greater identity expression threat for expressing an interest in computer science compared to men and compared to expressing interest in other fields (Study 3), and (d) identity expression threat mediates the relationship between gender and likelihood of downplaying interest in computer science (Study 3). Women may have to contend not only with the "chilly" climate inside

the field, but also with expressing an identity that is perceived as incompatible with the female gender role to those outside the field.

Study 1: The identity-expressive nature of choosing a major

In the first study, we investigate whether students on a US university campus see their major as serving an identity-expressive function. We ask students how often others on campus inquire what they are majoring in and whether one's major signals to others the kind of person one is. We predict that students will report that major information serves an identity-expressive function because learning about a student's major provides useful information about that student. Materials, datasets, and codebooks for all studies are available at https://osf.io/azxgv/.

Method

Pretest

Fifty participants on campus were asked to fill out a questionnaire that asked: "Imagine meeting another student for the first time. What questions are you most likely to ask them?" Each participant listed up to three questions, for a total of 146 questions, of which 19 were distinct. Of the 19 distinct questions, variants of nine questions were generated by more than one person and included in the study below. These questions included: "What is your major?" (27% of listed questions; listed by 80% of participants), "Where are you from?" (21% of listed questions; listed by 62% of participants), "What is your name?" (16% of listed questions; listed by 46% of participants), "What year of school are you in?" (9% of listed questions; listed by 26% of participants), "What are your hobbies?" (8% of listed questions; listed by 20% of participants), "What classes are you taking?" (5% of listed questions; listed by 14% of participants), "How are you doing?"[1] (6% of listed questions; listed by 18% of participants), "How old are you?" (2% of listed questions; listed by 6% of participants), and "Where did you go to high school?" (1% of listed questions; listed by 4% of participants). The fact that one's major was the most commonly listed question and listed by the most participants provides preliminary support for the idea that choice of major is a prominent identity-related characteristic for undergraduates.

Participants

Seventy-five additional participants were recruited from the same university campus (45 women, 30 men; 36 Asian/Asian American, 26 White, 4 African American/Black, 4 Latinx/Hispanic, 2 multiracial, 1 Middle Eastern, 1 who indicated another race, 1 who did not specify).

Procedure

Participants answered two questions about each of the nine most common questions from the pretest: "When you first meet someone on campus, how likely is that person to

ask you the following questions?" and "How much do people think they know about a person when the questions below are answered?" Answers were provided on scales from 1 (*not at all likely/not much at all*) to 7 (*very likely/very much*). Each study concluded with demographic questions.

Results and discussion

Likelihood of being asked

A repeated-measures ANOVA revealed a significant effect of question, $F(5.83, 431.75) = 87.88$, $p < .001$. The Mauchly's test indicated that the sphericity assumption was violated, $\chi^2(35) = 115.24$, $p < .001$, thus degrees of freedom were corrected using Greenhouse-Geisser estimates ($\varepsilon = .73$). Undergraduates reported being significantly more likely to be asked about their name ($M = 6.41$, $SD = 1.35$) than their major ($M = 5.96$, $SD = 1.28$), $F(1, 74) = 6.05$, $p = .02$, $d_{av} = .35$. Compared to being asked about their major, participants were less likely to report being asked about their year in school ($M = 5.53$, $SD = 1.42$), $F(1, 74) = 12.58$, $p < .001$, $d_{av} = .32$; classes they were taking ($M = 5.52$, $SD = 1.45$), $F(1, 74) = 10.28$, $p = .002$, $d_{av} = .32$; where they were from ($M = 4.84$, $SD = 1.70$), $F(1, 74) = 40.03$, $p < .001$, $d_{av} = .74$; how their day had been ($M = 4.69$, $SD = 2.11$), $F(1, 74) = 24.69$, $p < .001$, $d_{av} = .73$; their hobbies ($M = 3.32$, $SD = 1.48$), $F(1, 74) = 160.32$, $p < .001$, $d_{av} = 1.91$; where they attended high school ($M = 2.80$, $SD = 1.56$), $F(1, 74) = 240.87$, $p < .001$, $d_{av} = 2.22$; and their age ($M = 2.64$, $SD = 1.58$), $F(1, 74) = 252.45$, $p < .001$, $d_{av} = 2.31$. For both Asians/Asian Americans and Whites, field of study was rated as one of the top two questions most likely to be asked in a first encounter with someone on campus. Other racial groups' sample sizes were too small to examine separately. After one's name, one's field of study was the most common question undergraduates reported asking each other when meeting for the first time.

Knowledge about a person

A repeated-measures ANOVA revealed a significant effect of question, $F(8, 584) = 35.53$, $p < .001$. Undergraduates reported that people think they would know the most about a person if they learned the person's hobbies ($M = 5.32$, $SD = 1.40$), and this was significantly higher than learning about their major ($M = 4.23$, $SD = 1.56$), $F(1, 73) = 48.18$, $p < .001$, $d_{av} = .74$. Learning about their major was not statistically different from learning about where they were from ($M = 4.30$, $SD = 1.51$), $F(1, 73) = 0.12$, $p = .73$, and the classes they were taking ($M = 4.18$, $SD = 1.51$), $F(1, 73) = 0.12$, $p = .73$. Participants believed that major signaled significantly more than their year in school ($M = 3.39$, $SD = 1.44$), $F(1, 73) = 29.61$, $p < .001$, $d_{av} = .56$; how they were doing today ($M = 3.31$, $SD = 1.70$), $F(1, 73) = 12.28$, $p < .001$, $d_{av} = .56$; their age ($M = 3.19$, $SD = 1.28$), $F(1, 73) = 35.05$, $p < .001$, $d_{av} = .73$; where they attended high school ($M = 2.96$, $SD = 1.42$), $F(1, 73) = 41.39$, $p < .001$, $d_{av} = .85$; and their name ($M = 2.54$, $SD = 1.61$), $F(1, 73) = 49.75$, $p < .001$, $d_{av} = 1.07$. Hobbies, major, and classes were listed by both Asians/Asian Americans and Whites as the top three dimensions providing information about one's identity to their peers. Other racial groups' sample sizes were too small to examine separately. Overall, one's field of study was perceived by undergraduates to be a prominent identity-related dimension that signals something about who they are to their peers.

