Female peer mentors early in college increase women's positive academic experiences and retention in engineering

Tara C. Dennehy[a] and Nilanjana Dasgupta[a,1]

[a]Department of Psychological and Brain Sciences, University of Massachusetts, Amherst, MA 01003

Edited by Sapna Cheryan, University of Washington, Seattle, WA, and accepted by Editorial Board Member Mary C. Waters April 14, 2017 (received for review August 6, 2016)

Scientific and engineering innovation is vital for American competitiveness, quality of life, and national security. However, too few American students, especially women, pursue these fields. Although this problem has attracted enormous attention, rigorously tested interventions outside artificial laboratory settings are quite rare. To address this gap, we conducted a longitudinal field experiment investigating the effect of peer mentoring on women's experiences and retention in engineering during college transition, assessing its impact for 1 y while mentoring was active, and an additional 1 y after mentoring had ended. Incoming women engineering students (n = 150) were randomly assigned to female or male peer mentors or no mentors for 1 y. Their experiences were assessed multiple times during the intervention year and 1-y postintervention. Female (but not male) mentors protected women's belonging in engineering, self-efficacy, motivation, retention in engineering majors, and postcollege engineering aspirations. Counter to common assumptions, better engineering grades were not associated with more retention or career aspirations in engineering in the first year of college. Notably, increased belonging and self-efficacy were significantly associated with more retention and career aspirations. The benefits of peer mentoring endured long after the intervention had ended, inoculating women for the first 2 y of college—the window of greatest attrition from science, technology, engineering, and mathematics (STEM) majors. Thus, same-gender peer mentoring for a short period during developmental transition points promotes women's success and retention in engineering, yielding dividends over time.

mentoring | stereotypes | gender | STEM education | diversity

The odds do not favor women in most physical sciences, engineering, and computing. Despite educational advances, women, who constitute 56% of university students in the United States (1), hold only 13–33% of bachelor's and master's degrees and 11–21% of doctoral degrees in these fields (2). Even among degree holders in engineering, computing, and physical sciences, women are less likely than men to hold jobs related to science, technology, engineering, and mathematics (STEM) degrees (2). Overall, the proportion of women in physical sciences, engineering, and computer science is very small relative to men and gets smaller still with every level of advancement (3). Engineering is notable for having one of the lowest proportions of women among all sciences (2) and is the focus of our research.

Attempts to explain the relative scarcity of women engineers as due to women's "free choice" to pursue alternate career paths (4), or lower aptitude and intrinsic motivation (5), neglect widespread structural and psychological contributors to this phenomenon (6, 7). Many engineering environments are subtly unfriendly or sometimes overtly hostile for women (8, 9). The numeric scarcity of women (10, 11), nonverbal behavior from male colleagues that excludes women from professional conversations (12), use of masculine pronouns to refer to all scientists and engineers (12, 13), and the prevalence of sexist jokes (14) all signal to women that they are outsiders who do not belong in engineering (6, 15, 16). Even in organizations that prioritize diversity, the ideal engineer is implicitly assumed to be male (17), eroding women's belonging and self-efficacy, leading to burnout and attrition (18).

A number of interventions aim to counter negative effects of STEM stereotypes on women (19), but few have been tested in naturally existing field settings (cf. refs. 20 and 21). One real-world exception, aimed at increasing diversity, is mentoring, which is in widespread use in the academy (22), government (23), and industry (24), and commonly assumed to work because it is correlated with positive health, attitudes, motivation, and behaviors (25). Despite its popularity, however, evidence supporting mentoring is shaky because serious methodological flaws make it impossible to separate benefits of mentoring from confounds (see refs. 25–28 for meta-analyses). Most studies used correlational surveys, case studies, pretest–posttest studies of a single mentored group with no comparison group or nonequivalent comparison groups. Participants opted in knowing these studies were on mentoring and self-reported how mentors affected them, raising concerns about sampling bias and self-report bias, which could have inflated positive results. Mentees and mentors often chose each other, raising doubts as to whether mentoring in general, or a unique connection between mentor–mentee, produced the benefits. Randomized controlled experiments are rare in mentoring research, making it impossible to determine whether having a mentor (vs. no mentor) produced any benefits.

Significance

The scarcity of women in the American science and engineering workforce is a well-recognized problem. However, field-tested interventions outside artificial laboratory settings are few. We provide evidence from a multiyear field experiment demonstrating that women in engineering who were assigned a female (but not male) peer mentor experienced more belonging, motivation, and confidence in engineering, better retention in engineering majors, and greater engineering career aspirations. Female mentors promoted aspirations to pursue engineering careers by protecting women's belonging and confidence. Greater belonging and confidence were also associated with more engineering retention. Notably, grades were not associated with year 1 retention. The benefits of mentoring endured beyond the intervention, for 2 y of college, the time of greatest attrition from science, technology, engineering, and mathematics (STEM) majors.

Author contributions: N.D. designed research; T.C.D. performed research; T.C.D. analyzed data; and T.C.D. and N.D. wrote the paper.

The authors declare no conflict of interest.

This article is a PNAS Direct Submission. S.C. is a guest editor invited by the Editorial Board.

Freely available online through the PNAS open access option.

[1]To whom correspondence should be addressed. Email: dasgupta@psych.umass.edu.

This article contains supporting information online at www.pnas.org/lookup/suppl/doi:10.1073/pnas.1613117114/-/DCSupplemental.