Study 2: Identifying likely sources of identity expression threat

Are women's concerns about expressing an identity that is incompatible with their gender role elicited most prominently by their peers outside computer science? In this study, we examine women's reports of who in their lives are most likely to evoke these concerns (i.e., parents, professors outside computer science, computer science professors, acquaintances, friends, strangers who are not in computer science, females outside computer science, females in computer science, males outside computer science, and males in computer science). We hypothesize that the threat of expressing an identity incompatible with one's gender role by expressing interest in computer science is elicited most prominently by peers outside of computer science.

Participants

Students (N = 100 women; 55 Asian/Asian American, 32 White, 11 multiracial, and 2 Latinx/Hispanic) were recruited from the psychology participant pool. The most common majors were psychology (13%), business (11%), and biology (11%). One participant (1%) was a computer science major.

Materials and procedure

The threat of expressing an identity incompatible with one's gender role was measured using two questions: "If you majored in computer science, how worried would you be that [source] would label you as being unfeminine?" and "If you majored in computer science, how much would [source] label you as being unfeminine?[2]" These questions were asked for 11 sources: "others (not in computer science)[3]" (r = .69), "your parents" (r = .76), "your professors (not in computer science)" (r = .77), "your professors (in computer science)" (r = .84), "your acquaintances" (r = .73), "your friends" (r = .81), "people you don't know who aren't in computer science" (r = .80), "female students not in computer science" (r = .81), "male students not in computer science" (r = .65), "female students in the field of computer science" (r = .92), "male students in the field of computer science" (r = .66).

Other items in the questionnaire measured additional gender-related concerns, including gender devaluation, perceived discrimination, stereotype threat concerns, self-efficacy, sense of belonging, romantic concerns, goal incongruity, and fear of backlash. These items were not analyzed (but were in the next study) because there was no relevant comparison group (i.e., male participants, other fields). Self-reported femininity/masculinity, desire to appear feminine/masculine, importance of being seen as feminine by one's peers, gender identification, racial identification, and fit with computer science stereotypes were also included but not analyzed because they were outside of the scope of current hypotheses.

Results and discussion

A repeated-measures ANOVA revealed a significant effect of source, $F(5.41, 535.15) = 19.34$ $p < .001$. The Mauchly's Test indicated that the sphericity assumption was violated, χ^2 (54) = 342.59, $p < .001$, thus degrees of freedom were corrected using the Greenhouse-Geisser estimates ($\varepsilon = .54$). Women reported that identity expression threat would be most elicited by males outside of computer science ($M = 2.67$, $SD = 1.41$). Males outside of computer science were not statistically significantly more likely to elicit identity expression threat than females outside computer science ($M = 2.50$, $SD = 1.68$), $F(1, 99) = 3.09$, $p = .08$, strangers ($M = 2.45$, $SD = 1.61$), $F(1, 99) = 3.64$, $p = .06$, and others ($M = 2.45$, $SD = 1.38$), $F(1, 99) = 3.44$, $p = .07$. Eliciting significantly less identity expression threat than males outside of computer science were males inside computer science ($M = 2.29$, $SD = 1.25$), $F(1, 99) = 12.14$, $p = .001$, $d_{av} = .28$, acquaintances ($M = 2.22$, $SD = 1.32$), $F(1, 99) = 13.07$, $p < .001$, $d_{av} = .33$, friends ($M = 1.96$, $SD = 1.29$), $F(1, 99) = 32.71$, $p < .001$, $d_{av} = .53$, professors inside computer science ($M = 1.83$, $SD = 1.20$), $F(1, 99) = 42.87$, $p < .001$, $d_{av} = .64$, professors outside of computer science ($M = 1.73$, $SD = 1.03$), $F(1, 99) = 60.69$, $p < .001$, $d_{av} = .76$, parents ($M = 1.64$, $SD = 0.95$), $F(1, 99) = 48.90$, $p < .001$, $d_{av} = .86$, and females inside computer science ($M = 1.51$, $SD = 0.96$), $F(1, 99) = 80.28$, $p < .001$, $d_{av} = .96$. Comparing Asians/Asian Americans and Whites revealed statistically similar levels of identity expression threat across the different sources, $ts < 1.86$, $ps > .06$. Other racial groups' samples were too small to look at separately. Identity expression threat seems to be more a concern about violating gender role prescriptions to one's peers outside of computer science rather than to authority figures and peers inside computer science.