Another source of ambiguity in mentoring research comes from not knowing whether ingroup vs. outgroup mentors are most beneficial. Some research suggests that women reap more benefits from male mentors in professional settings because men, being advantaged, confer organizational legitimacy on their mentees and provide resources required for success (29, 30). However, other studies argue that for women who are a small minority in achievement settings, female mentors enhance social belonging in otherwise alienating environments (6, 31, 32). Role model research also suggests that mere exposure to successful ingroup (vs. outgroup) members enhances motivation and aspirations among negatively stereotyped individuals (31, 33–36). Applied to women in STEM, past research supports three possible predictions: male mentors may be best; female mentors may be best; or any mentor regardless of gender may be better than no mentor. Unfortunately, the absence of controlled experiments comparing the effect of mentor gender on women in STEM makes it impossible to adjudicate this issue.

Our goal is to investigate these unresolved questions by assessing whether mentoring—presumed to be beneficial—has any real causal benefits for women in engineering, using a longitudinal randomized controlled field experiment. Second, we sought to test whether mentors' group membership has any impact on mentee outcomes, and if so, why. Third, if mentoring is beneficial, we sought to investigate how long that benefit endures after the mentor is gone. Finally, whereas mentoring is usually a hierarchical relationship between experts and novices (25), we focused on peer mentoring (37) between advanced students and first-years because this is easy to scale up without placing undue burden on women faculty in STEM if same-gender mentors are necessary. These goals were informed by the Stereotype Inoculation Model (6), which predicts that—analogous to a biomedical vaccine that inoculates one's physical body against noxious bacteria—exposure to ingroup experts and peers serves as a "social vaccine" that inoculates one's mind against noxious stereotypes, and is especially effective during developmental transitions when individuals experience most self-doubt.

Current Study

We conducted a multiyear longitudinal field experiment investigating whether a peer mentoring intervention, with advanced students as mentors, would increase the success of women who are beginners in engineering. We predicted that beginning women students paired with female peer mentors would have better experiences in engineering than women without mentors, in terms of belonging in the major, self-efficacy, less anxiety (threat), and more motivation (challenge). Second, we expected that women with female mentors would have higher retention in engineering and more intentions to pursue advanced engineering degrees than controls. Third, we proposed that positive everyday experiences in engineering (such as feelings of belonging) would likely mediate any effects of having a female mentor on women's future intentions to pursue engineering after college. Fourth, the benefits of same-gender mentoring were expected to endure long after mentoring ended. Finally, we had competing predictions regarding the impact of male mentors. Although some past research suggests that women with any mentor regardless of gender fare better than those without mentors (38), other research suggests that women with male mentors fare best in fields where men dominate (29, 30), whereas research on stereotype inoculation and role modeling suggests that women with female mentors fare best (6, 31).

To test these predictions, we recruited 150 female students, all incoming majors in engineering at a public university, by sending mass emails to all women in each entering class. Participants were randomly assigned to one of three conditions: one-third was assigned to female peer mentors, one-third to male peer mentors, and the rest had no mentor (control group). Mentor–mentees met in person roughly once a month and mentors kept track of their interactions using online surveys. All were blind to experimental hypotheses (see details in *SI Materials and Methods*). Mentoring relationships lasted for 1 y. We surveyed mentees' experiences in engineering at three time points during year 1: before mentor assignment at the beginning of the year, and then at the middle and end of the academic year when mentoring relationships were active. A fourth survey was administered 1 y after mentoring had ended (year 2). We measured participants' belonging in engineering, self-efficacy, feelings of threat and challenge, career aspirations, and global appraisals of engineering. College transcripts, obtained from the university registrar with students' consent, provided grades and retention information in engineering majors.

Results

Mentoring Quality. Male and female mentors did not differ in the quality or quantity of their interactions with mentees. Participants perceived their mentors to be equally supportive regardless of mentor gender; they admired and felt connected to all mentors regardless of gender; and they met equally frequently regardless of mentor gender, all indicating that male and female mentors were equally conscientious (Tables S1 and S2). The only advantage for female mentors was that women mentees felt somewhat closer and more similar to female mentors than male mentors.

Analytic Strategy. Multilevel modeling was used to analyze whether random assignment to mentor condition changed mentees' experiences over 1 and 2 y, using participant experiences before mentor assignment as the baseline. Below, we first describe how women's engineering outcomes change over time separately within each mentor condition. We then compare whether change trajectories differed significantly across conditions.

Female Mentors Protect Positive Academic Experiences in Engineering. In terms of belonging in engineering, women with no mentors and those with male mentors reported steep declines in feelings of belonging in engineering from the beginning to end of the first year ($B = -0.45$, SE = 0.17, $P = 0.007$, and $B = -0.42$, SE = 0.18, $P = 0.02$, respectively), whereas women with female mentors maintained positive belonging that did not change across the first year of college ($B = 0.13$, SE = 0.18, $P = 0.46$). Comparing change trajectories between conditions, women with female mentors reported more stable belonging than those without mentors ($B = 0.58$, SE = 0.25, $P = 0.03$) or with male mentors ($B = 0.58$, SE = 0.25, $P = 0.024$). Women with male mentors did not differ from those without mentors ($B = -0.04$, SE = 0.26, $P = 0.89$) (Fig. 1).

We next examined the impact of mentoring on students' self-efficacy in engineering. Women without mentors showed steep declines in self-efficacy across the first year ($B = -0.63$, SE = 0.17, $P < 0.001$), as did those with male mentors ($B = -0.29$, SE = 0.17, $P = 0.08$). In contrast, women with female mentors maintained positive self-efficacy that did not change ($B = 0.03$, SE = 0.17, $P = 0.862$). Comparing change trajectories between conditions, students with female mentors reported more stable self-efficacy than those with no mentors ($B = 0.66$, SE = 0.24, $P = 0.007$). Male mentors fell in-between and did not differ from either group (*SI Results*) (Fig. 2).