Study 3: Identity expression threats in three fields

In this study, we compare identity expression threats with other known threats that women face in computer science, including gender devaluation, perceived discrimination, stereotype threat concerns, self-efficacy, low sense of belonging, romantic concerns, goal incongruity, and fear of backlash. In addition, we compare women's identity expression threat in computer science with their identity expression threat in biology, another STEM field, but one that is now majority women at the undergraduate level (National Science Foundation, 2018) and is less stereotypically associated with males (Cheryan et al., 2017), and English, a non-STEM field. We predict that women will report greater identity expression threat for declaring an interest in computer science than will men and also than in biology or English, whereas these concerns will not be present (or will be reversed) for men. We further predict that identity expression threat will be a distinct concern from other known gender-related concerns. In addition to the original sample, a second replication sample was asked about a subset of the concerns in computer science and English.

Participants

Original sample

Students ($N = 150$; 64 women, 86 men; 47 White, 3 African American/Black, 76 Asian/Asian American, 16 multiracial, 5 Latinx/Hispanic, 1 Native American/American Indian, and 2 others) were recruited from the psychology participant pool. The most

Table 1. Questions measuring other gender-related constructs in Study 3.

Construct	Questions	Adapted from	Reliability
Gender Devaluation	How much do you feel that people of your gender would be valued by the others in [field]? (reversed) How much do you feel that you would be respected by the others in [field]? (reversed)	Purdie-Vaughns, Steele, Davies, Ditlmann, & Crosby, (2008); Steele, James, & Barnett (2002)	computer science: $r = .63$ biology: $r = .55$ English: $r = .54$
Perceived Discrimination	If you majored in [field], how much do you think you would be discriminated against in this field? If you majored in [field], how much do you think people of your gender would be discriminated against in this field?	Ensher, Grant-Vallone, & Donaldson, (2001); Pinel, (1999); Branscombe, (2001); Jetten, Branscombe, Schmitt, & Spears, (2001)	computer science: $r = .87$ biology: $r = .77$ English: $r = .74$
Stereotype Threat	How anxious would you be about confirming a negative stereotype about your gender if you majored in [field]? If you majored in [field], how much would you worry that people would draw conclusions about your gender based on your performance? If you majored in [field], how much would you worry that people would draw conclusions about you, based on what they think about your gender?	Cohen & Garcia, (2005); Marx, Stapel, & Muller, (2005)	computer science: $\alpha = .85$ biology: $\alpha = .87$ English: $\alpha = .90$
Self-Efficacy	How well do you think you would do in [field]? How well do you think you would perform as a [field] major?	Cheryan, Siy, Vichayapai, Drury, & Kim, (2011); Correll, (2001)	computer science: $r = .95$ biology: $r = .93$ English: $r = .92$
Sense of Belonging	How similar do you think you are to the students in [field]? How much do you think you would fit in with the people in [field]? How much do you think you would fit into the environment in [field]?	Cheryan et al., (2009); Good et al., (2012)	computer science: $\alpha = .90$ biology: $\alpha = .94$ English: $\alpha = .94$
Romantic Concerns	If you majored in [field], how worried would you be about being seen as romantically undesirable? If you majored in [field], how worried would you be that it would be difficult to find a romantic partner?	Park et al., (2011)	computer science: $r = .87$ / $r = .74$ (replication) biology: $r = .86$ English: $r = .83$ / $r = .77$ (replication)
Goal Incongruity	If you majored in [field], how worried would you be that you wouldn't be able to work with others? If you majored in [field], how worried would you be that you wouldn't be able to make a positive difference in society?	Diekman et al, (2011)	computer science: $r = .58$ biology: $r = .57$ English: $r = .41$
Fear of Backlash	If you majored in [field], would you worry about being labeled negatively? If you majored in [field], would you be afraid that others would think you were odd? If you majored in [field], would your friends be likely to (negatively) tease you? If you majored in [field], would you be afraid that you might be disliked?	Rudman & Fairchild, (2004)	computer science: $\alpha = .89$ / $r = .88$ (replication) biology: $\alpha = .90$ English: $\alpha = .84$ / $r = .89$ (replication)

common majors were business (15%), psychology (11%), and biology (11%). Nine participants (6%) were computer science majors, and one participant (1%) was an English major.

Replication sample

Students (N = 115; 67 women, 48 men; 52 Asian/Asian American, 28 White, 15 multiracial, 9 African American/Black, 6 Latinx/Hispanic, 4 Middle Eastern, and 1 Native Hawaiian/Pacific Islander) were recruited from the psychology participant pool. The most common majors were biology (16%), public health (9%), biochemistry (7%), business (6%), and nursing (6%). Five participants (4%) were computer science majors, and two (2%) were English majors.

Materials and procedure

Participants completed an online questionnaire that asked them questions about computer science (both samples), biology (original sample), and English (both samples; fields counterbalanced). Three questions measured identity expression threat: (a) "If you told others (not in [field]) that you were interested in [field], how worried would you be that others would see you as being unfeminine" (original sample only), (b) "If you told others (not in [field]) that you were interested in [field], how concerned would you be that others would think that you are deviating from gender norms?," and (c) "If you told others (not in [field]) that you were interested in [field], how worried would you be that others would see you as differing from your gender role [original sample]/not fitting in with members of your gender [replication sample]?" (original sample: computer science α = .88, biology α = .96, English α = .92; replication sample: computer science r = .74, English r = .84).

Additional questions for the original sample measured gender devaluation, perceived discrimination, stereotype threat, self-efficacy, sense of belonging, romantic concerns, goal incongruity, and fear of backlash. For the replication sample, additional questions measured romantic concerns and fear of backlash (see Table 1 for questions and reliabilities).