Female mentors also affected the degree to which students' anxiety about engineering (threat) was offset by their belief that they possessed skills to overcome academic difficulties (challenge). This was measured as the ratio of threat vs. challenge. A threat/challenge ratio greater than 1 indicates that women's anxiety overwhelmed their perceived skills; a ratio less than 1 indicates that perceived skills outweighed anxiety, and a ratio of 1 indicates an equal standoff between anxiety and perceived skills. Women with no mentors felt increasingly threatened more than challenged as the first year progressed ($B = 0.32$, SE = 0.13, $P < 0.001$), as did those with male mentors ($B = 0.17$, SE = 0.09, $P = 0.059$). In contrast, women with female mentors did not show

PSYCHOLOGICAL AND COGNITIVE SCIENCES

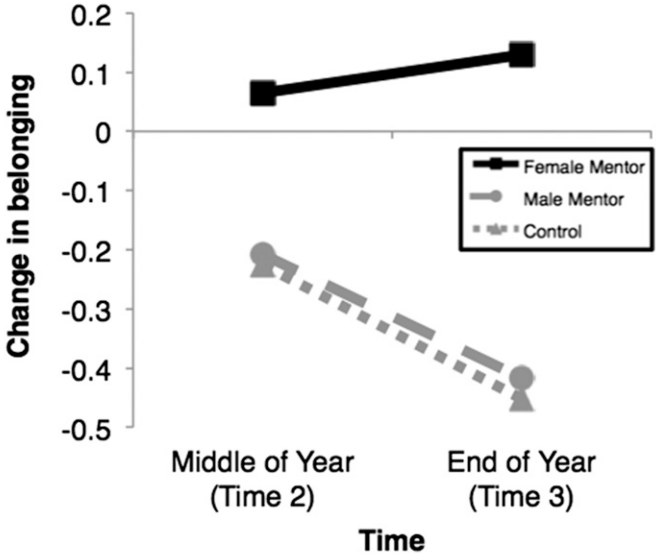

Fig. 1. Effect of mentor condition on women's belonging in engineering. The *y*-axis values are difference scores from time 1, before mentor assignment. Deviations from zero show a relative increase or decrease from time 1. Statistical analyses were conducted using actual responses, not difference scores.

any change in threat vs. challenge across the year (B = 0.07, SE = 0.09, P = 0.445). Comparing change trajectories between conditions, women with female mentors exhibited significantly less rise in threat vs. challenge than those with no mentors (B = −0.25, SE = 0.13, P = 0.047). Students with male mentors fell between the other two conditions, nonsignificantly different from both (Fig. 3). These results are specific to threat/challenge ratio; threat and challenge, considered separately, did not yield group differences (details in *SI Results*).

Female Mentors Protect Retention and Postdegree Aspirations in Engineering. To examine whether mentoring would reduce women's attrition from engineering, we examined the frequency with which women thought about switching majors, their objective retention rates in engineering majors, and their intentions to pursue advanced degrees in engineering after college. Women without mentors increasingly thought about switching to another major over time (B = 0.94, SE = 0.28, P < 0.001), whereas for those with female and male mentors, thoughts about switching majors did not change over time (B = 0.27, SE = 0.27, P = 0.31, and B = 0.19, SE = 0.26, P = 0.47 respectively). Comparing change trajectories between conditions, women without mentors reported a marginally greater increase in thoughts of switching majors than those with female or male mentors (B =0.74, SE = 0.38, P = 0.055; B =0.66, SE = 0.39, P = 0.089, respectively) (Fig. S1).

Although thoughts about switching majors looked similar for the two mentor conditions, when it came to actual decisions to stay or leave, female mentors were more beneficial: 100% of women with female mentors remained in engineering majors at the end of year 1 compared with 82% with male mentors, and 89% without mentors (χ^2 = 8.19, P < 0.01, Cohen's d = 0.48) (Fig. 4).

In terms of after-college aspirations, women with no mentors and male mentors showed declining intentions to pursue advanced degrees in engineering (B = −1.06, SE = 0.25, P < 0.001, and B = −0.71, SE = 0.24, P = 0.003, respectively), whereas those with female mentors maintained consistent intentions to pursue advanced degrees in engineering over time (B = −0.06, SE = 0.23, P = 0.806). Comparing trends across conditions, there was a significant drop in advanced degree intentions for women without mentors compared with those with female mentors (B = −1.01, SE = 0.34, P = 0.004), and a marginal drop compared with male mentors (B = −0.65, SE = 0.33, P = 0.054). Trends in advanced degree intentions did not differ significantly between the two mentor conditions (B = 0.36, SE = 0.34, P = 0.298) (Fig. 5). In short, women with female mentors consistently intended to pursue advanced engineering degrees after college as the year progressed; this trajectory was significantly better than the trend for those without mentors, whereas women with male mentors fell in between.

Social Belonging and Self-Efficacy Mediate the Relation Between Mentor Condition and Engineering Career Aspirations. We used multilevel structural equation modeling to test whether change over time in women's belonging, self-efficacy, or threat relative to challenge (treated as multiple mediators) would mediate the effects of mentor condition on changes in engineering career aspirations during the first year of college. Our analyses revealed that women with female mentors (vs. no mentors) reported more stable feelings of belonging and self-efficacy in engineering over time, both of which in turn predicted increased intentions to pursue future careers in engineering [B = 0.24, SE = 0.12, P = 0.041, lower-level confidence interval (LLCI) = 0.03, upper-level confidence interval (ULCI) = 0.49, and B = 2.58, SE = 0.98, P = 0.008, LLCI = 0.65, ULCI = 4.49, respectively]. Although having a female mentor also protected feelings of threat vs. challenge, this variable did not significantly mediate the relation between mentor condition and engineering career aspirations (B = −1.77, SE = 0.93, P = 0.058, LLCI = −3.59, ULCI = 0.05). These results suggest that having a female peer mentor (vs. no mentor) protects women's career aspirations in engineering by preserving belonging and feelings of self-efficacy. See Table S3 and *SI Results* for more details.

Comparing women with female vs. male mentors, only social belonging emerged as a significant mediator. Specifically, women with female mentors reported more stable feelings of belonging in engineering over time than others with male mentors; belonging in turn predicted increased intentions to pursue engineering careers (B = 0.22, SE = 0.11, P = 0.046, LLCI = 0.02, ULCI = 0.46). Analyses comparing the male-mentor vs. no-mentor conditions were nonsignificant. See Table S3 and *SI Results*. Taken together,

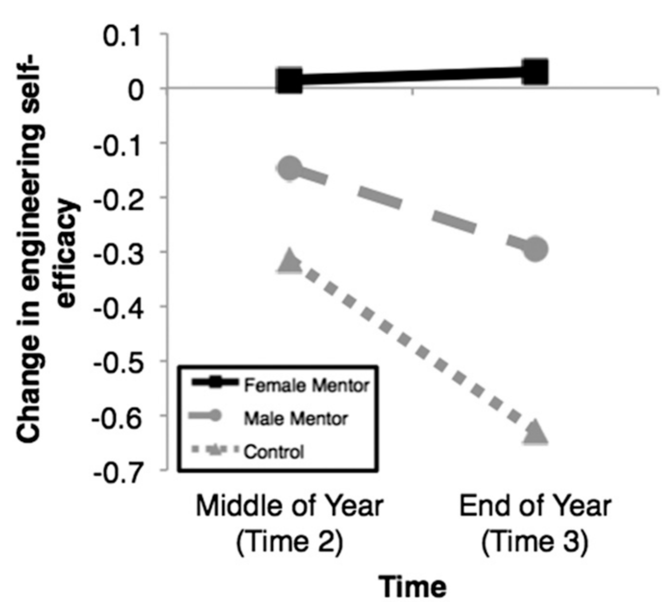

Fig. 2. Effect of mentor condition on women's self-efficacy in engineering. The *y*-axis values are difference scores from time 1, before mentor assignment. Deviations from zero show a relative increase or decrease from time 1. Statistical analyses were conducted using actual responses, not difference scores.

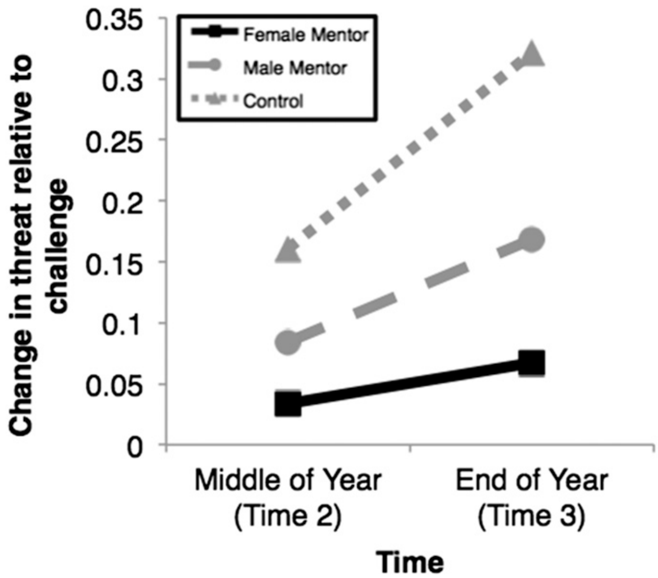

Fig. 3. Effect of mentor condition on women's feelings of threat vs. challenge in engineering. The *y*-axis values are difference scores from time 1, before mentor assignment. Deviations from zero show a relative increase or decrease from time 1. Statistical analyses were conducted using actual responses, not difference scores.

these results suggest that greater belonging and self-efficacy may serve as underlying psychological processes that explain why female peer mentors, who are slightly more advanced in college, would promote engineering career aspirations among women who are new to engineering.

One Year Later: Long-Term Effects of Female Mentors on Student Outcomes. We used a subsample of women who had completed their second year in college (n = 78) to examine the long-term effects of peer mentoring 1 y after the mentors were gone. The results are promising but preliminary because of the smaller sample size. Results showed that women who had male mentors in year 1 showed a consistent decline in belonging through the end of year 2 (B = −0.03, SE = 0.01, P = 0.007), whereas those with female mentors showed stable belonging through the end of year 2 even after their mentors had graduated (B = 0.02, SE = 0.01, P = 0.209). Students without mentors exhibited a nonsignificant decline in belonging through the end of year 2 (B = −0.01, SE = 0.01, P = 0.184). Upon comparing conditions, the belonging trajectory for women with male mentors was significantly more negative than that for female mentors (B = −0.03, SE = 0.02, P = 0.024), with the no-mentor condition falling between, not differing from either (Fig. S2*A*).

For feelings of threat, women with male mentors in year 1 displayed a sharp increase in threat through the end of year 2 (B = 0.06, SE = 0.01, P < 0.001) as did those with female mentors (B = 0.02, SE = 0.01, P = 0.016) and no mentors (B = 0.03, SE = 0.01, P < 0.001). A comparison of trends across conditions showed that participants with female mentors displayed significantly less increase in threat than others with male mentors (B = −0.03, SE = 0.01, P = 0.038); the control condition fell between, not significantly different from either (Fig. S2*B*). This pattern was only true for threat; relative threat vs. challenge through the end of year 2 did not differ by mentor condition. See *SI Results*.