Participants were also asked how likely they were to downplay interest in each of the fields with these questions: "How likely would you be to downplay your interest in [field] so that people do not get the wrong idea about you?" (original sample only) and "How likely would you be to downplay your interest in [field] to others (not in [field])?" (original sample: computer science r = .88, biology r = .79, English r = .88). Questions were asked on a scale from 1 (*not at all/not well at all*) to 7 (*very [much/much so/well/likely]*).

Other questions beyond the scope of current hypotheses were also asked: social appropriateness for males/females to be interested in fields (original sample), extent to which stating your major would reduce social invitations (original sample), fit with fields' stereotypes (original sample), consideration of majoring in fields (replication sample), interest in majoring in fields (replication sample), number of courses taken in fields (both samples), gender identification questions (both samples), and self-rated masculinity/femininity (both samples).

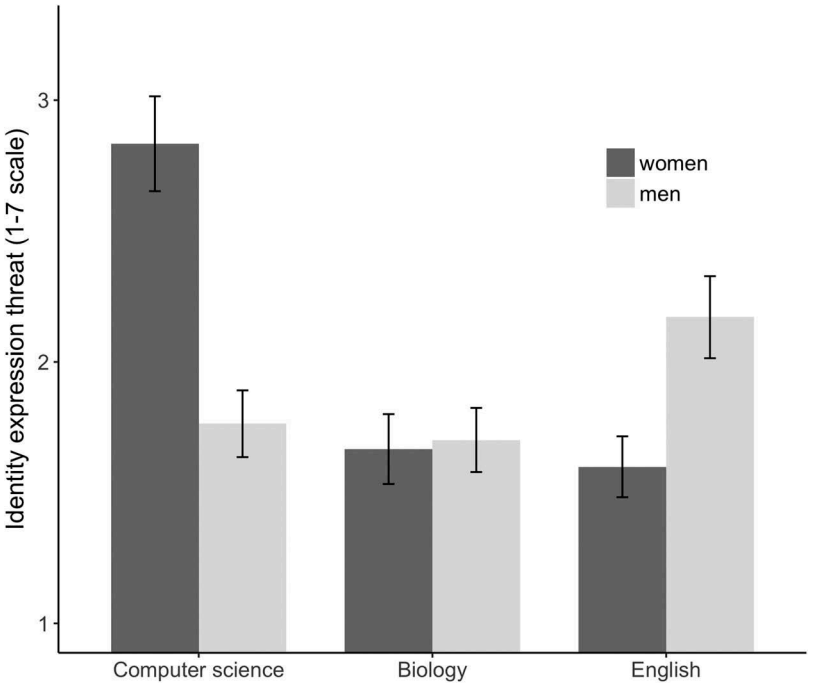

Figure 1. Women report significantly greater identity expression threat in computer science than do men in Study 3 (original sample). Women and men do not statistically differ in reports of identity expression threat in biology. Men report significantly greater identity expression threat in English than computer science. Error bars represent standard errors.

Results

Identity expression threat

In the original sample, a 3 (field; within) × 2 (gender; between) mixed-model ANOVA on identity expression threat revealed a main effect of field, $F(2, 296) = 19.96$, $p < .001$, no main effect of gender, $F(1, 148) = 0.86$, $p = .36$, and a significant field by gender interaction, $F(2, 296) = 35.62$, $p < .001$ (see Figure 1). Women reported significantly higher levels of identity expression threat in computer science ($M = 2.83$, $SD = 1.45$) than did men ($M = 1.76$, $SD = 1.18$), $F(1, 148) = 24.69$, $p < .001$, $d = .83$. However, men ($M = 2.17$, $SD = 1.45$) expressed significantly greater identity expression threat in English than did women ($M = 1.60$, $SD = 0.93$), $F(1, 148) = 7.60$, $p = .01$, $d = .46$. Women and men did not significantly differ in identity expression threat in biology (women: $M = 1.67$, $SD = 1.07$; men: $M = 1.70$, $SD = 1.14$), $F(1, 148) = 0.04$, $p = .85$. Seen differently, women reported significantly greater identity expression threat in computer science than biology, $F(1, 148) = 57.99$, $p < .001$, $d_{av} = .92$, and English, $F(1, 148) = 59.58$, $p < .001$, $d_{av} = 1.01$. Biology and English were not significantly different from one another, $F(1, 148) = 0.25$, $p = .62$, simple effect of field: $F(2, 296) = 42.72$, $p < .001$. Men reported significantly greater

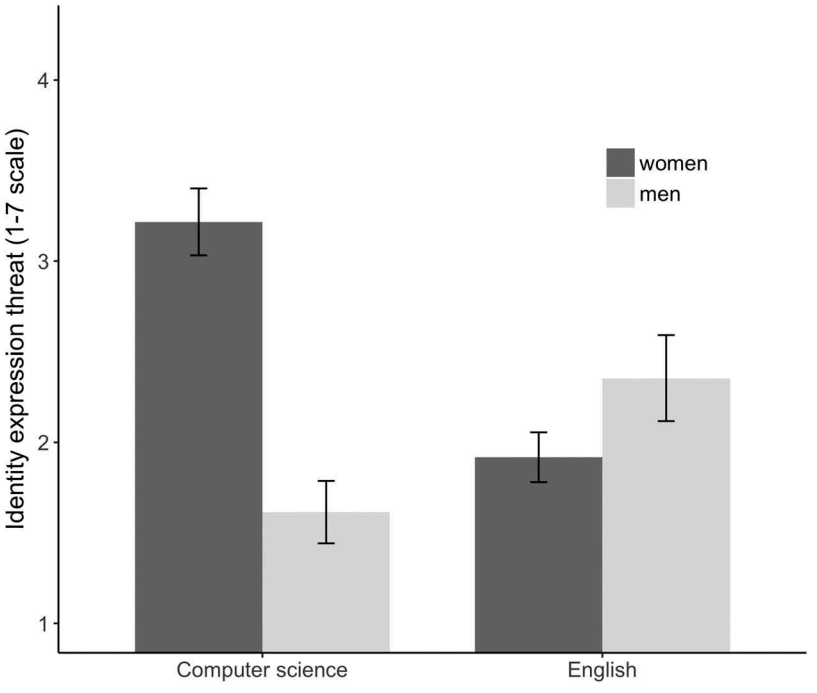

Figure 2. Women report significantly greater identity expression threat in computer science than do men in Study 3 (replication sample). Women and men do not significantly differ in their report of identity expression threat in English. Error bars represent standard errors.

identity expression threat in English than computer science, $F(1, 148) = 8.70$, $p = .004$, $d_{av} = .31$, and biology, $F(1, 148) = 15.90$, $p < .001$, $d_{av} = .36$; computer science and biology were not significantly different from one another, $F(1, 148) = 0.22$, $p = .64$, simple effect of field: $F(2, 296) = 7.74$, $p = .001$.

In the replication sample, a 2 (field; within) × 2 (gender; between) mixed-model ANOVA on identity expression threat revealed a statistically nonsignificant effect of field, $F(1, 113) = 3.89$, $p = .05$, a main effect of gender, $F(1, 113) = 7.12$, $p = .01$, and a significant field by gender interaction, $F(1, 113) = 51.67$, $p < .001$ (see Figure 2). Women expressed greater identity expression threat in computer science ($M = 3.22$, $SD = 1.51$) than did men ($M = 1.61$, $SD = 1.20$), $F(1, 113) = 37.16$, $p < .001$, $d = 1.16$. Women ($M = 1.92$, $SD = 1.13$) and men ($M = 2.35$, $SD = 1.64$) did not significantly differ in their reports of identity expression threat in English, $F(1, 113) = 2.86$, $p = .09$. Seen differently, women expressed greater identity expression threat in computer science than English, $F(1, 113) = 50.25$, $p < .001$, $d_{av} = .97$, whereas men expressed greater identity expression threat in English than computer science, $F(1, 113) = 11.68$, $p = .001$, $d_{av} = .52$.

A meta-analysis across the two studies using fixed effects and weighting the effect sizes by sample size (Goh, Hall, & Rosenthal, 2016) revealed a large effect of gender on identity expression threat in computer science, $d = .96$, 95% CI [.70, 1.22], $Z = 7.30$,

$p < .001$, two-tailed. A meta-analysis comparing Asian/Asian American women to White women revealed no significant differences in reports of identity expression threat in computer science, $d = .06$, 95% CI [–.36,.48], $Z = .27$, $p = .79$, two-tailed. Other racial groups' sample sizes were too small for statistical comparisons.

Downplaying interest

In the original sample, a 3 (field; within) × 2 (gender; between) mixed-model ANOVA on downplaying interest revealed a main effect of field, $F(2, 296) = 7.24$, $p < .001$, no main effect of gender, $F(1, 148) = 1.08$, $p = .30$, and a significant interaction of gender and field, $F(2, 296) = 3.85$, $p = .02$. Women ($M = 2.48$, SD = 1.37) downplayed interest in computer science significantly more than did men ($M = 1.95$, $SD = 1.34$), $F(1, 148) = 5.59$, $p = .02$, $d = .39$. There were no significant effects of gender on downplaying interest in English (women: $M = 2.16$, $SD = 1.54$; men: $M = 2.16$, $SD = 1.39$), $F(1, 148) = 0.001$, $p = .98$, and biology (women: $M = 1.87$, $SD = 1.28$; men: $M = 1.81$, $SD = 1.22$), $F(1, 148) = 0.07$, $p = .79$. Seen differently, women were significantly more likely to downplay interest in computer science than biology, $F(1, 148) = 17.77$, $p < .001$, $d_{av} = .46$, but not significantly more likely to downplay interest in computer science compared to English, $F(1, 148) = 3.49$, $p = .06$, and were not significantly more likely to downplay interest in English compared to biology, $F(1, 148) = 3.15$, $p = .08$, simple effect of field: $F(2, 296) = 7.26$, $p = .001$. In contrast, men were not significantly more likely to downplay interest in computer science compared to biology, $F(1, 148) = 1.15$, $p = .29$, and computer science compared to English, $F(1, 148) = 2.12$, $p = .15$, but were more likely to report downplaying interest in English than biology, $F(1, 148) = 6.16$, $p = .01$, $d_{av} = .28$, simple effect of field: $F(2, 296) = 3.25$, $p = .04$.

In the replication sample, we again found a significant main effect of field, $F(1, 113) = 13.01$, $p < .001$, no main effect of gender, $F(1, 113) = 0.04$, $p = .85$, and a significant interaction of gender and field on downplaying interest, $F(1, 113) = 11.67$, $p = .001$. Women ($M = 2.55$, $SD = 1.37$) and men ($M = 2.06$, $SD = 1.44$) did not differ significantly in their reports of downplaying interest in computer science, $F(1, 113) = 3.42$, $p = .07$, $d = .35$. Men ($M = 3.17$, $SD = 1.75$) and women ($M = 2.58$, $SD = 1.56$) also did not differ significantly in their report of downplaying interest in English, $F(1, 113) = 3.54$, $p = .06$. Seen differently, women were not significantly more likely to report downplaying interest in computer science compared to English, $F(1, 113) = 0.02$, $p = .88$. Men were significantly more likely to report downplaying interest in English than computer science, $F(1, 113) = 21.17$, $p < .001$, $d_{av} = .69$.