Declining interest in advanced engineering degrees persisted through the end of year 2 for women who had male mentors or no mentors in year 1 (B = −0.08, SE = 0.02, P < 0.001; and B = −0.05, SE = 0.02, P = 0.006), whereas those with female mentors maintained stable interest in advanced engineering degrees through the end of year 2 (B = −0.02, SE = 0.02, P = 0.248) (Fig. S2*C*). Comparing trajectories across condition, participants without mentors showed significantly greater decline in their advanced degree intentions compared with those with female mentors (B = −0.07, SE = 0.03, P = 0.011); participants with male mentors fell in between, not significantly different from either. In sum, the results of this 1-y follow-up are consistent with data from year 1 when mentoring was active, suggesting that the benefits of having a female mentor persisted through 2 y, extending after mentors were gone, and were evident across multiple outcomes. With that said, we recommend interpreting these results with some caution because this follow-up subsample is smaller than the original sample.

Male Peer Mentors Provide Limited Benefits. Although the effects of male mentors sometimes mimicked those of female mentors, women's outcomes in the male-mentor condition tended to be weaker and no different from the control condition, with one exception. Women with male mentors showed stable engineering grade point averages (GPAs) across 2 y (B = −0.0004, SE = 0.007, P = 0.952), whereas women with female mentors and no mentors showed typical GPA declines as coursework became more advanced (B = −0.014, SE = 0.006, P = 0.038, and B = −0.02, SE = 0.006, P = 0.003, respectively) (39) (Fig. S3). A comparison of the GPA trajectory across 2 y showed a significant difference between male-mentor vs. control conditions (B = 0.02, SE = 0.009, P = 0.043), but no difference between male- vs. female-mentor conditions (B = 0.01, SE = 0.009, P = 0.158), suggesting that male mentors did not protect grades any more than female mentors.

Several findings suggest that the stable GPA advantage for women with male mentors is not a good predictor of women's retention and career aspirations in engineering. Rather, subjective feelings of belonging and self-efficacy in engineering are strongly implicated in retention and persistence in engineering (40). First, year 1 GPA was not significantly associated with women's retention in engineering majors (Wald χ^2 = 0.37, P = 0.542), whereas social belonging and self-efficacy at the end of year 1 were both significantly associated with retention in engineering in year 1 (Wald χ^2 = 4.65, P = 0.031, and Wald χ^2 = 16.35, P < 0.001 respectively). Second, recall that engineering retention for women with male mentors was significantly lower

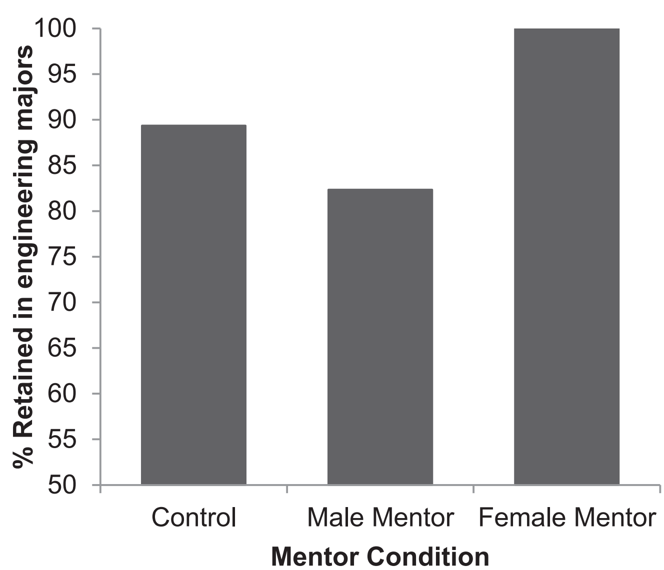

Fig. 4. Effect of mentor condition on women's retention in engineering majors at end of year 1.

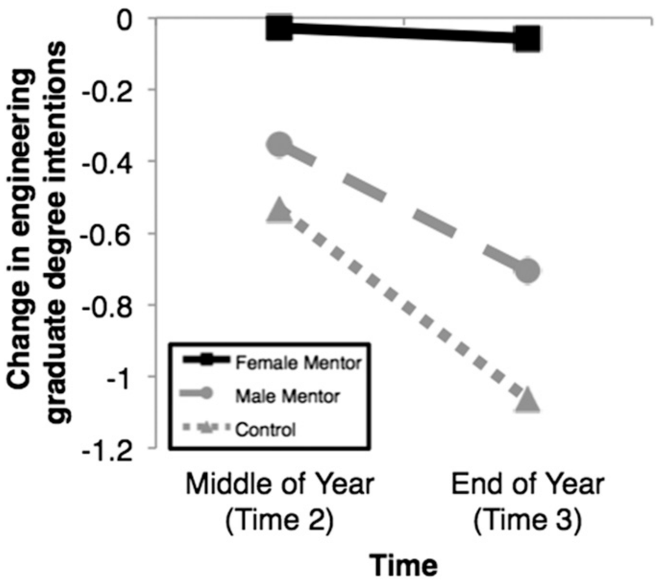

Fig. 5. Effect of mentor condition on women's intentions to pursue advanced degrees in engineering. The *y*-axis values are difference scores from time 1, before mentor assignment. Deviations from zero show a relative increase or decrease from time 1. Statistical analyses were conducted using actual responses, not difference scores.