A meta-analysis across the two studies using the same procedures as above revealed a small-to-medium effect of gender on reports of downplaying interest in computer science, $d = .37$, 95% CI [.13, .62], $Z = 2.97$, $p = .003$, two-tailed. A meta-analysis comparing Asian/Asian American women to White women revealed no significant differences in reports of downplaying interest in computer science, $d = .20$, 95% CI [–.22, .62], $Z = .94$, $p = .35$, two-tailed. Samples from other racial groups were too small for statistical comparisons. An additional meta-analysis revealed no significant effect of gender on reports of downplaying interest in English, $d = .16$, 95% CI [–.09, .40], $Z = 1.24$, $p = .21$, two-tailed.

Distinguishing identity expression threat from related constructs

We distinguish identity expression threat from other gender-related concerns by examining correlations and gender by field interactions. Identity expression threat in computer science was correlated with perceived discrimination, stereotype threat concerns, romantic concerns, goal incongruity, and fear of backlash for both women and men (see Table 2). However, all correlations for women were below .6, thus sharing less than one-third of its variance with the other measures and suggesting that identity expression threat is capturing a unique concern (Carlson & Herdman, 2012). Identity expression threat in computer science was not significantly correlated with gender devaluation, self-efficacy, and sense of belonging for women or men.

We conducted 3 (field; within) × 2 (gender; between) mixed-model ANOVAs on the other gender-related concerns, including perceived gender devaluation, perceived discrimination, stereotype threat concerns, self-efficacy, sense of belonging, romantic concerns, goal incongruity, and fear of backlash (see Table 3 for descriptive statistics and simple effects). The field by gender interaction was significant for perceived gender devaluation, $F(2, 296) = 12.77$, $p < .001$, perceived discrimination, $F(2, 296) = 55.93$, $p < .001$, stereotype threat concerns, $F(2, 296) = 5.40$, $p = .005$, self-efficacy, $F(2, 296) = 10.00$, $p < .001$, and sense of belonging, $F(2, 296) = 13.55$, $p < .001$. The only constructs that had a significant gender by field interaction and were significantly correlated with identity expression threat were stereotype threat concerns and perceived discrimination. However, unlike identity expression threat, women reported significantly greater stereotype threat concerns and anticipated more discrimination than did men in biology. The field by gender interaction was not significant for romantic concerns, original sample: $F(2, 296) = 0.10$, $p = .90$; replication sample: $F(1, 113) = 0.40$, $p = .53$, goal incongruity, original sample: $F(2, 296) = 0.79$, $p = .45$, and fear of backlash, original sample: $F(2, 296) = 0.71$, $p = .49$, replication sample: $F(1, 113) = 2.63$, $p = .11$.

Mediation

We conducted a mediation analysis on the original sample with 10,000 bootstrap resamples using the mediate function from the psych R package (Revelle, 2018) to examine whether identity expression threat mediated the relationship between gender and downplaying interest in computer science. As seen in the original sample above, women (coded as 1) were more likely than men (coded as 0) to report downplaying interest in computer science, $b = 0.53$, $SE = 0.22$, $p = .02$, and more likely than men to report identity expression threat in computer science, $b = 1.07$, $SE = 0.22$, $p < .001$. Identity expression threat significantly predicted the likelihood of downplaying interest in computer science upon controlling for gender, $b = 0.48$, $SE = 0.08$, $p < .001$. The relationship between gender and downplaying interest in computer science was fully attenuated upon controlling for identity expression threat, $b = 0.01$, $SE = 0.21$, $p = .95$. Identity expression threat significantly mediated the relationship between gender and downplaying interest in computer science, $b = 0.51$, SE = 0.14, 95% CI [.28, .81].

A second mediation in the replication sample revealed that women (coded as 1) and men (coded as 0) did not significantly differ in their likelihood to downplay interest in computer science, $b = 0.49$, $SE = 0.26$, $p = .07$. Women were significantly more likely than

Table 2. Correlations between computer science questions in Study 3.

Constructs	1	2	3	4	5	6	7	8	9	10
1. Identity Expression Threat	-	.49** [.60**]	.07	.56**	.57**	−.13	−.16	.38**	.30**	.38**
2. Downplaying Interest	.43** [.31**]	-	.12	.57**	.63**	−.09	−.09	.62** [.33*]	.38**	.67** [.44**]
3. Gender Devaluation	.30	.35**	-	.18	.07	−.27*	−.41**	.03	.09	.08
4. Perceived Discrimination	.41**	.36**	.42**	-	.52**	−.11	−.01	.33**	.32**	.35**
5. Stereotype Threat	.57**	.35**	.26*	.51**	-	−.14	−.07	.53**	.56**	.64**
6. Self-Efficacy	−.17	−.31*	−.26*	−.26*	−.17	-	.65**	−.15	−.10	−.15
7. Sense of Belonging	−.22	−.35**	−.30*	−.17	−.10	.67**	-	−.10	−.09	−.21*
8. Romantic Concerns	.42**	.39** [.40**]	.27*	.31*	.41**	−.11	−.10	-	.48**	.75**
9. Goal Incongruity	.34**	.42**	.21	.33**	.38**	−.31*	−.20	.68**	-	.53**
10. Fear of Backlash	.44**	.47** [.57**]	.23	.35**	.53**	−.24	−.26*	.74**	.62**	-

Note. Correlations are reported separately for women (below diagonal) and men (above diagonal). Values in brackets indicate correlations from the replication sample. Degrees of freedom equal 62 (original sample)/65 (replication sample) for women and 84 (original sample)/46 (replication sample) for men.
**$p < .01$ and *$p < .05$.