(82%) than for those with female mentors (100%) and no different from controls (89%). Third, GPA for students with male mentors did not correlate with their feelings of belonging in engineering ($r = -0.04$, $P = 0.82$), thoughts of switching majors ($r = -0.03$, $P = 0.87$), interest in pursuing engineering careers ($r = -0.11$, $P = 0.57$), or advanced degrees ($r = -0.06$, $P = 0.76$) (Table S4). Fourth, although second-year GPA was significantly associated with engineering retention aggregated across all conditions (Wald $\chi^2 = 7.21$, $P = 0.007$), by this time women with male mentors [mean (M) = 3.14, SE = 0.12] and female mentors (M = 3.08, SE = 0.12) had similar GPAs [$t_{(63)} = 0.38$, $P = 0.708$]. In sum, the stable GPA advantage for women with male mentors does not translate to better retention and career aspirations for women in engineering. See *SI Results*.

Discussion

In conclusion, same-gender peer mentoring during the transition to college appears to be an effective intervention to increase belonging, confidence, motivation, and ultimately retention of women in engineering. Our findings make four contributions that advance knowledge about how best to increase and sustain gender diversity in STEM. First, our data show not all peer mentors are equally effective even though the objective content and frequency of mentor–mentee interactions may be similar. Shared identity matters for retention and other engineering outcomes. Second, female mentors protect women's feelings of belonging and connection to other peers in engineering during their first year in college, when they are most vulnerable to self-doubt; greater belonging in turn protects women's aspirations to pursue careers in engineering after college. Third, contrary to common wisdom, better performance in engineering courses (higher GPA) does not necessarily correspond to stronger feelings of belonging or more intentions to pursue engineering careers and advanced degrees. Instead, women's subjective experiences in engineering—notably their feelings of belonging and self-efficacy—predict retention in engineering majors and engineering career intentions. Fourth, the benefits of same-gender peer mentors endured long after mentoring had ended, inoculating women for 2 y of college, the window of greatest attrition from STEM majors (41).

Although female peer mentors had significantly more desirable effects on first-year women in engineering, this does not mean male mentors are unimportant. We expect that female mentors' support will become less critical as women move beyond the college transition, at which point male and female mentors may be equally effective (42). This speculation is consistent with the Stereotype Inoculation Model (6, 10), which identifies developmental transitions, such as the beginning of college, as times of special vulnerability to negative stereotypes. Moreover, whereas our intervention focused on peer mentors, male faculty who are scientists and engineers likely play important roles as advisors and career sponsors.

Findings from this randomized longitudinal field experiment open the door to future tests of the generalizability and boundary conditions of mentoring interventions. First, future research should test whether our findings generalize to disciplines other than engineering where women are also negatively stereotyped and exist in tiny numbers well below critical mass (43). Second, future research should also explore whether female peer mentors would be similarly beneficial to women experiencing other transitions in academic or professional life (e.g., transition to graduate school). Third, our theory (6) affords the prediction that ingroup peer mentors may be beneficial for members of other groups that are underrepresented and negatively stereotyped in high achievement environments (e.g., African American and Latino students); the question of whether our findings would generalize to such other groups is an important one to pursue. Finally, we propose that the importance of ingroup peer mentors is likely to diminish as individuals become more advanced, as their numbers in a field increase, and as negative stereotypes about their ability fade; these are important boundary conditions to investigate. Our findings, and the future research avenues identified above, have important implications for scientists and engineers in higher education, university leaders, and policy makers searching for evidence-based interventions to increase equality in higher education and to diversify the American workforce.

Materials and Methods

Participants. Female students majoring in engineering ($n = 158$) at the University of Massachusetts Amherst participated in our experiment after we obtained approval from the institutional review board. Women account for a tiny minority (16%) of all engineering students at this university, similar to the national average (44). They were paid $20 to $35 for each survey. Of the original recruits, eight (5.1%) dropped out of the experiment soon after the baseline assessment and before mentor contact. The final sample included 150 women. The mean age was 18.34 (SD = 1.34). The majority were White (67.3%); others were Asian (17.3%), multiracial (5.3%), Black (2.7%), Hispanic (2.7%), or indicated another ethnicity (2%). Most were American citizens (91.3%); 16% were first-generation college students and 28% had parents in engineering-related occupations. Mentors were mostly seniors and some juniors who were student leaders of engineering organizations and high performers in engineering. They received an honorarium of $100 for each mentee. See *SI Materials and Methods*.

Procedure. Female recruits were unaware that the experiment had anything to do with mentoring. All provided written consent approved by the university institutional review board and completed a baseline assessment in early fall of their starting academic year (time 1), a midyear assessment in winter (time 2), and a year-end assessment in late spring (time 3). A time 4 survey was administered 1 y later in the spring. Grades were obtained from the university registrar each year. After time 1, participants were randomly assigned—within their engineering major—to a female mentor ($n = 52$), male mentor ($n = 51$), or not given a mentor (control group; $n = 47$) (for details, see *SI Materials and Methods* and *SI Results*).

Datasets. All of the data reported in this manuscript are available in Dataset S1, which is accompanied by two coding guides explaining all variables (Datasets S2 and S3).

ACKNOWLEDGMENTS. We are indebted to the women who participated in this experiment as well as to all mentors who generously gave their time. We are grateful to Drs. Paula Rees and Bernhard Schliemann of the College of

Engineering for their support with participant and mentor recruitment. Our deep thanks to Kristopher Preacher, David DeSteno, and Aline Sayer for their advice on multilevel mediation models. Thank you also to members of the Implicit Social Cognition Laboratory for their comments on an earlier version of this manuscript. Finally, thanks to Elizabeth Adewale, Stephanie Ambroise, Emma Anderson, Rashon Braxton, Nicolas Dundas, Anqi Li, Dia Majumdar, Sarah McHale, Atreyi Mukherji, Victoria Nabaggala, Jane Nabbale, Hanna Pinsky, Celia Santana-Figueroa, Sanaa Siddiqui, Ashley Silberman, and Katherine Richardson for their assistance with data collection, and Kirsten Fraser, Fariba Ghayebi, Kim Meader, Colleen Regan, Jason Robbat, and Kayla Schleicher for their assistance with data entry and coding. This research was supported by National Science Foundation Grant GSE 1132651 (to N.D.).

1. Eagan K, et al. (2015) *The American Freshman: National Norms Fall 2015* (Higher Education Research Institute, Los Angeles).
2. National Center for Science and Engineering Statistics (2013) Scientists and Engineers Statistical Data System (SESTAT) (National Science Foundation, Arlington, VA). Available at www.nsf.gov/statistics/sestat/. Accessed January 25, 2016.
3. Corbett C, Hill C (2015) *Solving the Equation: The Variables for Women's Success in Engineering and Computing* (AAUW, Washington, DC).
4. Ceci SJ, Williams WM, Barnett SM (2009) Women's underrepresentation in science: Sociocultural and biological considerations. *Psychol Bull* 135:218–261.
5. Pinker S (2008) *The Sexual Paradox: Extreme Men, Gifted Women and the Real Gender Gap* (Random House, Canada).
6. Dasgupta N (2011) Ingroup experts and peers as social vaccines who inoculate the self-concept: The stereotype inoculation model. *Psychol Inq* 22:231–246.
7. Dasgupta N, Stout JG (2014) Girls and women in science, technology, engineering, and mathematics: STEMing the tide and broadening participation in STEM careers. *Policy Insights Behav Brain Sci* 1:21–29.
8. Logel C, et al. (2009) Interacting with sexist men triggers social identity threat among female engineers. *J Pers Soc Psychol* 96:1089–1103.
9. Settles IH, Cortina LM, Malley J, Stewart AJ (2006) The climate for women in academic science: The good, the bad, and the changeable. *Psychol Women Q* 30:47–58.
10. Dasgupta N, Scircle MM, Hunsinger M (2015) Female peers in small work groups enhance women's motivation, verbal participation, and career aspirations in engineering. *Proc Natl Acad Sci USA* 112:4988–4993.
11. Hunt J (2016) Why do women leave science and engineering? *Ind Labor Relat Rev* 69: 199–226.
12. Barthelemy RS, McCormick M, Henderson C (2016) Gender discrimination in physics and astronomy: Graduate student experiences of sexism and gender microaggressions. *Physical Rev Physics Educ Res* 12:020119.
13. Stout JG, Dasgupta N (2011) When he doesn't mean you: Gender-exclusive language as ostracism. *Pers Soc Psychol Bull* 37:757–769.
14. Gonsalves AJ, Danielsson A, Pettersson H (2016) Masculinities and experimental practices in physics: The view from three case studies. *Physical Rev Physics Educ Res* 12: 020120.
15. Murphy MC, Steele CM, Gross JJ (2007) Signaling threat: How situational cues affect women in math, science, and engineering settings. *Psychol Sci* 18:879–885.
16. Cheryan S, Plaut VC, Davies PG, Steele CM (2009) Ambient belonging: How stereotypical cues impact gender participation in computer science. *J Pers Soc Psychol* 97: 1045–1060.
17. Nosek BA, Banaji MR, Greenwald AG (2002) Math = male, me = female, therefore math not = me. *J Pers Soc Psychol* 83:44–59.
18. Hall WM, Schmader T, Croft E (2015) Engineering exchanges: Daily social identity threat predicts burnout among female engineers. *Soc Psychol Personal Sci* 6:528–534.
19. Spitzer B, Aronson J (2015) Minding and mending the gap: Social psychological interventions to reduce educational disparities. *Br J Educ Psychol* 85:1–18.
20. Miyake A, et al. (2010) Reducing the gender achievement gap in college science: A classroom study of values affirmation. *Science* 330:1234–1237.
21. Walton GM, Logel C, Peach JM, Spencer SJ, Zanna MP (2015) Two brief interventions to mitigate a "chilly climate" transform women's experience, relationships, and achievement in engineering. *J Educ Psychol* 107:468–485.
22. Zambrana RE, et al. (2015) "Don't leave us behind": The importance of mentoring for underrepresented minority faculty. *Am Educ Res J* 52:40–72.
23. Jarrett V, Tchen CM (2012) *Keeping America's Women Moving Forward: The Key to an Economy Built to Last* (The White House Council on Women and Girls, Washington, DC). Available at purl.fdlp.gov/GPO/gpo21492. Accessed February 26, 2016.
24. Woetzel J, et al. (2015) *The Power of Parity: How Advancing Women's Equality Can Add $12 Trillion to Global Growth* (McKinsey Global Institute, London).
25. Eby LT, Allen TD, Evans SC, Ng T, Dubois D (2008) Does mentoring matter? A multidisciplinary meta-analysis comparing mentored and non-mentored individuals. *J Vocat Behav* 72:254–267.
26. Allen TD, Eby LT, Poteet ML, Lentz E, Lima L (2004) Career benefits associated with mentoring for protégeé: A meta-analysis. *J Appl Psychol* 89:127–136.
27. DuBois DL, Holloway BE, Valentine JC, Cooper H (2002) Effectiveness of mentoring programs for youth: A meta-analytic review. *Am J Community Psychol* 30:157–197.
28. Underhill CM (2006) The effectiveness of mentoring programs in corporate settings: A meta-analytical review of the literature. *J Vocat Behav* 68:292–307.
29. Dreher GF, Cox TH, Jr (1996) Race, gender, and opportunity: A study of compensation attainment and the establishment of mentoring relationships. *J Appl Psychol* 81: 297–308.
30. Ragins BR, Sundstrom E (1989) Gender and power in organizations: A longitudinal perspective. *Psychol Bull* 105:51–88.