Table 3. Descriptive statistics of potential gender-related concerns in computer science, biology, and English by gender in Study 3.

	Computer science				Biology				English			
	Women	Men			Women	Men			Women	Men		
Mediator	*M* (*SD*)	*M* (*SD*)	*p*	*Cohen's d*	*M* (*SD*)	*M* (*SD*)	*p*	Cohen's *d*	*M* (*SD*)	*M* (*SD*)	*p*	Cohen's *d*
Gender devaluation	3.66 (1.59)	3.06 (1.55)	.02	.39	2.88 (1.37)	3.17 (1.61)	.23	.20	2.95 (1.30)	3.65 (1.53)	.004	.48
Perceived discrimination	3.76 (1.34)	1.64 (0.98)	<.001	1.86	2.56 (1.29)	1.72 (1.09)	<.001	.72	2.18 (1.24)	2.28 (1.51)	.67	.07
Stereotype threat	3.30 (1.47)	2.15 (1.40)	<.001	.80	2.52 (1.38)	1.77 (1.13)	<.001	.61	2.64 (1.54)	2.10 (1.39)	.03	.37
Self-efficacy	3.05 (1.71)	4.07 (1.60)	<.001	.62	4.35 (1.50)	4.35 (1.57)	.99	.00	4.61 (1.51)	4.22 (1.80)	.17	.23
Sense of belonging	3.06 (1.57)	3.81 (1.19)	.001	.55	4.51 (1.37)	3.94 (1.33)	.01	.42	3.90 (1.49)	3.46 (1.44)	.07	.30
Romantic concerns (original)	2.39 (1.58)	2.42 (1.65)	.92	.02	1.74 (1.15)	1.83 (1.21)	.67	.07	1.68 (1.04)	1.81 (1.09)	.47	.12
Romantic concerns (replication)	2.24 (1.36)	2.33 (1.61)	.73	.06					2.22 (1.33)	2.16 (1.50)	.80	.05
Goal incongruity	2.51 (1.43)	2.29 (1.35)	.34	.16	2.14 (1.22)	2.03 (1.14)	.59	.09	2.57 (1.44)	2.62 (1.27)	.84	.03
Fear of backlash (original)	2.17 (1.37)	1.96 (1.22)	.33	.16	1.71 (1.09)	1.72 (1.07)	.95	.01	2.29 (1.39)	2.18 (1.17)	.60	.09
Fear of backlash (replication)	2.09 (1.13)	1.99 (1.18)	.66	.08					2.54 (1.41)	2.90 (1.54)	.19	.25

men to report identity expression threat in computer science, $b = 1.60$, $SE = 0.26$, $p < .001$. Identity expression threat significantly predicted downplaying interest in computer science when controlling for gender, $b = 0.42$, $SE = 0.09$, $p < .001$. The relationship between gender and downplaying interest in computer science was not significant after controlling for identity expression threat, $b = -0.18$, $SE = 0.28$, $p = .51$. Identity expression threat significantly mediated the relationship between gender and downplaying interest in computer science, $b = 0.67$, $SE = 0.16$, 95% CI [.40, 1.03].

Discussion

Identity expression threat emerged as a coherent threat and distinct from other gender-related concerns already established in the literature, including gender devaluation, perceived discrimination, stereotype threat concerns, self-efficacy, sense of belonging, romantic concerns, perceptions of goal incongruity, and fear of backlash.

Women reported significantly greater identity expression threat than did men in computer science but not in biology or English. In both biology and English, women's mean level of reported identity expression threat was below 2 on a 7-point scale. In computer science, women's mean identity expression threat was higher by nearly a full point, though like the other threats included in the questionnaire, it remained below the midpoint. In biology, women and men reported similar levels of identity expression threat, even as women anticipated greater discrimination and stereotype threat than did men. These findings thus underscore the importance of disaggregating STEM fields, and the gender-related threats that exist within them, when studying gender disparities (Cheryan et al., 2017).

In English, men expressed greater identity expression threat than did women, revealing that this threat is not unique to women but is present when there is a perceived incompatibility between the field's stereotypes and one's gender role. Though men reported greater identity expression threat in English than did women, they were no more likely than women to say that they would downplay interest in English.[4] One possibility is that men respond to identity expression threat in a different manner than do women and do not downplay interest in academic fields as a result. A second possibility is that our sample (i.e., psychology participant pool) selected for men who have chosen to pursue more stereotypically feminine fields and thus have already decided not to downplay their interest in these fields, despite their knowledge of the possible perceived gender role violation. This latter possibility could be further tested by investigating whether the identity expression threat perceived by women in male-dominated STEM fields also does not predict a greater tendency than their male peers to downplay interest in those fields. A third possibility is that women may also be downplaying their interest in English because it is perceived as being lower status or less prestigious than other disciplines.

The more that women reported identity expression threat in computer science, the more likely they were to downplay interest in computer science. Indeed, women's greater reports of identity expression threat in computer science relative to men's

reports mediated women's greater likelihood of downplaying interest in computer science. Concerns about violating gender role prescriptions may result in women hiding interest from others.