31. Stout JG, Dasgupta N, Hunsinger M, McManus MA (2011) STEMing the tide: Using ingroup experts to inoculate women's self-concept in science, technology, engineering, and mathematics (STEM). *J Pers Soc Psychol* 100:255–270.
32. Ensher EA, Murphy SE (1997) Effects of race, gender, perceived similarity, and contact on mentor relationships. *J Vocat Behav* 50:460–481.
33. Beaman L, Duflo E, Pande R, Topalova P (2012) Female leadership raises aspirations and educational attainment for girls: A policy experiment in India. *Science* 335: 582–586.
34. Latu IM, Mast MS, Lammers J, Bombari D (2013) Successful female leaders empower women's behavior in leadership tasks. *J Exp Soc Psychol* 49:444–448.
35. Marx DM, Roman JS (2002) Female role models: Protecting women's math performance. *Pers Soc Psychol Bull* 28:1183–1193.
36. Asgari S, Dasgupta N, Cote NG (2010) When does contact with successful ingroup members change self-stereotypes? A longitudinal study comparing the effect of quantity vs. quality of contact with successful individuals. *Soc Psychol* 41:203–211.
37. Bennion EA (2004) The importance of peer mentoring for facilitating professional and personal development. *PS Polit Sci Polit* 37:111–113.
38. Blake-Beard S, Bayne ML, Crosby FJ, Muller CB (2011) Matching by race and gender in mentoring relationships: Keeping our eyes on the prize. *J Soc Issues* 67:622–643.
39. Felder RM, et al. (1995) A longitudinal study of engineering student performance and retention. III. Gender differences in student performance and attitudes. *J Eng Educ* 84:151–163.
40. Kronberger N, Horwath I (2013) The ironic costs of performing well: Grades differentially predict male and female dropout from engineering. *Basic Appl Soc Psych* 35: 534–546.
41. Ohland MW, et al. (2008) Persistence, engagement, and migration in engineering programs. *J Eng Educ* 97:259–278.
42. Burke RJ, McKeen CA (1990) Mentoring in organizations: Implications for women. *J Bus Ethics* 9:317–332.
43. Kanter RM (1977) Some effects of proportions on group life: Skewed sex ratios and responses to token women. *Am J Sociol* 82:965–990.
44. Yoder BL (2014) *Engineering by the Numbers* (American Society for Engineering Education, Washington, DC).
45. Good C, Rattan A, Dweck CS (2012) Why do women opt out? Sense of belonging and women's representation in mathematics. *J Pers Soc Psychol* 102:700–717.
46. Jamieson JP, Mendes WB, Blackstock E, Schmader T (2010) Turning the knots in your stomach into bows: Reappraising arousal improves performance on the GRE. *J Exp Soc Psychol* 46:208–212.
47. Tomaka J, Blascovich J (1994) Effects of justice beliefs on cognitive appraisal of and subjective, physiological, and behavioral responses to potential stress. *J Pers Soc Psychol* 67:732–740.
48. White JB (2008) Fail or flourish? Cognitive appraisal moderates the effect of solo status on performance. *Pers Soc Psychol Bull* 34:1171–1184.
49. Mendes WB, Gray HM, Mendoza-Denton R, Major B, Epel ES (2007) Why egalitarianism might be good for your health: Physiological thriving during stressful intergroup encounters. *Psychol Sci* 18:991–998.
50. Putwain DW, Symes W, Wilkinson HM (2017) Fear appeals, engagement, and examination performance: The role of challenge and threat appraisals. *Br J Educ Psychol* 87:16–31.
51. Lazarus RS, Folkman S (1984) *Stress, Appraisal, and Coping* (Free Press, New York).
52. Hobfoll SE (1989) Conservation of resources. A new attempt at conceptualizing stress. *Am Psychol* 44:513–524.
53. Dasgupta N, Asgari S (2004) Seeing is believing: Exposure to counterstereotypic women leaders and its effect on automatic gender stereotyping. *J Exp Soc Psychol* 40: 642–658.
54. Aron A, Aron EN, Smollan D (1992) Inclusion of Other in Self Scale and the structure of interpersonal closeness. *J Pers Soc Psychol* 63:596–612.
55. Aron A, et al. (2004) Including others in the self. *Eur Rev Soc Psychol* 15:101–132.
56. Greenwald AG, McGhee DE, Schwartz JL (1998) Measuring individual differences in implicit cognition: The implicit association test. *J Pers Soc Psychol* 74:1464–1480.
57. Raudenbush SW, Bryk AS, Congdon R (2013) *HLM 7 for Windows* (Scientific Software International, Skokie, IL).
58. Preacher KJ, Zyphur MJ, Zhang Z (2010) A general multilevel SEM framework for assessing multilevel mediation. *Psychol Methods* 15:209–233.
59. Hayes AF, Preacher KJ (2014) Statistical mediation analysis with a multicategorical independent variable. *Br J Math Stat Psychol* 67:451–470.
60. Schmader T, Johns M, Forbes C (2008) An integrated process model of stereotype threat effects on performance. *Psychol Rev* 115:336–356.
61. Spencer SJ, Logel C, Davies PG (2016) Stereotype threat. *Annu Rev Psychol* 67: 415–437.
62. Cheryan S, Drury BJ, Vichayapai M (2012) Enduring influence of stereotypical computer science role models on women's academic aspirations. *Psychol Women Q* 37: 72–79.
63. Drury BJ, Siy JO, Cheryan S (2011) When do female role models benefit women? The importance of differentiating recruitment from retention in STEM. *Psychol Inq* 22: 265–269.