General discussion

Choosing a major is seen as a public act that communicates important information about a person's identity. Women who consider pursuing computer science have to contend not only with the threatening climate they anticipate within the field, but also with *identity expression threat*, or their concerns about violating gender expectations to those outside the field. Identity expression threat was greater among women considering computer science than men doing the same and greater than when women considered English and biology.

The extent to which women reported identity expression threat in computer science also predicted their greater likelihood of indicating that they would downplay interest in computer science to others. Indeed, the gender difference in identity expression threat mediated the relationship between gender and likelihood of downplaying interest in computer science. It may be the case that women would not encounter judgment from their peers (Prentice & Miller, 1996) or that they would find ways to cope with it (e.g., making friends inside the field to buffer against threats from those outside the field), but the mere *anticipation* of encountering social disapproval may preclude women from public displays of interest to those outside the field (e.g., joining a programming club, taking an optional computer science course). Gender differences in expressing interest subsequently contribute to a perception that computer science is more appropriate for men, creating an unfortunate self-reinforcing cycle.

Identity expression threat was distinct from threats that are more commonly studied in social psychology, such as discrimination and stereotype threat (e.g., Ceci, Williams, & Barnett, 2009; Major & Schmader, 1998; Shapiro & Neuberg, 2007). Women's perception that pursuing the field would constitute a gender role violation is thus an additional threat that may explain why gender disparities in computer science and related fields have been notoriously difficult to remedy (National Science Foundation, 2018). Taken together, these studies show that women anticipate greater negative judgment compared to men from not only within the field, but also from outside when considering a future in computer science. Simultaneous social pressures from inside and outside the field of computer science make it doubly daunting for women.

Identity expression threat differed from fear of backlash (e.g., Moss-Racusin & Rudman, 2010; Rudman & Fairchild, 2004; Rudman & Phelan, 2008) and romantic concerns (Park et al., 2011). Even when women do not fear tangible repercussions like being teased or considered less romantically attractive, they may have concerns about how they will be seen by those outside the field for violating gender role prescriptions, and these concerns may motivate them to downplay stereotypically masculine interests.

There are several possible approaches to alleviating identity expression threat for women in computer science. First, broadening the image of computer science to include more characteristics stereotypically associated with the female gender role may reduce the conflict women feel between the computer science major and their

gender role prescriptions. Second, cultural interventions to counteract the conflation of one's academic major with one's identity may help alleviate identity expression threat. Third, implementing strategies to counteract students' worries about expressing an identity that violates gender roles to those outside the field, such as recruiting women in groups to study computer science, may provide short-term relief from concerns about expressing an interest that is perceived as a violation of one's gender role. Fourth, self-affirmation, used to reduce negative effects of stereotype threat (Cohen, Garcia, Purdie-Vaughns, Apfel, & Brzustoski, 2009; Walton, Logel, Peach, Spencer, & Zanna, 2015), could be tested as a way to reduce the negative consequences of identity expression threat. Finally, women may use their own strategies to cope with identity expression threat, such as distancing from aspects of the female gender role perceived to be the most incompatible with having a computer science identity (e.g., Pronin, Steele, & Ross, 2004).

Future work could also examine individual and cultural differences to further understand identity expression threat. First, some women – for instance, high self-monitors, those who are more concerned about how they present themselves to others (Snyder, 1974) – may be more prone to feeling these concerns than other women. Second, the theory should be applicable to younger (e.g., high school) students, who may be particularly influenced by what they think their peers think of them (Harter, 1990; Somerville, 2013). Third, individuals in cultures that place less emphasis on individual choice and self-expression (Charles & Bradley, 2009; Markus & Kitayama, 2010) may experience less identity expression threat when it comes to choosing a field of study.

In the US, "What's your major?" is a common question posed to undergraduates, and their answers convey the kind of person they are. As a result, a student's choice of major might be influenced by a desire to convey a socially acceptable identity to their peers. If a student perceives that she may face negative judgment from peers outside of the major for choosing a major that violates gender role prescriptions, she may downplay her interest in that field and risk forgoing potentially beneficial opportunities to advance her career. In addition to resulting in potential negative professional consequences for women, on a larger scale, downplaying interest in the field could contribute to the maintenance of stereotypes depicting women as unsuited for computer science. For women considering fields such as computer science, social threats from both within and outside the major may operate together to make the prospect of computer science education seem unusually daunting. Understanding current gender disparities in STEM requires considering not only the "chilly" climate within these fields but how women believe they will be judged by those outside the fields for entering them.

Notes

1. The "How are you doing?" category also included three questions that were related to location (e.g., "How do you like UW?").
2. Two other questions were included in this study that asked about "masculine" instead of "unfeminine." Including these questions generated similar results.
3. The second question asking about others had slightly different wording: "label you as being" was replaced with "see you as."

4. Per a reviewer's request, we examined and found that the relationship between gender and downplaying interest in English was indirectly mediated by men's greater identity expression threat in English relative to women in the original sample (a path: $b = -0.57$, $SE = 0.21$, $p = .007$; b path: $b = 0.68$, $SE = 0.08$, $p < .001$; c path: $b = -0.01$, $SE = 0.24$, $p = .98$; c' path: $b = 0.38$, $SE = 0.20$; 95% CI [−.67, −.13]) but not the replication sample (a path: $b = -0.44$, $SE = 0.26$, $p = .09$; b path: $b = 0.54$, $SE = 0.10$, $p < .001$; c path: $b = -0.58$, $SE = 0.31$, $p = .06$; c' path: $b = -0.35$, $SE = 0.28$; 95% CI [−.60, .04]).

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